DEPARTMENT OF ENERGY

10 CFR Parts 820 and 835

[Docket No. EH–RM–02–835]

RIN 1901–AA95

Procedural Rules for DOE Nuclear Activities and Occupational Radiation Protection

AGENCY: Office of Health, Safety and Security, Department of Energy.

ACTION: Final rule.

SUMMARY: The Department of Energy (DOE) today amends its Procedural Rules for DOE Nuclear Activities, and its Occupational Radiation Protection requirements. The amendments to 10 CFR part 820, the Procedural Rules for DOE Nuclear Activities, update its provisions to take into account the establishment of the National Nuclear Security Administration (NNSA). The amendments to 10 CFR part 835, the Occupational Radiation Protection requirements, update its provisions to account for lessons learned since the initial adoption of these regulations, comments from the Defense Nuclear Facilities Safety Board (DNFSB) and members of the public, new recommendations from the International Commission on Radiological Protection (ICRP), and the establishment of the NNSA.

DATES: This rule is effective July 9, 2007.

FOR FURTHER INFORMATION CONTACT: Mr. Peter V. O'Connell, U. S. Department of Energy, Office of Worker Safety and Health Policy (HS–11), 1000 Independence Avenue, SW., Washington, DC 20585; (301) 903–5641.

SUPPLEMENTARY INFORMATION:

I. Background of 10 CFR Part 820

Part 820 sets forth the procedural rules relating to DOE nuclear safety requirements. Among other matters, 10 CFR part 820 sets forth the process for granting exemptions from nuclear safety requirements and the process for issuing civil penalties for violations of nuclear safety requirements. DOE proposed 10 CFR part 820 on December 9, 1991 (56 FR 64290) and issued a clarification on May 15, 1992 (57 FR 20796). DOE published 10 CFR part 820 as a final rule on August 17, 1993 (58 FR 43680) and amended it on October 8, 1997 (62 FR 52479), on March 22, 2000 (65 FR 15218), and on November 28, 2006 (71 FR 68727).

DOE proposed its latest amendments to 10 CFR part 820 on August 10, 2006 (71 FR 45996). Today's final rule modifies 10 CFR part 820 by:

(1) Formalizing the use of enforcement letters; and

(2) Making explicit the role of NNSA in giving direction to NNSA contractors pursuant to 10 CFR part 820.

As discussed in this notice of final rulemaking, this final rule was developed after consideration of comments received during a public hearing and through written and electronic public comments on the notice of proposed rulemaking (NOPR).

II. Discussion of Changes to 10 CFR Part 820

The National Nuclear Safety Administration Act (NNSA Act) (Title XXXII of Pub. L. 106–65, 50 U.S.C. 2401 *et seq.*) established the NNSA. The Act contains provisions that affect 10 CFR part 820. In particular, non-NNSA DOE personnel, other than the Secretary and Deputy Secretary, are prohibited from giving direction to NNSA contractors. On November 28, 2006, DOE published a final rule that amended the Code of Federal Regulations to address the fact that several Assistant Secretaries and the Deputy Assistant Secretary for Naval Reactors positions were converted into NNSA Deputy Administrator positions by the NNSA Act (71 FR 68727–38).

A. Definition of ''Secretarial Officer''

The November 28, 2006 final rule revised the definition of ''Secretarial Officer'' in 10 CFR 820.2 to mean an individual who is appointed to a position in the Department of Energy by the President of the United States with the advice and consent of the Senate or the head of a departmental element who is primarily responsible for the conduct of an activity under the Atomic Energy Act of 1954, as amended. The revised definition in the final rule also states that with regard to activities and facilities covered under E.O. 12344, 42 U.S.C. 7158 note, pertaining to Naval nuclear propulsion, Secretarial Officer means the Deputy Administrator for Naval Reactors.

B. Investigations

DOE adds two new subsections to § 820.21 to codify current practices. The final rule adds section 820.21(g), which recognizes the use of enforcement letters to communicate expectations during an investigation into a possible violation of a nuclear safety requirement. It also adds section 820.21(h), which provides that the Director may sign, issue and serve subpoenas during an investigation. These changes were in the proposal and DOE received no comments on them.

C. Direction of NNSA Contractors

The NNSA Act provides at 50 U.S.C 2410(b) that non-NNSA DOE personnel (other than the Secretary and Deputy Secretary) are prohibited from giving direction to NNSA contractors. Since the establishment of the NNSA, the NNSA and other elements of DOE, including the Office of Enforcement, have worked together to ensure 10 CFR part 820 operates in a manner consistent with section 2410(b). New § 820.13 codifies current practices and makes clear that NNSA is responsible for signing, issuing and serving actions that give direction to NNSA contractors. These changes were in the proposal and DOE received no comments on them.

D. Appendix on Enforcement Policy

DOE updates the Appendix on Enforcement Policy to reflect the changes this final rule makes to 10 CFR part 820. These changes were in the proposal and DOE received no comments on them.

III. Background of 10 CFR Part 835

Part 835 of title 10 of the CFR sets forth the nuclear safety requirements that provide radiological protection for DOE workers and members of the public in a controlled area at a DOE facility. DOE proposed 10 CFR part 835 on December 9, 1991 (56 FR 64334) and published it as final on December 14, 1993 (58 FR 65458). DOE amended 10 CFR part 835 on November 4, 1998 (63 FR 59662) and on November 28, 2006 (71 FR 68727).

DOE proposed its latest amendment to 10 CFR part 835 on August 10, 2006 (71 FR 45996). Today's final rule amends 10 CFR part 835 by:

(1) Clarifying those requirements in 10 CFR part 835 which apply to radioactive material transportation;

(2) Excluding from the scope of 10 CFR part 835 material, equipment, and real property approved for release in accordance with DOE approved authorized limits which have been approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer. (Note: At the time of DOE's proposed amendment, August 10, 2006, this function was to be accomplished by the Office of the Assistant Secretary for Environment, Safety and Health. After publication of the NOPR, DOE reorganized the Office of Environment, Safety and Health into the Office of Health, Safety and Security. Under this reorganization the Secretarial Officer responsible for environment, safety and health matters is the Chief Health, Safety and Security Officer);

(3) Updating the dosimetric models and dose terms to be consistent with newer recommendations from ICRP, including use of updated tissue and radiation weighting factors and updated derived air concentration (DAC) values;

(4) Establishing DAC values for Special Tritium Compounds (STCs);

(5) Lowering the maximum amount of radioactive material which need not be labeled;

(6) Allowing use of thresholds for recording occupational exposures;

(7) Establishing DAC default values for radionuclides not listed in the rule; and

(8) Revising values in Appendix E to be consistent with newer dosimetric models and adding values for STCs.

These final amendments were developed after consideration of input received during a public hearing and through written and electronic public comments on the NOPR.

The schedule for achieving compliance with the amendments to 10 CFR part 835 is as follows. As provided at § 835.101(g)(3), updated radiation protection programs must be submitted to DOE within 180 days following the effective date of this final rule or January 4, 2008. Changes that do not decrease the effectiveness of the radiation protection program (RPP) may be implemented prior to DOE approval. Changes that decrease the effectiveness of the RPP require DOE approval prior to implementation. As provided at § 835.101(i), an update of the RPP shall be considered approved 180 days after its initial submission unless rejected by DOE at an earlier date. Consistent with the proposal, today's final rule, at § 835.101(f), requires that RPPs include plans, schedules, and other measures for achieving compliance with regulations of this part such that full compliance with the regulatory changes is achieved within three years of the effective date of the final rule, which is July 9, 2007.

IV. Discussion of Changes to 10 CFR Part 835

DOE is amending 10 CFR part 835 for a number of reasons. In some cases, an analysis of the operating experience with 10 CFR part 835 indicated that DOE's needs could be met more effectively if there was a change. In other cases, the DNFSB staff or members of the public have suggested changes. In addition, the ICRP has issued newer recommendations on areas covered by 10 CFR part 835.

DOE received several comments proposing new changes, not related to proposed changes in the NOPR. DOE has decided there is no need to consider these proposed changes now and, if it were to do so, it would be required by section 553 of the Administrative Procedures Act (5 U.S.C. 553) to engage in further notice and comment proceedings. DOE is not making any new changes that are unrelated to the proposed changes in the NOPR.

A. Scope of 10 CFR Part 835

1. *U.S. Nuclear Regulatory Commission (NRC) Regulated Activity Exclusion.* One comment noted that the exclusion in 10 CFR 835.1(b)(1) refers to activities regulated through a license by the NRC, or a State under an agreement with the NRC, including activities certified by the NRC under section 1701 of the Atomic Energy Act. The exclusion is limited by 10 CFR 835.1(c) which indicates that occupational doses received as a result of excluded activities shall be considered when determining compliance with DOE's occupational dose limits. The preamble to the proposed rule indicates that ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, will be the basis for the rule's terminology and methodology. Under certain circumstances, when a DOE worker conducts multiple activities involving both excluded and un-excluded activities under 10 CFR 835.1(b)(1), clarification is needed as to how the rule would be applied when using different dose coefficients and weighting factors to calculate the overall cumulative total effective dose for the worker. DOE agrees with this comment and will provide guidance (see discussion of 10 CFR part 835.2).

2. *Material, Equipment, and Real Property Exclusion.* DOE proposed to amend § 835.1 (Scope) by inserting a new paragraph (b)(6) which would exclude radioactive material on or within material, equipment, and real property that is approved for release when the radiological conditions of the material, equipment, and real property have been documented to comply with the criteria for release set forth in a DOE authorized limit that has been approved by a Secretarial Officer in consultation with the Office of the Assistant Secretary for Environment, Safety and Health. The NOPR explained that under DOE O 5400.5, *Radiation Protection of the Public and the Environment*, real property on a DOE site and material and equipment from a DOE site may be released for unrestricted or restricted use by members of the public in accordance with a process to determine the risk to an individual from the residual radioactive material remaining on or within the material, equipment, or property. Such material, equipment, or real property may sometimes contain contaminated surfaces which exceed the surface contamination levels in 10 CFR part 835 appendix D. The appendix D values trigger application of occupational radiological controls for contaminated areas.

Accordingly, prior to today's final rule, even though DOE may have determined that this material, equipment, or property posed a minimal risk to individuals, if DOE activities were still associated with the material, equipment, or property, then certain radiological controls in 10 CFR part 835, such as those for access control, posting and training, would apply to portions of this material, equipment, or property.

To eliminate this potential inconsistency, DOE proposed a new § 835.1(b)(6) that would exclude from the scope of 10 CFR part 835 radioactive material on or within material, equipment, and real property which has been approved by DOE for release.

In this final rule, DOE modifies the language in the new § 835.1(b)(6) to exclude radioactive material on or within material, equipment, and real property which is approved for release when the radiological conditions of the material, equipment, and real property have been documented to comply with the criteria for release set forth in a DOE authorized limit which has been approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer. As previously noted, the functions of the Office of the Assistant Secretary for Environment, Safety and Health have been transferred to the Chief Health, Safety and Security Officer and the final rule reflects that change.

DOE recognizes that, depending on the potential exposure, requiring approval at the Secretarial Officer, level may be a higher level of approval than required by DOE O 5400.5. However,

this level of approval is consistent with other provisions of 10 CFR part 835 for which there are alternative means of compliance, such as alternatives to the DOELAP, use of planned special exposures, and exemptions from specified provisions of 10 CFR part 835. The requirement for consultation with the Chief Health, Safety and Security Officer would be satisfied by providing copies of a Secretarial Officer's approved authorized limits and supporting documentation to the cognizant office within the Office of Health, Safety and Security (currently the Office of Nuclear Safety and Environment (HS–20)) for review and comment. The Office of Nuclear Safety and Environment will coordinate the review and comment with the Office of Worker Safety and Health Policy (HS–11). After comments have been resolved, the consultation process is complete. The intent for this change is to allow for the exclusion to apply for material, equipment, or real property regardless of whether the property has been released from DOE control. The Department also expects the material, equipment, or real property to which this exclusion is applied will be released from DOE control according to a specified time interval.

DOE received several comments that the proposed change would be beneficial and may promote better harmony between DOE occupational radiation protection and environmental protection requirements.

DOE also received a comment requesting clarification of the applicability of this exclusion to real property which has been remediated under the criteria and conditions specified in an approved Record of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The process for determining CERCLA remediation criteria and conditions is analogous to the process for determining an authorized limit pursuant to the requirements of DOE O 5400.5. Accordingly, for the purpose of excluding real property from the scope of 10 CFR part 835, approved CERCLA remediation criteria may be considered equivalent to an authorized limit if the DOE site office has determined that the criteria meet DOE requirements for authorized limits and provided that the use of these criteria as DOE authorized limits is documented and approved as would be an authorized limit, i.e., by a Secretarial Officer or designee in consultation with the Chief Office of Health, Safety, and Security Officer.

3. *Radioactive Material Transportation.* DOE proposed revising § 835.1 to clarify which requirements in 10 CFR part 835 apply to the transportation of radioactive material by or on behalf of the DOE. Specifically, DOE proposed to delete existing § 835.1(b)(4) and replace it with a new § 835.1(d) that would state clearly that subparts F (Entry Control Program) and G (Posting and Labeling) do not apply to radioactive material transportation conducted by a DOE individual or DOE contractor, when the radioactive material is under the continuous observation and control of an individual who is knowledgeable of and implements required exposure control measures. This proposed change was not intended to affect the application of requirements to radioactive material transportation in the other subparts of 10 CFR part 835.

The proposal stated that DOE did not intend 10 CFR part 835 to apply to transportation by the U. S. Postal Service or a commercial carrier, such as Fedex or UPS, which transport radioactive material as part of their normal operations. A company or subsidiary of a corporation that operates a DOE facility would not be considered a commercial carrier—even if such an organization transports radioactive material as part of its contractual agreement with DOE. This position is consistent with NRC practice. See, for example, 10 CFR 30.13, 40.12, and 70.12. DOE requested comments as to whether there should be an explicit exclusion of these carriers from the scope of 10 CFR part 835.

DOE also proposed changes to the definition of ''radioactive material transportation'' in § 835.2(a) to improve the regulatory language. The NOPR stated that these proposed changes were not intended to affect the existing scope of this definition, which excludes activities related to transportation such as the preparation of material or packagings for transportation, storage of material awaiting transportation, or application of markings and labels required for transportation.

DOE received comments requesting guidance on the new exclusion, particularly the proposed ''continuous observation'' provision. One commenter noted that, if the radioactive material ceases to be under ''continuous observation'' the requirements of subparts F and G should apply because to do otherwise, could result in potential exposure of workers or the public. DOE agrees with this comment. However, DOE recognizes that there are some cases when it may be impractical to maintain ''continuous observation.'' To address this situation and still provide adequate warning to workers and members of the public, DOE adds a provision to § 835.1(d) to allow exception from subparts F and G for transportation by DOE and DOE contactors for radioactive material transportation conducted in accordance with Department of Transportation (DOT) regulations or DOE orders that govern such movements. For radioactive material transportation that is not subject to DOT regulations or DOE transportation orders (for situations where DOE and a contractor had not included such orders in the contract), the conditions for the exception from subparts F and G would be met by conducting the transportation activity per DOT regulations or DOE orders whether or not these are regulatory or contractually required for the transportation activity. DOE believes that the provisions at § 835.1(d) fulfill its intentions with regard to protection of workers and the public.

Another commenter noted that material staged for some period on DOE property was still technically in transit and requested guidance for continuous observation for such material. DOE disagrees with this comment, and the definition of ''radioactive material transportation'' does not include preparation of material or packagings for transportation or storage of material awaiting transportation such as what might occur when material is staged on DOE property. In accordance with the definition of ''radioactive material transportation,'' the exclusion applies while the material is in the process of undergoing movement, including nominal stoppages such as for traffic considerations or refueling activities.

Another commenter stated that this change should lead to cost savings for DOE laboratories. A commenter also requested a definition of ''radioactive material'' be added to the rule.

DOE also received a comment that there should be a specific exclusion for a ''company or subsidiary of a corporation that operates a DOE facility.'' At most DOE facilities the prime contractor transports radioactive materials as part of routine facility operations. DOE disagrees with the comment that its contractors conducting radioactive material transportation should be excluded from all the provisions of 10 CFR part 835. While DOE agrees that, at most DOE facilities, the prime contractor commonly transports radioactive materials as part of routine facility operations, it is the Department's position that all DOE occupational exposures to ionizing radiation to DOE and DOE contractor employees should, to the extent practicable, be subject to the provisions

of 10 CFR part 835. For example, provisions in 10 CFR part 835 that should apply to workers involved in radioactive material transportation, are qualification and training requirements, necessary radiation exposure monitoring, and As Low As is Reasonably Achievable (ALARA) requirements.

The NOPR stated DOE's intention that 10 CFR part 835 not apply to transportation by the U.S. Postal Service or a commercial carrier, such as Fedex or UPS, which transport radioactive material as part of their normal operations. DOE adds a provision to § 835.1(b) explicitly excluding all radioactive material transportation from the scope of 10 CFR part 835 that is not performed by DOE or a DOE contractor. This change clarifies the applicability of the transportation exclusion by making it an explicit regulatory provision.

There may be situations where DOE or DOE contractor personnel also perform radioactive material transportation activities for other than DOE related purposes (such as DOE or DOE contractor personnel performing work for a commercial transportation company after normal work hours). This situation is comparable to that where a DOE individual or a DOE contractor works part-time at an NRC regulated facility. Occupational exposure resulting from working at a NRC regulated facility (*i.e.*, an excluded activity) is considered when evaluating compliance with the dose limits. Accordingly, DOE is including in 10 CFR 835.1(c) a provision that occupational doses received as a result of radioactive material transportation performed by other than the DOE or a DOE contractor, be considered to the extent practicable when determining compliance with the occupational dose limits.

One commenter suggested imposing a time limit on the radioactive material transportation exclusion. The commenter noted that there is already a time-based exception for posting radiological areas when there is a knowledgeable person controlling access to the area, for up to eight hours (§ 835.604(a)). A comparable approach was suggested for radioactive material transportation. DOE believes this is an impractical approach for the radioactive material transportation exclusion due to the wide variation in shipment circumstances (including variable time periods) expected to be encountered across the DOE complex.

This final rule includes the changes to the radioactive material transportation provisions in the NOPR with the following additional changes: Section 835.1(b)(7) is added excluding radioactive material transportation not performed by the DOE or a DOE contractor. Section 835.1(c) is modified such that occupational doses received as a result of radioactive material transportation performed by other than the DOE or a DOE contractor, must be considered to the extent practicable when determining compliance with the occupational dose limits.

Section 835.1(4) is added excluding radioactive material transportation not performed by the DOE or a DOE contractor. Section 835.1(d) is modified to exclude DOE and DOE contractors performing radioactive material transportation from subpart G and F if such transportation is conducted under the continuous observation and control of an individual who is knowledgeable of and implements required exposure control measures or if the transportation is conducted in accordance with DOT regulations or DOE orders that govern such movements.

B. Definitions in 10 CFR Part 835

DOE proposed to change most of the dosimetric terms used in 10 CFR part 835 to reflect the recommendations for assessing dose and associated terminology from ICRP Publication 60, *1990 Recommendations of the ICRP on Radiological Protection*, and ICRP Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*. DOE proposed this change mainly because these recommendations are based on updated scientific models and more accurately reflect the occupational doses to workers than the models currently used by DOE. DOE currently uses models that were used in developing *Radiation Protection Guidance to Federal Agencies for Occupational Exposures*, published by the Environmental Protection Agency (52 FR 2822, January 27, 1987), which are based upon 1977 recommendations from the ICRP. In the NOPR, DOE noted that other federal agencies, including the Environmental Protection Agency (EPA), the Food and Drug Administration (FDA), and the National Institute of Occupational Safety and Health (NIOSH), have already adopted parts of the current ICRP recommendations related to dosimetry in recent guidance documents and requirements. NIOSH uses the newer recommendations in performing DOE worker dose assessments under the Energy Employees Occupational Illness Compensation Program Act of 2000, which is contained in the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (Pub. L. 106–398). EPA has adopted the recommendations in Federal Guidance Report Number 13, *Cancer Risk Coefficients for Environmental Exposure to Radionuclides*. In addition, recommendations published by the National Council on Radiation Protection and Measurements for the past several years, as well as several standards issued by the American National Standards Institute, have used the newer dosimetric quantities and units endorsed by the ICRP.

Internal doses would still be calculated based on a 50-year committed dose. The following ''cross-walk'' was provided in the NOPR to show the new terms DOE proposed and the terms that would be replaced:

Current dosimetric terms	Proposed dosimetric terms
Committed effective dose equivalent.	Committed effective dose.
Committed dose equivalent.	Committed equivalent dose.
Cumulative total effective dose equivalent.	Cumulative total effective dose.
Deep dose equivalent	Deep equivalent dose.
Dose equivalent	Equivalent dose.
Effective dose equivalent.	Effective dose.
Lens of the eye dose equivalent.	Lens of the eye equivalent dose.
Quality factor	Radiation weighting factor.
Shallow dose equivalent.	Shallow equivalent dose.
Weighting factor	Tissue weighting factor.
Total effective dose equivalent.	Total effective dose.

Note: Throughout the text of the NOPR, the above terms were proposed to be revised.

In addition, DOE proposed revising the following definitions: Annual limit on intake, Derived air concentration, Radiation area, Radiological worker, Dose, External dose or exposure, and Internal dose or exposure. Also, consistent with ICRP Publication 60, the table of weighting factors for neutrons would no longer list a column for neutron flux density.

DOE recognized that the proposed changes to most of the dosimetric terms used in 10 CFR part 835 to reflect the recommendations for assessing dose and associated terminology from ICRP Publications 60 and 68 would require revising many site documents and updating training materials. Although in June 2004 and again in June 2006, the ICRP released a draft of updated recommendations, which included some adjustment of Tissue Weighting Factors and Radiation Weighting Factors, DOE expressed its belief that

this was still an opportune time to make these changes rather than waiting for the draft recommendations to be finalized. It may be several years before the ICRP finalizes and issues the revised recommendations and accompanying dose conversion factors. DOE evaluated the effect of the June 2004 proposed revisions to Tissue Weighting Factors on derivation of dose conversion factors used in ICRP Publication 68. The evaluation found, for radionuclides of most interest to DOE, that the ICRP proposed Tissue Weighting Factors revisions would have minimal impact on the ICRP Publication 68 derived secondary limits (*i.e.*, the DACs and Sealed Radioactive Source Accountability values). The ICRP's June 2006 proposed revisions to Tissue Weighting Factors will also have minimal impact. Any future need by DOE to revise weighting factors should have minimal administrative impact for such activities as revising procedures and training materials. It is envisioned that, over time, updated recommendations to make revisions to dosimetry calculation models will periodically be made by national and international consensus groups. Given that fact, and the significant financial and resource impact, DOE recognizes that historical doses, recorded and reported to individuals prior to the effective implementation date of this proposed amendment, should still be considered to be the official doses of record. Barring some unforeseen reason or factor (e.g., discovery of a site or vendor specific miscalculation in assigned doses), DOE would not require the updating of historical doses to reflect these changes. DOE considered several options for amending part 835 including:

- Allowing sites to choose either converting to the newer dosimetric terminology and Tissue and Radiation Weighting Factors or retaining the existing requirements;
- Not specifying in part 835 a specific set of Tissue and Radiation Weighting Factors, but requiring sites to specify in their DOE approved Radiation Protection Program the weighting factors to be used and the technical basis for that determination;
- Updating the Tissue and Radiation Weighting Factors to reflect the newer research without revising the dose terminology;
- Updating the Tissue and Radiation Weighting Factors to reflect the newer research and revising the dose terminology; and
- Converting to the newer dosimetric terminology and Tissue and Radiation Weighting Factors and not updating the DAC values (appendices A and C to part 835) and appendix E to part 835 values.

DOE considered the best approach, which it proposed, was to convert all terminology and methodology, including the appendices A, C and E to part 835 values, to reflect ICRP Publications 60 and 68. DOE solicited comments on all of these different options.

DOE recognized in the NOPR that the proposed dosimetric changes would result in the need to update numerous site documents and proposed a three-year implementation schedule to alleviate the burden of making the changes. Therefore, DOE considered that many of the changes can be made during the regularly scheduled document updating processing. An extended implementation date also was proposed because DOE recognized that the benefit of updating documents to reflect the dosimetric changes may not justify the cost at sites nearing closure. The NOPR stated that DOE would allow sites to use the exemption process in 10 CFR part 820 to request relief, if appropriate, for closure sites which are scheduled to continue operation beyond the implementation date for the proposed changes. In the proposal, DOE requested input on any other constructive ways to reduce the costs of implementing this proposed change.

DOE received several comments supporting DOE's proposed changes to reflect the recommendations for assessing dose and associated terminology from ICRP Publications 60 and 68. Comments noted that there would be associated costs and appreciated DOE's three-year implementation schedule to meeting this change. The same comments applied to the updates to appendices A, C and E to part 835 to reflect ICRP Publications 60 and 68 methodologies.

One commenter stated that DOE should be aware that some difficulties in communications with radiation workers and perhaps even members of the public will likely linger for many years, and there did not appear to be an identifiable benefit in terms of worker protection to be gained from this change.

Comments were also received stating that DOE should not incorporate draft ICRP recommendations into this revision of 10 CFR part 835. DOE is not incorporating draft ICRP recommendations into this revision of 10 CFR part 835. DOE agrees that this action would be premature.

DOE agrees that these changes will have some impact on site operations, particularly in updating site documents and training of workers on the new terminology. Accordingly, to lessen the impact, DOE proposed and is adopting in § 835.101 a three-year implementation schedule. DOE intends to provide revised guidance documents during this time period to facilitate site implementation of these changes.

Comments were received that DOE should consult with the NRC and other federal agencies and not make these changes unless the NRC makes these changes. In preparing the NOPR, DOE did consult with the NRC and, as a member of the Interagency Scientific Committee on Radiation Standards, consulted with other federal agencies having radiation protection responsibilities. No significant objections were raised prior to publication of the proposed rule. Other federal agencies, including EPA, FDA, and NIOSH, have already adopted dosimetric aspects of the current ICRP recommendations in recent guidance documents and requirements. The NRC was the only federal agency who submitted public comments on the proposed rule. The NRC recommended postponing updating the dosimetric models and terms.

A review of significant unplanned radiation exposures at DOE facilities over the past several years reflects that, at DOE facilities, significant unplanned radiation exposures have been from internal exposures, resulting from intakes of radioactive material. As the owner and regulator of these facilities, DOE believes it is prudent and warranted to assess these exposures using dose assessment methods more current than those in the current rule. DOE notes that the NRC has authorized selected fuel cycle facilities to use this approach. DOE continues to believe that, for DOE facilities, these changes are an improvement.

DOE received a comment that, under certain circumstances, when an individual conducts multiple activities involving both activities under 10 CFR 835.1(b)(1) and excluded activities (*e.g.*, activities involving NRC licensed activities) it is ambiguous as to how the rule would be applied when using different dose coefficients and weighting factors to calculate the total effective dose for the worker from both activities. DOE agrees that guidance is needed for this provision. For the purpose of compliance with 10 CFR 835.1(b)(1), DOE considers the following terms to be equivalent:

Dosimetric term as defined by excluded activity cognizant regulator	DOE amended dosimetric term
Committed effective dose equivalent.	Committed effective dose.
Committed dose equivalent.	Committed equivalent dose.
Cumulative total effective dose equivalent.	Cumulative total effective dose.
Deep dose equivalent	Equivalent dose to the whole body.
Dose equivalent	Equivalent dose.
Effective dose equivalent.	Effective dose.
Lens of the eye dose equivalent.	Equivalent dose to the lens of the eye.
Quality factor	Radiation weighting factor.
Shallow dose equivalent.	Equivalent dose to the skin or Equivalent dose to any extremity.
Weighting factor	Tissue weighting factor.
Total effective dose equivalent.	Total effective dose.

In response to another comment, DOE replaces the term ''nonstochastic'' with the term ''deterministic.''

One commenter stated that there did not appear to be significant benefit to changing the dosimetric methodologies. DOE disagrees with the comment and, to the contrary, believes that using more up-to-date models for assessing worker dose is beneficial. Under the 10 CFR part 820 exemption process, DOE already authorizes the Y–12 and Savannah River Site facility to use ICRP Publications 60 and 68 methodologies for assessing doses. The contractors requested the change and noted that the improved accuracy in determining worker doses would be beneficial. Similarly, as noted previously, the NRC authorized selected fuel cycle facilities to use this approach.

DOE also received a comment that DOE should move the phrase ''(1 rem = 0.01 sieverts)'' to the end of the definition for ''annual limit on intake,'' rather than with the definition of ''committed equivalent dose,'' because this would be the first use of the term ''Sievert.''

DOE makes these editorial changes, with the exception that the phrase ''(1 rem = 0.01 Sv)'' is included in the definition of ''annual limit on intake,'' the first usage of the term ''Sievert'' in 10 CFR part 835.

One commenter noted that the definition of ''absorbed dose'' should refer to energy imparted and not energy absorbed. DOE agrees with this comment and changes the definition. One commenter requested the addition of several additional dosimetric terms/operational quantities in the rule such as ''ambient dose'' and ''personal dose equivalent.'' DOE agrees that these quantities are important because they are the operational quantities that have been recommended by ICRP for use in assessing compliance with the numerical dose criteria for external exposure specified in this part. However, DOE does not believe it is necessary to define or revise additional dosimetric terms, such as ''ambient dose,'' and ''personal dose equivalent.'' Definitions of such terms are best left in supporting documents, such as implementation guides for 10 CFR part 835 and the technical standards for the DOELAP. For clarification, DOE provides a discussion of this topic in section U of this part.

One commenter requested that DOE not use the terms ''deep equivalent dose,'' ''lens of the eye equivalent dose'' and ''shallow equivalent dose'' because these terms are not defined in the referenced ICRP publications. DOE agrees with this comment and replaces these terms with ''equivalent dose to the whole body,'' ''equivalent dose to the lens of the eye,'' ''equivalent dose to the skin,'' or ''equivalent dose to the extremity,'' as appropriate, in §§ 835.202, 835.205, 835.402, 835.502, and 835.702. DOE adds the following sentence to the definition of ''equivalent dose'' in § 835.2(b) ''For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue.''

DOE received a comment that it should clarify the definition of ''committed effective dose'' to assure consistency with the equations of Section 6 of ICRP Publication 68 and the methodology for calculating the ''remainder'' dose. DOE agrees with these comments and revises the definition of ''committed effective dose'' and footnote number 1 under the table of Tissue Weighting Factors to be consistent with ICRP Publication 68.

One commenter pointed out that footnote 2 to the table on radiation weighting factors in the definition of ''radiation weighting factor'' in § 835.2(b) did not provide information on the radiation weighting factor for Auger electrons emitted by radioactive atoms incorporated into DNA and requested either deletion of the exclusion or clarification on the appropriate radiation weighting factor.

After reevaluation of this topic, DOE has determined that from a regulatory perspective, the benefits of this footnote to worker health and safety may be outweighed by difficulties in complying with the footnote. The reasons are: (1) This footnote only applies to dose received by the DNA of a cell and, thus, is a very small fraction of the dose received by the entire tissue; (2) assessment of doses and risks will require information on the distribution of radionuclides within tissues and cells which may not be readily available, and which will depend on the chemical form involved; and (3) except for accidents, most exposures of this type are therapeutic and would not be covered by provisions of 10 CFR part 835. Accordingly, footnote 2 to the table on radiation weighting factors in § 835.2(b) from the proposed rule is not included in the final rule and DOE will develop guidance to address the infrequent situations and complex dosimetry resulting from incorporation of Auger electron emitters in DNA.

DOE received a comment recommending DOE permit sites to choose to either convert to the newer tissue and radiation weighting factors or remain with the existing requirements. Another option suggested by the commenter was for DOE to not include tissue weighting factors, radiation weighting factors, and DACs in the rule. Rather, this information may be placed into a set of guidance documents and incorporated by reference in the rule. After considering all the comments DOE has received, DOE still considers the best approach to be to convert all terminology and methodology, including the appendices A, C and E values, to reflect ICRP Publications 60 and 68. DOE did not propose excluding tissue weighting factors, radiation weighting factors, and DACs from the rule and is not making this change.

DOE received a comment that the dose methodology in the proposed 10 CFR part 835 is not consistent with DOE's requirements for the protection of the public. The commenter believed that the standards for the public and environment and the standard for DOE workers should be revised at the same time to avoid situations where some DOE standards are based on new ICRP recommendations and some standards are based on older ICRP recommendations. DOE does not agree with this comment. DOE has already initiated adoption of the more recent ICRP recommendations as demonstrated by its guidance on radiation risk estimation (endorsing Federal Guidance Report Number 13, which is consistent with ICRP Publication 60). DOE sees no conflict in making this change at this time and no benefit in waiting until all

of its environmental policy and guidance is updated.

As part of DOE's response to a comment regarding application of appendix D surface contamination values to areas of fixed contamination consisting of special tritium compounds (STCs), DOE is adding a definition of ''special tritium compound.'' The definition is from DOE technical standard, *Radiological Control Programs for Special Tritium Compounds*, DOE–HDBK–1184–2004.

One commenter requested clarification of the term ''personal property'' which is used in the definition of ''real property.'' DOE revised the definition of ''real property'' to not include the term ''personal property.''

DOE received a comment that a definition of ''activity median aerodynamic diameter'' (AMAD) should be included in the rule. DOE agrees with is comment and has added a definition, based on ICRP Publication 66, *Human Respiratory Tract Model for Radiological Protection*, for AMAD. DOE also clarifies, in the appendix A notes, that AMAD is the appropriate particle size value.

DOE received a comment that, because of the uncertainties in the biological effect of high energy radiation and difficulties in measuring radiation at such levels, DOE should insert a binding statement in 10 CFR part 835 requiring DOE contractors to evaluate and justify the radiation weighting factors used for photon and particle energies above 10 MeV.

DOE agrees that at high energies, such as those above 10 MeV, the biological impact of particles on human tissue may be more uncertain than at other energies and that monitoring of workplaces and individuals exposed to particles with these energies may be very challenging. However, other challenging radiological conditions exist in the DOE complex that are not explicitly addressed in 10 CFR part 835. Moreover, radiation fields consisting of particles greater than 10 MeV do not occur extensively within the DOE complex. When such conditions are identified, efforts should be focused on significantly limiting exposure to these types of radiation fields through the application of engineered and administrative controls. If doses to workers result from exposure to such radiation fields, provisions in subpart E of 10 CFR part 835 require that instruments and equipment used for monitoring individuals and workplaces be appropriate for the types, levels and energies of the radiations encountered, and that monitoring be performed to detect changes in radiological conditions. Finally, DOE notes that the purpose of radiation weighting factors is to establish dose limits, set up other dose dependent criteria for protection purposes, and plan radiological work. They are not for the purpose of measuring radiation fields and individual doses. Accordingly, DOE does not believe there is a need to include a specific provision in the final rule specifying evaluation and justification of the radiation weighting factors used for photon and particle energies above 10 MeV. DOE, however, will include in guidance a recommendation to evaluate and document the technical bases for the equivalent dose response of instruments and equipment used to monitor workplaces and individuals exposed to photon and particle energies above 10 MeV.

A commenter proposed that neutron flux to dose conversion factors be added as conversion factors in 10 CFR part 835 and that DOE sites be permitted to use different values if they could defend their position.

DOE believes that if the neutron energy spectrum is known in sufficient detail to permit the use of more radiation weighting factors than are currently provided in the proposed amendment to 10 CFR part 835, a more detailed set of radiation weighting factors would be appropriate. Such an approach was used in the previous versions of 10 CFR part 835 which included a table containing mean quality factors for 21 values of neutron energy. Accordingly, the formula recommended in ICRP Publication 60 relating to neutron energy and radiation weighting factors is added to footnote 3 of the radiation weighting factors table in the definition of ''radiation weighing factor.''

DOE will not provide neutron fluence to dose conversion factors, as proposed by the commenter, because they are a function of many more factors than the relationship between neutron energy and radiation weighting factors and would not be as widely applicable throughout the DOE complex.

Regarding a comment to permit DOE sites to use different neutron fluence to dose conversion factors, DOE's decision to include the formula relating neutron energy and radiation weighting factors obviates the need for such a change to the final rule. As long as the neutron fluence to dose conversion factors incorporate the radiation weighting factors permitted by 10 CFR part 835, DOE sites may use conversion factors appropriate to local conditions to relate neutron fluence to equivalent dose and effective dose.

Note that the radiation weighting factors are only for use in calculating equivalent dose, effective dose, committed effective dose, and total effective dose. The operational radiation dose quantities used in the measurement of radiation dose use other modifiers of absorbed dose, such as quality factors, to account for the biological impact of the radiation type. However, to ensure compliance with the dose quantities specified in 10 CFR part 835, the operational radiation dose quantities must provide a dose estimate equal to or greater than the dose quantities specified in 10 CFR part 835.

In summary, DOE makes the proposed changes to the dosimetric terms used in 10 CFR part 835 to reflect the recommendations for assessing dose and associated terminology from ICRP Publications 60 and 68. DOE revises the definition ''nonstochastic effects'' to read ''deterministic effects.'' As previously discussed, DOE revises the definitions of ''committed effective dose,'' ''committed equivalent dose,'' and ''absorbed dose.'' DOE adds definitions for ''activity median aerodynamic diameter'' and ''special tritium compound.'' DOE deletes the proposed definitions of ''deep equivalent dose,'' ''lens of the eye equivalent dose,'' ''shallow equivalent dose,'' and footnote 2 to the table on radiation weighting factors in § 835.2(b) that addresses the radiation weighting factor for Auger electrons emitted by radioactive atoms incorporated into DNA.

DOE adds the following formula to the definition of ''radiation weighting factor (w_R):''

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

DOE revises 10 CFR 835.2(c) to state that terms defined in the Atomic Energy Act of 1954 or in 10 CFR part 820 and not defined in this part are used consistent with the meanings given in the Atomic Energy Act of 1954 or in 10 CFR part 820. Accordingly DOE removes the definitions of ''Contractor'' and ''Secretarial Officer'' from 10 CFR part 835 and uses the terms as defined in 10 CFR part 820.

C. Radiological Units in 10 CFR Part 835

DOE proposed to revise the text of § 835.4 to allow use of additional units, such as dpm, mass units, μCi/cc, and dpm/100cm^2 in records required by this part. The original intent of this provision was to preclude the exclusive use of the SI units of becquerel, gray (Gy) and sievert (Sv). As stated in the NOPR, the intent was not to preclude use of other conventional units, such as those previously listed. The proposed change was intended to achieve the original intent of this section. DOE received comments that the allowance for the additional units of measurement should prove to be beneficial and the continued preclusion of the exclusive use of the SI units is beneficial and appreciated. The final rule makes the changes as proposed in the NOPR.

D. Radiation Protection Programs

DOE proposed to add a new sentence at the end of § 835.101(f) that would provide that unless otherwise specified in part 835, compliance with the amendments made by this final rule shall be achieved no later than three years following the effective date of the final rule. The reasons DOE proposed an extended implementation date are the same as those discussed in connection with the changes to the dosimetric terms.

DOE received several comments that given the extensive changes proposed, the proposed three-year implementation period would be beneficial. One commenter believed that the three-year implementation period was excessive and could cause confusion at sites with multiple contractors where each contractor may implement the amendments at different times. DOE will provide guidance for this situation. One commenter believed that the three-year implementation time period may not be adequate for all sites. DOE believes that the three-year period is reasonable. Contractors still have the option of requesting an extension of the implementation date through the 10 CFR part 820 exemption process, on a case by case basis. The final rule makes the changes as proposed in the NOPR.

E. Occupational Dose Limits for General Employees

DOE proposed amending § 835.202 by revising the dosimetric terms to be consistent with the revised definitions. One commenter noted that the phrase ''for external exposures'' was redundant because that phrase was already included in the definitions of ''deep equivalent dose' and ''shallow equivalent dose.'' As discussed previously, DOE is not including in the final rule definitions for ''deep equivalent dose'' or ''shallow equivalent dose.'' The term ''for external exposures'' is no longer redundant in § 835.202(a)(2). DOE makes the following changes: § 835.202(a)(2) is rewritten as ''The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye''; § 835.202(a)(3) is rewritten as an ''equivalent dose to the lens of the eye''; and § 835.202(a)(4) is rewritten as ''The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity.''

F. Combining Internal and External Equivalent Doses

DOE proposed amending § 835.203 by revising the dosimetric terms to be consistent with the revised definitions. DOE received a comment requesting clarification on the proposed change to § 835.203(b) by specifying that the radiation weighting factor values, in addition to the tissue weighting factor values, provided in § 835.2 shall be used in determining effective dose. Although the definition of ''radiation weighting factor'' already specifies the factors to be used, DOE agrees that the additional words in § 835.203(b) will clarify the requirement. DOE makes the changes as proposed in the NOPR with the exception that the phrase ''radiation and'' is added before the phrase ''tissue weighting factor.''

G. Occupational Dose Limits for Minors

DOE proposed amending § 835.207 by revising the dosimetric terms to be consistent with the revised definitions. DOE received a comment that the term ''equivalent'' in the first line on the proposed change to section 835.207 was incorrect. As stated, the sentence contradicts the revised definitions in the NOPR. DOE agrees and makes the changes as proposed in the NOPR with the exception that the word ''equivalent'' is deleted from the first sentence.

H. General Requirements for Monitoring Individuals and Areas in 10 CFR Part 835

DOE proposed amending § 835.401(a)(5) by revising the text ''engineering and process controls'' to read ''engineering and administrative controls.'' This change was proposed in order to make the use of the terms consistent with DOE Policy 450.4 ''Safety Management System Policy.'' DOE considered the terms to be equivalent. DOE received comments that the proposed change to § 835.401(a)(5) was a beneficial clarification. One commenter recommended that wherever the term ''engineering control(s)'' is used in the rule that it be changed to ''engineered control(s).'' This is primarily a matter of clarity in meaning. ''Engineering control'' can have several meanings. ''Engineered control'' is less ambiguous. DOE agrees with this editorial comment and makes this change throughout the rule.

I. Monitoring of Packages Containing Radioactive Material in 10 CFR Part 835

DOE proposed amending § 835.405(c)(2) by changing ''unless the package contains less than a Type A quantity'' to ''if the package contains a Type B quantity.'' DOE received comments that the proposed change in the requirements pertaining to Type A quantities is a useful clarification and should have insignificant associated costs. DOE received a comment that its proposed change to the definition of ''radioactive material transportation,'' by removing the text ''when such movement is subject to DOT regulations or DOE orders that govern such movements,'' creates ambiguity as to when receipt surveys are required under § 835.405. The commenter provided an example: If material is transported on-site via a cart, receipt surveys would not be required; however, if the same package was transported in a truck (*i.e.*, a ''highway vehicle''), surveys would be required. While DOE agrees that there is ambiguity in the requirement, DOE does not agree that keeping the text ''when such movement is subject to Department of Transportation regulations or DOE orders that govern such movements'' in the rule addresses this ambiguity.

Section 835.405(d) requires, in part, that packages received from radioactive material transportation, which meet the criteria of § 835.405(b), be monitored as soon as practicable following receipt of the package. The purpose of this monitoring is to verify the radiological condition of the package (*e.g.*, contamination levels and/or radiation

levels). The verification is needed because, other than the visual indications listed in § 835.405(b)(3), the recipient typically has no knowledge of the physical rigors the package was subject to while in transit. Monitoring is needed to ensure protective actions for subsequent package handlers as well as notifying the transporter if unexpected radiological conditions are identified.

The exclusion in § 835.1(d) applies to radioactive material transportation conducted by a DOE employee or DOE contractor employee, when the radioactive material is under the continuous observation and control of an individual who is knowledgeable of and implements required exposure control measures. For situations meeting this exclusion, DOE sees no benefit in post-transit monitoring of the packages to verify the radiological condition of the package (*e.g.*, contamination levels and/or radiation levels). The verification is not needed because a DOE employee or DOE contractor employee had the package under continuous observation and is knowledgeable of the physical rigors the package was subject to while in transit.

Accordingly, DOE adds a new § 835.405(e) to reflect that receipt monitoring is not required for packages transported on a DOE site which have remained under the continuous observation and control of a DOE employee or DOE contractor employee who is knowledgeable of and implements required exposure control measures. The final rule makes the other changes as proposed in the NOPR.

J. Exception for Labeling Requirements in 10 CFR Part 835

DOE proposed to establish an upper limit of 0.1 Ci for a quantity of radioactive material which would be excepted from the labeling requirement in § 835.606(a)(2). After the establishment of the radioactive material labeling requirements in the 1998 amendment to 10 CFR part 835, DOE noted that the exception to labeling requirements for radioactive materials appeared excessive for certain isotopes. DOE currently exempts from labeling items and containers if a quantity of radioactive material is less than one tenth of the values specified in appendix E of 10 CFR part 835. For some isotopes this quantity is significant. For example, a container of tritiated water need not be labeled ''Caution, Radioactive Material'' as long as there is less than 16 Ci of tritiated water in the container. While the basis for this exception, as discussed in the preamble to the 1998 amendment to 10 CFR part 835, is technically defensible, DOE believes that it is prudent to establish an upper limit for the labeling exception. The approach DOE proposed is similar to that taken by the NRC, except that the NRC upper limit is 0.001 Ci. DOE believes that the proposed 0.1 Ci upper limit in § 835.606 would provide an acceptable level of protection, based on the exposure scenario discussed in the preamble to the 1998 amendment (63 FR 59672–73, November 4, 1998), and still provides for sufficient operational flexibility in not being overly restrictive in the labeling requirements.

DOE received comments that the proposed change to establish an upper limit of 0.1 Ci for a quantity of radioactive material which would be excepted from the labeling requirement provides an acceptable level of protection in harmony with operational flexibility. Anticipated costs for compliance would be negligible.

The final rule makes the changes as proposed in the NOPR.

K. Individual Monitoring Records Requirements in 10 CFR Part 835

DOE proposed to revise § 835.702(b) to give sites the option of not assessing and recording any internal dose monitoring result estimated to be less than 10 millirems committed equivalent dose. This change was proposed in response to concerns that, under the current requirements, there is no threshold for positive internal dose monitoring results which need not be assessed and a dose recorded. DOE stated in the NOPR that this flexibility would likely be of most benefit for routine bioassay results from tritium and uranium operations. For tritium, under the current rule, positive bioassay results could result in the need to determine and record doses that are less than one millirem. DOE proposed the revision to allow some relief from the need to perform a dose assessment and to record these very small doses. DOE envisioned that this would most easily be achieved through the development and use of default values, below which no further dose assessment or recording would be required. Establishing a dose threshold for any single bioassay and/or air monitoring result would make the DOE requirements consistent with nationally accepted standards as discussed in ''American National Standard for Design of Internal Dosimetry Programs'' (ANSI/HPS N13.39–2000). The proposed provision would still require the maintenance of bioassay and/or air monitoring results in case they are needed by DOE in the future.

The NOPR also stated that DOE's policy has been that the current monitoring threshold of 100 millirems should not be interpreted as an objective for internal dose monitoring. DOE fully recognizes that routine internal dose monitoring is not capable of detecting doses at the monitoring threshold for some radionuclides. Consistent with that policy, DOE stated that the proposed threshold values for assessing internal dose should not be construed as the establishment of thresholds for internal dose monitoring.

As stated in the NOPR, the proposed revision would provide flexibility for assessing and recording doses for any single bioassay and/or air monitoring result. It also included an annual limit for doses that need not be assessed or recorded based on 50 percent of the applicable monitoring threshold at § 835.402(c)(1) through (4). DOE recognized that sites wishing to invoke the flexibility offered by this proposed change would need to develop and implement a program to track bioassay results to ensure that dose constraints are not exceeded without recording the doses. DOE stated its intention to provide guidance on acceptable implementation methods.

DOE received several comments supportive of the proposed change. DOE also received a comment recommending changing § 835.702(b) such that the annual threshold dose which must be assessed and recorded as a result of internal monitoring be increased from 50 percent to 100 percent of the applicable monitoring threshold. DOE agrees with this comment and adopts this recommendation.

A few commenters were opposed to the proposed change to 10 CFR 835.702(b). Reasons stated included: A belief that any dose should be assessed when there is monitoring data available; the change would cause more trouble than relief; DOE might be accused of making the change in order to lower DOE's collective dose; not reporting dose when bioassay samples have been taken may lead to litigation and require dose reconstruction for former workers; and a more effective change might be to raise the monitoring threshold to 500 millirems instead of 100 millirems. One commenter suggested an alternative approach of assigning a minimum dose to all non-monitored workers.

DOE believes that, consistent with ANSI/HPS N13.39–2000 recommendations, it is acceptable to only assess and record doses exceeding 10 millirems, provided that the monitoring data are maintained. DOE continues to believe that the change is beneficial, and the change is supported

by several commenters. DOE anticipates a slight drop in the collective dose as a result of this change. According to DOE's 2004 REMS Report, approximately 31 rems collective dose was from individual exposures of less than 100 millirems. This is approximately 3 percent of the collective dose. As DOE has done in the past, DOE will ensure that the reason for this slight decrease is clearly explained in DOE's REMS report. DOE does not believe that this change will lead to extensive litigation because the individual monitoring results must still be maintained, and they will be available. DOE already conservatively maintains an internal exposure monitoring threshold of 100 millirems, which contrasts with the NRC's value of 500 millirems, and requires maintenance of the individual monitoring results. DOE believes this approach should suffice to avoid future expensive dose reconstruction efforts and supports DOE's continuance of the 100 millirems monitoring threshold. DOE sees no benefit in assigning a minimum dose to all workers, monitored or not.

One comment stated that, in order to be consistent with ANSI/HPS N13.39–2000, one of the stated objectives for making the change discussed in the NOPR, the value for not requiring the assessing and recording of an internal dose monitoring result should be 10 millirems committed effective dose, rather than 10 millirems committed equivalent dose. DOE received another comment that this change may not provide significant relief because there are requirements to assess and record both whole body internal doses (committed effective doses) and organ or tissue internal doses (committed equivalent doses). The commenter suggested that a threshold for not requiring assessing and recording of an internal dose be applied to both whole body and organ or tissue internal doses. DOE agrees with these comments. The intent of the proposed change was to provide relief from having to assess and record all internal doses which are well below DOE's conservative internal dose monitoring threshold. To meet this intent, DOE revises the provision to not require recording of whole body internal doses (committed effective doses) and organ or tissue internal doses (committed equivalent doses) as long as the monitoring data are estimated to correspond to an individual receiving less than 10 millirems committed effective dose. For radionuclides of most concern to DOE, the 10 millirems committed effective dose threshold is suitable to ensure adequate evaluation of organ or tissue doses as well.

In summary, DOE revises § 835.702(b) to not require recording of whole body internal doses (committed effective doses) and organ or tissue internal doses (committed equivalent doses) as long as the monitoring data are estimated to correspond to an individual receiving less than 10 millirems committed effective dose. DOE revises the value for unrecorded internal dose estimated for any individual in a year to be the applicable monitoring threshold at § 835.402(c).

L. Radiation Safety Training

DOE proposed amending § 835.901(b) by adding the text ''applied training,'' after ''by successful completion of,'' in the introductory language of that paragraph. The training and applied training is to be commensurate with the hazards in the area and the required controls. DOE already requires that each individual demonstrate knowledge of the radiation safety training topics listed in § 835.901(c) by successful completion of an examination and performance demonstrations. The current requirement for performance demonstration implies that the training will include practical factors or ''applied training.'' Accordingly, DOE considered the proposed change to be only editorial.

DOE considered comments on options for adding a provision for retention testing in 10 CFR part 835. DOE specifically noted in the NOPR that DOE–HDBK–1131–98 includes an attachment ''Evaluating the Effectiveness of Radiological Training.'' This attachment discusses a recommended approach to implementing a retention testing program.

DOE also solicited comments on adding a provision, in subpart J, for radiological control technician (RCT) training. The NOPR noted that 10 CFR part 835 already requires individuals responsible for developing and implementing measures necessary for ensuring compliance with the requirements of 10 part CFR 835 (including RCTs) to have the appropriate education, training, and skills. The NOPR referenced DOE guidance which details DOE's expectations for the appropriate level of training, retraining, testing and qualifications of RCTs. DOE, however, solicited comments on whether DOE should specifically include requirements for RCT training, retraining, testing, and qualifications in 10 CFR part 835.

DOE received a comment that several changes need to be made in the area of radiation safety training. Specifically, the commenter requested that DOE:

- Add a requirement for applied training and performance demonstrations for the periodic requalification;
- Add a requirement for retention testing;
- Make changes to the testing process to ensure that computer-based training does not allow the trainee to pass the examination based on trial and error;
- Reinstate the training requirements for RCTs.

Regarding the comment to add a requirement for applied training and performance demonstrations for periodic requalification, 10 CFR 835.901(e) currently specifies the training requirements for requalification. DOE has had no indication that the lack of performance demonstration requirements for requalification has created a radiation protection concern. DOE searched its occurrence reporting data, and could not identify significant examples of radiological occurrences resulting from improper radiological work practices due to lack of performance demonstrations during requalification training. Although DOE is not amending 10 CFR part 835 as requested by the commenter, it may update its implementation guide to recommend that sites periodically evaluate individuals' abilities to perform acceptable radiological work practices (such as donning and doffing protective clothing) and include, as necessary, performance demonstrations during the requalification training.

Regarding the comment that DOE should add a requirement for retention testing, as discussed in the NOPR, DOE provides, and maintains several guidance documents which address retention testing. Several other comments stated that there is no need for a retention testing requirement in 10 CFR part 835. DOE has searched its occurrence reporting data and found no significant examples of radiological occurrences resulting from lack of retaining information from radiological worker training or equivalent training. Consequently, at this time, DOE is not adding a requirement for retention testing for radiation safety training. DOE continues to support retention testing as a good practice and is willing to work with DOE sites to improve previously discussed guidance documents relating to retention testing.

Regarding the comment to make changes to the testing process to ensure that computer-based training does not

allow the trainee to pass the examination based on trial and error, DOE believes that permitting a trainee to pass by trial and error would be inconsistent with the requirement that individuals demonstrate an acceptable baseline knowledge level of radiation protection fundamentals and practices. DOE may update its implementation guide to clearly indicate that this practice is not consistent with the requirement.

Regarding the comment to reinstate the training requirements for RCTs, DOE explained its basis for specifying the training and qualification requirements for individuals responsible for implementing 10 CFR part 835 requirements, which include RCTs, when DOE amended 10 CFR part 835 on November 4, 1998 (63 FR 59662).

Under the original rule, published on December 14, 1993 (58 FR 65458), DOE specified training and retraining requirements for RCTs in § 835.903. To address a number of shortcomings in its provisions for training RCTs, DOE proposed, in its December 23, 1996, NOPR, to amend 10 CFR part 835 by codifying the definition of ''radiological control technician'' at § 835.2(a). DOE also solicited comments on four alternative approaches. Alternative Approach 4 included specifying the training and qualification requirements for individuals responsible for implementing 10 CFR part 835 requirements, including RCTs, under a new § 835.103. Public comments indicated that DOE's proposed definition of the term ''radiological control technician'' did not adequately describe the roles and responsibilities of individuals filling this position. DOE received comments endorsing each of the proposed alternative approaches, with the majority of the comments endorsing Alternative Approach 4. DOE subsequently chose this approach because it provided the flexibility necessary to cover the wide range of individuals involved in developing and implementing measures necessary for ensuring compliance with 10 CFR part 835, including cognizant managers, supervisors, auditors, engineers, clerks, and technicians. DOE has decided that the current approach in § 835.103 is the optimal approach for specifying training requirements for RCTs. DOE received several comments supporting this position.

DOE has searched its occurrence reporting data, and could not identify significant examples of radiological occurrences resulting from inadequate training or qualifications of RCTs. Consequently, DOE is not making any revisions to the training requirements for RCTs at this time.

DOE will, however, continue to assist sites in meeting § 835.103 by improving and maintaining those previously discussed guidance documents relating to the training, retraining, and qualifications of RCTs.

DOE also received comments that the proposed change to § 835.901(b) was confusing. DOE proposed to specify that each individual shall demonstrate knowledge of the radiation safety training topics established in § 835.901(c), commensurate with the hazards in the area and required controls, by successful completion of applied training. There were questions concerning the new term ''applied training'' and requests for DOE to either delete this change or make revisions to clarify the intent. DOE provides the following clarification in response to these comments. DOE believes that radiation safety training should include appropriate theoretical training (such as radiological fundamentals, limits, and controls) as well as applied training (such as reading and understanding work permits and donning and doffing protective clothing). DOE recognizes that there are different training methods available to effectively provide this training, including classroom instruction, computer-based training, on-the-job mentoring, or combinations of these methods. Successful completion of such training is demonstrated by completion of an examination and performance demonstrations. As DOE stated in the NOPR, the current requirement for performance demonstration already implies that the training includes applied training. DOE has decided, after considering the comments, that the proposed addition of the term ''applied training'' to the training requirements does not clarify or improve the requirement. Consequently, DOE does not make the proposed change to § 835.901(c) in today's rule. In summary, DOE makes no revisions to subpart J as part of this final rule.

M. Design and Control Requirements in 10 CFR Part 835

DOE proposed to amend § 835.1001(a) by replacing the text ''physical design features and administrative control'' with ''engineering and administrative controls.'' DOE also proposed to amend § 835.1001(b) by replacing the text ''physical design features'' with ''engineering controls'' and proposed to amend § 835.1003 by replacing the text ''physical design features and administrative controls'' with ''engineering and administrative controls.'' These changes were proposed in order to make the terms used in 10 CFR part 835 consistent with those in DOE Policy 450.4, ''Safety Management System Policy.'' DOE considered the terms to be equivalent.

DOE received a comment that the proposed changes to § 835.1001(a) will clarify the text and will be beneficial. DOE makes the changes as proposed in the NOPR with exception that the term ''engineering'' will be replaced with the term ''engineered.'' See discussion in section IV. H. of this preamble.

N. General Provisions to Emergency Exposure Situations in 10 CFR Part 835

DOE proposed to amend the general provisions to emergency exposure situations to clarify that the resumption of operations, pursuant to § 835.1301(d), only applies to operations which have been suspended as a result of a dose in excess of the limits specified in § 835.202. DOE considered the proposed change to be only editorial.

DOE received a comment that § 835.1301(d) should also require operations which have resulted in a dose in excess of the limits specified in § 835.202, except those received in accordance with § 835.204, to be suspended. DOE does not agree with this comment. Implementing a requirement such as this would be problematic. Past DOE experience with exposures in excess of the limits have involved situations where the exposure was not determined for a considerable time period after the operation causing the exposure. Sometimes the operation causing the exposure had already ceased by the time the exposure was assessed. Other times the operation causing the exposure was never determined. The rule is not the appropriate vehicle for such management of DOE operations.

DOE received another comment that the proposed clarification of § 835.1301(d) will be beneficial. The final rule makes the changes as proposed in the NOPR.

O. DAC Values, Introductory Paragraph, and Footnotes in Appendix A in 10 CFR Part 835

There is discussion earlier in this preamble of DOE's adoption in this final rule of the system of dosimetry for intake of radioactive materials set forth in more recent ICRP Publications. DOE also proposed to modify the DAC values contained in appendix A to part 835 to reflect the previously mentioned ICRP publications. The salient changes proposed were:

- The use of updated dose per unit intake conversion factors (dose coefficients) specified in ICRP

Publication 68 instead of the dose per unit intake conversion factors in the EPA Federal Guidance Report Number 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, which is the basis for the current appendix A values. ICRP Publication 68 lists committed effective dose coefficients which are used in deriving the DAC limit based on the stochastic limit of 5 rem. In order to determine if the non-stochastic (organ) limit of 50 rems to any organ or tissue is more limiting, DOE used the ICRP computer program, *The ICRP Database of Dose Coefficients: Workers and Members of the Public*, ISBN 0 08 043 8768. As in the current set of DAC values, the more limiting value (stochastic or non-stochastic) is used.

- The use of the ICRP Publication 66, *Human Respiratory Tract Model for Radiological Protection*, classification of radioactive material by absorption type [F(fast), M(medium), and S(slow)] instead of by lung clearance classes [D(days), W(weeks), and Y(years)] as specified in ICRP Publication 30. Values were calculated in units of Bq/m^3 and converted to units of μCi/mL. The table presents both units, each truncated to one significant figure.
- The use of default particle size distribution of 5 micrometers instead of a default particle size distribution of 1 micrometer, if the actual particle size distribution is not known.

In addition to the changes in the dosimetric models used to calculate the DACs in appendix A, several other changes to this appendix were proposed. One proposed change was to establish DAC values for tritiated particulate aerosols and insoluble organically bound tritium and default values for radionuclides not listed in the appendix.

Subsequent to the November 4, 1998 amendment to 10 CFR part 835, Occupational Radiation Protection (63 FR 59662), the Department developed guidance for controlling individual exposures to tritiated particulate aerosols and insoluble organically bound tritium. In 2001, the DOE Office of Worker Protection Policy and Programs (EH–52) issued Radiological Control Technical Position RCTP 2001–02, *Acceptable Approach for Developing Air Concentration Values for Controlling Exposures to Tritiated Particulate Aerosols and Organically Bound Tritium*, which provided guidance on the use of acceptable air concentration values. In 2004, EH–52 also published a technical standard, *Radiological Control Programs for Special Tritium Compounds*, DOE–HDBK–1184–2004, which provided additional guidance on use of acceptable air concentration values. DOE proposed including DAC values for tritiated particulate aerosols based on the methodology described in DOE–HDBK–1184–2004, adjusted to use the ICRP 60 dosimetric quantities and adjusted to use a default 5 micron particle size. This handbook is available for review at: *http://www.hss.energy.gov/HealthSafety/WSHP/radiation/ts.html.*

Appendix A of 10 CFR part 835 does not include default values for radionuclides not listed in the appendices. Consistent with the NRC practice, DOE proposed to establish default values for radionuclides not listed in appendix A. One default value would apply to any isotope not already listed with a decay mode other than alpha emission or spontaneous fission and with a radioactive half-life greater than two hours. The default value would be the most restrictive applicable DAC value already listed in appendix A for that type of decay, *i.e.*, 4 E–11 μCi/mL (1 Bq/m^3). The second default value would apply to any isotope not already listed with a decay mode of alpha emission or spontaneous fission. The second default value would also apply to any mixture for which the identity or the concentration of any radionuclide in the mixture is not known. The default value would likewise be the most restrictive applicable DAC value already listed in appendix A, *i.e.*, 2 E–13 μCi/mL (8 E–03 Bq/m^3).

DOE received a comment that the proposed note at the end of appendix A which states that a DAC value for ''any mixture for which the identity or the concentration of any radionuclide in the mixture is not known'' conflicted with the existing note at the beginning of appendix A which states that for ''unknown radionuclides, the most restrictive DAC (lowest value) for those isotopes not known to be absent shall be used.'' DOE agrees with this comment and, in the final rule, omits the text regarding ''any mixture for which the identity or the concentration of any radionuclide in the mixture is not known.'' DOE also moves the two notes at the end of appendix A, pertaining to default values for any single radionuclide not listed in the appendix, to the beginning of appendix A.

DOE received a comment that, for amendment items pertaining to STCs, consideration be given to recent ICRP and published information regarding STCs, such as the October 2004 Health Physics Society Journal paper, *Application of the ICRP Clarification of the Tritium Metabolic Model.* DOE reviewed updated published information regarding STCs, including the Health Physics Society Journal paper referenced. DOE believes that the methodology and values in DOE–HDBK–1184–2004 continue to provide the best approaches to developing acceptable controls such as DAC values and the posting and labeling criteria for STCs, which are adjusted to use the ICRP Publication 60 dosimetric quantities and a default 5 micron particle size. Accordingly, in today's final rule, DOE makes the proposed changes to DAC values for tritiated particulate aerosols and organically bound tritium. For consistency with terminology in DOE–HDBK–1184–2004, the revised footnote to appendix D, and the definition of ''special tritium compound'' in § 835.2, DOE replaces the terms ''tritiated particulate aerosol and organically bound H–3 (insoluble)'' and ''organically bound H–3 (soluble)'' with ''STCs (insoluble)'' and ''STCs (soluble).''

DOE received a comment that a single set of DACs, based only on committed effective dose values (*i.e.* no DAC values based on the non-stochastic limit to an organ or tissue), would provide a much simpler framework, which still would provide adequate protection to the worker. DOE does not believe that this change would significantly simplify the regulatory framework and does not make this change.

DOE received a comment that the definition of ''derived air concentration'' should include reference to the ICRP computer program, *The ICRP Database of Dose Coefficients: Workers and Members of the Public*, ISBN 0 08 043 8768. This program was referenced in the NOPR preamble as being a source for calculation of appendix A values. DOE agrees with this comment and makes this change.

DOE received two comments that DOE should allow sites to derive their own DAC values. The commenters stated that DOE should allow sites to derive default DAC values for nuclides not listed in appendix A, and that DOE should allow use of alternate self-absorption factors for determining DACs for STCs. DOE does not agree with these comments. DOE believes it is beneficial for DOE to use a consistent set of DACs across the complex, with variation permitted for particle size as specified in appendix A. The need for use of site-specific DACs may be addressed through the 10 CFR part 820 exemption process.

P. DAC Values, Introductory Paragraph, and Footnotes in Appendix C in 10 CFR Part 835

DOE proposed to amend appendix C of 10 CFR part 835 by changing the term ''contaminated atmospheric cloud'' to ''cloud of airborne radioactive material.'' DOE considered this proposed change to be only editorial. Consistent with DOE's proposal to adopt the system of dosimetry for intake of radioactive materials set forth in more recent ICRP publications, DOE proposed to replace the air immersion DAC values in appendix C with new values which were determined using ICRP Publication 68 methodology. Specifically, the proposed values were derived from the dose conversion factors in Annex D of ICRP publication 68 and assumed 250 days (50 weeks times 5 days per week) exposure per year to get an effective dose of 5 rems in a year. Consistent with the NRC, DOE also proposed to establish a default value for any single radionuclide not listed in appendix C to part 835. The default value would apply to any isotope not already listed with a decay mode other than alpha emission or spontaneous fission and with a radioactive half-life less than two hours. The DAC would be the most restrictive value already listed, i.e., 6 E–06 μCi/mL (2 E+04 Bq/m^3).

DOE received a comment that the change in terminology proposed for appendix C to part 835 would be welcomed, especially at accelerator facilities. The final rule makes the changes as proposed in the NOPR.

Q. Text and Footnotes in Appendix D in 10 CFR Part 835

Several changes to appendix D were proposed in order to codify guidance issued by the Department in Radiological Control Technical Positions (RCTP) and to enhance the clarity of this section. In *10 Code of Federal Regulations Part 835 Appendix D—Surface Radioactivity Values,* RCTP 96–02, DOE provided guidance on the application of footnote 5 to appendix D to part 835 that addresses surface contamination values for mixed fission products containing Sr–90. Based on this guidance, DOE proposed to revise appendix D to part 835 as follows: In the second group of nuclides (total surface radioactivity value − 1000 dpm/100 cm^2; removable surface radioactivity value − 200 dpm/100 cm^2), DOE proposed to insert the parenthetical phrase ''including mixed fission products where the Sr-90 fraction is 90 percent or more of the total activity.'' DOE proposed to add a new group to appendix D to part 835 (between the existing second and third groups) that would consist of mixed fission products where the Sr-90 fraction is more than 50 percent but less than 90 percent of the total activity. For this proposed group, the total surface radioactivity value would be 3000 dpm/100 cm^2 and the removable surface radioactivity value would be 600 dpm/100 cm^2.

In addition, DOE proposed to clarify footnote seven to appendix D by replacing the term ''(alpha)'' with the sentence ''These limits apply only to the alpha emitters within the respective decay series.''

DOE did not propose additional changes to the surface radioactivity values in appendix D to part 835. DOE is aware of newly developed surface radioactivity criteria (see American National Standard—Surface and Volume Radioactivity Standards for Clearance (ANSI/HPS N13.12–1999)), for the release of property and other items, which are more clearly based on potential risks than the surface contamination values in appendix D to part 835. However, to maintain a consistent application in the use of surface radioactivity values for the protection of workers; the public; and the environment, DOE has decided to continue evaluation of appendix D to part 835 surface contamination values as a coordinated project that addresses both occupational and environmental aspects of this topic.

DOE–HDBK–1184–2004 recommends applying the 10 CFR part 835 subpart L provisions if the contamination levels from insoluble tritiated particles fixed to a surface exceed the removable tritium limit. DOE solicited comments on the need to revise the rule to reflect this recommendation.

DOE received comments opposed to codifying the guidance issued by RCTP 96–02 into appendix D to part 835. Although the change was proposed with the intent of clarifying the requirements, some commenters stated that they believed that the revised text would increase costs and make compliance much more difficult. More specifically, they claimed that application of the more conservative contamination values for some Sr-90 mixtures could create a significant challenge because of the difficulty in detecting those values consistently in a field setting with current techniques and available instrumentation. Moreover, implementation of the proposed three-tiered Sr-90 contamination values would be complex due to the need to determine the relative abundance of Sr-90 in the specific mixture being dealt with, in order to determine which contamination value to apply. Commenters suggested that DOE adopt the ANSI N 13.12 groupings.

DOE's intent with the proposed change to appendix D to part 835 was to provide clearer requirements. Under the current appendix D to part 835, footnote 5, the higher limit (total surface radioactivity value − 5000 dpm/100 cm^2; removable surface radioactivity value − 1000 dpm/100 cm^2) does not apply to Sr-90 which has been separated from the other fission products or mixtures where the Sr-90 has been enriched. This footnote applies to mixed fission products which, through the passage of time, have resulted in mixtures where the Sr-90 is enriched. There had been questions regarding the applicability of this footnote to specific site operations, especially where mixed fission products had been stored for extended time periods. The intent of the proposed change to appendix D to part 835 was to clarify requirements for application of the surface radioactivity values for these mixtures, so as to not always require the lower limit (total surface radioactivity value − 1000 dpm/100 cm^2; removable surface radioactivity value − 200 dpm/100 cm^2) that applied to pure or enriched Sr-90.

In view of the negative comments on this proposed change, DOE questions whether the proposed change would simplify radiological operations or enhance radiological safety. Accordingly, DOE does not make the proposed changes that address surface contamination values for mixed fission products containing Sr-90. However, DOE will retain the guidance in this area.

DOE also received a comment that Pu-241 should not be included within the ''transuranic'' category. This category should only apply to alpha emitters. As noted in the NOPR preamble, DOE agrees that eventually DOE should move toward a risk-based, consensus value for surface contamination values such as the ANSI/HPS N13.12 values. DOE will continue to evaluate application of surface radioactivity values for protection of workers, the public, and the environment as a coordinated project that addresses both occupational and environmental aspects of this topic.

DOE received a comment that appendix D to part 835 should be updated to include recommendations regarding STCs as provided in DOE-HDBK–1184–2004, Section 3.2.1.1. Specifically, the commenter suggested that Section 3.2.1.1 implies that removable surface contamination values for STCs should be 1,000 dpm/100 cm^2. The handbook explains that if surface contamination levels are less than one tenth of the 10 CFR part 835 appendix

D value, (i.e., < 1,000 dpm/100 cm²) it may be appropriate to assume that there are no significant levels of STC contamination and additional controls such as posting, access control, and personnel monitoring are not required. The commenter suggests that a value of 1,000 dpm/100 cm² for removable surface contamination from STCs be added to appendix D to part 835, and the reference to tritiated compounds be deleted from footnote 6.

Based on both the intent of DOE HDBK 1184–2004 and consideration of the estimated dose consequence associated with surfaces contaminated by STCs, DOE has determined that it is unnecessary to decrease the surface radioactivity value for removable contamination in appendix D to part 835 that applies to tritiated compounds. However, DOE has added a footnote to appendix D to part 835 to address other situations involving surfaces contaminated by insoluble tritiated particles.

With regard to DOE HDBK 1184–2004, DOE notes that the guidance to initiate some radiological controls for STCs at a level of one tenth of the appendix D to 10 CFR part 835 value is based on the relative uncertainty associated with the activity-to-dose conversion factor for these compounds, the difficulties performing surface contamination measurements of these compounds, and the possibility that STCs may be located in areas where surveys are difficult to conduct. The factor of one tenth was estimated by assuming a three-to four-fold uncertainty in the activity-to-dose conversion factor and a two-to three-fold uncertainty in the measurement of surface contamination. Because the potential dose from STCs is related to the activity-to-dose conversion factor and the surface contamination measurement, the uncertainty in the potential dose from STCs could range from four- to five-fold. That is, the estimated potential dose from STCs could be only up to one fifth (0.2) of the actual potential dose from STCs. Thus, DOE believes that a factor of one tenth should reasonably account for uncertainties associated with determining the potential dose from STCs.

Establishing criteria for certain types of radiological controls at a factor of 0.1 of the normal surface radioactivity values for STCs is a way to account for uncertainties, reduce the chance of significant STC exposure to workers, and ensure compliance with the regulatory value for surface contamination. Because of the conservatism of this approach, the types of radiological controls recommended (performance of more surveys and evaluations to make sure that sources of STCs are comprehensively identified) are less stringent than those triggered by the appendix D to part 835 values (e.g. posting, personal monitoring and the use of personal protective equipment).

With regard to the dose consequence associated with surfaces contaminated by STCs, calculations (performed using RESRAD BUILD Version 3.0) indicate that exposure to a surface contaminated by insoluble tritiated particles at levels of 10,000 dpm/100 cm² will result in a yearly dose of 1.18 x 10–4 millirems. This value is four orders of magnitude below the criterion of 1 millirem/year generally accepted as the criterion for unrestricted release of materials. Thus, DOE believes there is no significant health benefit to be gained by lowering the appendix D to part 835 value for removable surface contamination that applies to tritiated compounds.

DOE also received a comment that appendix D to part 835 should be updated to include recommendations regarding STCs as provided in DOE-HDBK–1184–2004, Section 3.2.1.2. which addresses fixed surface contamination. This section of the handbook addresses the possibility that there may be cases where tritium binds tightly to the matrix into which it has diffused, and removable contamination levels are below the values in 10 CFR part 835 (i.e., 10,000 dpm/100 cm²), and recommends that provisions of part 835, subpart L, Radioactive Contamination Control, pertaining to total surface contamination values be applied when total contamination exceeds 10,000 dpm/100 cm². The commenter suggests that appendix D to part 835, Table and footnotes, be revised to address fixed surface contamination from STCs.

Consideration of the properties of STCs suggests that there may be cases where tritium binds tightly to a material into which it has diffused, and the removable contamination level on the surface of this material is below the value in 10 CFR part 835. Such cases could occur when a class of STCs called insoluble tritiated particles (ITPs) are fixed to a surface or from tritium exposure to bulk quantities of metals of the types from which ITPs are formed. Although this situation is not expected to occur often, DOE addresses it by modifying 10 CFR part 835 appendix D footnote 6, to indicate that there is a situation where tritium may exist in a form that can be considered to be fixed surface contamination. DOE also addresses it by specifying a total surface contamination value of 10,000 dpm/100 cm² as the value above which the appropriate requirements in 10 CFR part 835 are triggered. Because the definitions of insoluble metal tritides and insoluble tritiated particle are imprecise, it may be necessary to perform a technical evaluation of metals that have been exposed to tritium in order to determine if fixed surface contamination exists. DOE-HDBK–1184–2004 provides guidance to help in making such a determination.

In summary, the final rule revised appendix D to 10 CFR part 835 as follows. In the last row of the first column, the entry is changed to ''Tritium and STCs.'' In the last row of column three of 10 CFR part 835 appendix D, ''N/A'' is replaced with ''See Footnote 6.'' The following text is added to footnote 6, ''In certain cases, a 'Total' value of 10,000 dpm/100 cm² may be applicable either to metals, of the types which form insoluble special tritium compounds, that have been exposed to tritium; or to bulk materials to which particles of insoluble special tritium compound are fixed to a surface.'' Footnote 7 is revised to read ''These limits only apply to the alpha emitters within the respective decay series.''

R. Text and Footnote in Appendix E in 10 CFR Part 835

As discussed earlier, DOE proposed to adopt the system of dosimetry for intake of radioactive materials set forth in more recent ICRP publications. DOE proposed to revise the appendix E to part 835 values using the ICRP Publication 60 methodology and the same exposure scenarios discussed in the 1998 amendment to 10 CFR part 835. In summary, the values were based on the more limiting of the quantity of radioactive material which results in either an external or internal whole body dose, from either inhalation or ingestion, of 100 millirems. The external exposure scenario assumed a photon exposure for 12 hours a day for 365 days with the source distance being at 1 meter. The internal exposure scenario assumed an instantaneous intake of 0.001% of the material by an individual. Consistent with the other proposed changes, the values in appendix E to part 835 were recalculated to reflect the previously mentioned ICRP publications. DOE also proposed to reorder the entries in accordance with atomic weight rather than alphabetically.

DOE also proposed to add a footnote to appendix E to part 835 specifying a value of 10 Ci for any type of STC. This proposed change would be made to keep appendix E to part 835 consistent with the proposed change to appendix

A which includes the addition of STCs. The value of 10 Ci was derived using the same method as the other proposed values in appendix E to part 835, *i.e.*, they were based on the exposure scenario discussed in the preamble to the 1998 amendment. Specifically, the inhalation exposure scenario used to derive the 10 Ci value assumed a 100 millirems dose from a Type S hafnium tritide particle (the most restrictive STC) with a release fraction to be inhaled of 0.001%. A dose conversion value of 2.6 E–10 Sv/Bq, was determined by using the methodology from DOE-HDBK–1184–2004 and adjusted using the ICRP Publication 60 dosimetric quantities.

In addition, DOE proposed revising the value for Californium-252 in appendix E to part 835 calculated for an external neutron exposure situation, which was more limiting than the photon exposure. More specifically, DOE calculated the proposed appendix E to part 835 value for Californium-252 by substituting a neutron exposure for the photon exposure in the external exposure scenario using values from *Reference Neutron Radiations—Part 1: Characteristics and Methods of Production,* ISO/CD, 8529–1.

As mentioned in the appendix A to part 835 discussion, DOE received a comment that for amendment items pertaining to STCs, consideration should be given to recent ICRP publications and published information regarding STCs, such as the October 2004 Health Physics Society Journal paper, *Application of the ICRP Clarification of the Tritium Metabolic Model.* DOE reviewed updated published information regarding STCs, including the Health Physics Society Journal paper referenced. DOE believes that the methodology and values in DOE-HDBK–1184–2004 continue to provide the best approaches to developing acceptable controls such as DAC values and the posting and labeling criteria for STCs, adjusted to use the ICRP Publication 60 dosimetric quantities and a default 5 micron particle size. Accordingly, the final rule makes the changes to appendix E to part 835 values for tritiated particulates or organically-bound tritiated compounds as proposed. For consistency with the revised footnote to appendix D to part 835 and the added definition of STCs, DOE replaces the term ''tritiated particulate or organically-bound tritiated compound'' with ''STC.''

DOE also received a comment that the table appeared to be intended to be arranged in order of increasing atomic number, with all isotopes of the same element included together. The commenter thought this was a good approach that expedites finding the values for a given radionuclide. The commenter noted some ordering inconsistencies. DOE agrees with this comment and revises the table in appendix E to part 835 so that the order is by increasing atomic number with all isotopes of the same element included together.

DOE also received a comment that the basis for the appendix E to part 835 values in the NOPR is well-stated and if DOE decides to make this transition, this rationale should be retained in a footnote to the appendix or some other readily traceable reference. The comment stated that in practical radiation protection work, it is often useful to track down the origin of the values found in such tables. To do that, one needs clear traceability to their original derivation. DOE agrees with this comment and intends to add a discussion of this issue in the updated implementation guide for 10 CFR part 835.

DOE received a comment that the proposed change would likely result in many more sources exceeding the appendix E threshold. DOE does not agree with this comment. DOE compared proposed appendix E to part 835 values with the existing values for 22 representative radionuclides. The comparison showed that only six of the proposed values were more restrictive than the existing values and those values were only slightly more restrictive.

In summary, the final rule makes the changes as proposed in the NOPR, with the exception that DOE replaces the term ''tritiated particulate or organically-bound tritiated compound'' with ''STC.'' DOE revises the order to be in increasing atomic number with all isotopes of the same element included together.

S. Guidance Documents

The primary implementation guide which defines DOE's expectations for the existing rule is DOE's implementation guide G 441.1–1B, *Radiation Protection Programs Guide for Use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection.* This guide is available through the DOE radiation protection Web page on *http://www.hss.energy.gov/HealthSafety/WSHP/radiation/regs.html.*

DOE plans on updating this guide to reflect the amended requirements. DOE also plans to review and, as necessary, incorporate the DOE Radiological Control Technical Positions issued by the DOE Office of Worker Safety and Health Policy into the guide. DOE Technical Standards developed by the DOE Office of Worker Safety and Health Policy will also be updated. In particular, these Technical Standards include: DOE-STD–1098–99 *Radiological Control, DOE-STD–1121–98 Internal Dosimetry* and the series of handbooks relating to radiation protection training. DOE plans to have all guidance documents updated and available in sufficient time to be of use in meeting the amended 10 CFR part 835 implementation date.

T. Submitting Documents for DOE Approval

Part 835.101(g) requires contractors to update their Radiation Protection Program (RPP) and submit it to DOE within 180 days of the effective date of any modifications to part 835. In accordance with 10 CFR 835.101(f), the RPP shall include plans, schedules, and other measures for achieving compliance no later than three years following the effective date of the amendment. DOE issued guidance on submittal of RPPs in DOE G 441.1–1B, *Radiation Protection Programs Guide for Use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection.*

U. Protection and Operational Quantities

The ICRP Publication 60 dosimetric quantities adopted in 10 CFR part 835 have been designated by ICRP as ''protection quantities'' that are intended for defining and calculating the numerical limits and action levels used in radiation protection standards such as 10 CFR part 835. Protection quantities provide a way to relate the magnitude of a radiation exposure to the risk of a health effect that is applicable to an individual and that is largely independent of the type and source (internal or external) of the radiation. In addition the protection quantities can be easily calculated for use in planning radiological work.

These goals are achieved using a combination of theoretical and practical considerations. For example, absorbed dose is assumed to be averaged over a tissue or organ. Radiation weighting factors are used to account for the biological effectiveness of various types and energies of radiation and tissue weighting factors are used to account for the sensitivity of various tissues to radiation induced cancer. The tissue and radiation weighting factors are based on both biological and epidemiological studies and have been updated as new research becomes available. Nevertheless, the values of these weighting factors are

approximations that account for both uncertainty in the underlying data and the need to ensure that the protection quantities do not underestimate the true dose and hence the risk. Protection quantities used in 10 CFR part 835 include: equivalent dose, effective dose, committed equivalent dose, committed effective dose, total effective dose, and cumulative total effective dose.

Because protection quantities were developed to provide an index of the risk resulting from energy imparted to tissue by radiation, they are theoretical and not measurable. Fortunately, it is possible to use the measurable properties of radiation fields and radioactive materials associated with exposure to external radiation sources or intake of radioactive materials to estimate and demonstrate compliance with the protection quantities. These measurable quantities are called operational quantities.

Although many types of operational quantities are possible, a well characterized set of operational quantities for assessing doses received from external exposure have been selected by the International Commission on Radiation Units and Measurements (ICRU) in Report 51, *Quantities and Units in Radiation Protection Dosimetry.* These operational quantities have been adopted in recommendations of the ICRP and in the standards implementing the ICRP recommendations written by the International Atomic Energy Agency (IAEA) and the European Union (EU). In addition, the ICRP, in Publication 74, *Conversion Coefficients for Use in Radiological Protection Against External Radiation,* compared and contrasted doses determined using the ICRP system of protection quantities with doses determined using the ICRU based operational quantities. For almost all situations considered, doses determined with the operational quantities were greater or equal to the doses determined using protection quantities. These operational quantities and their relation to the protection quantities listed in the final version of 10 CFR part 835 are listed below.

RELATION BETWEEN PROTECTION QUANTITIES AND OPERATIONAL QUANTITIES FOR INDIVIDUAL MONITORING OF EXTERNAL EXPOSURE

Protection quantity	Operational quantity (depth [d] in tissue [mm])
Equivalent dose to the whole body from external sources*	$H_p(10)$.
Equivalent dose to the lens of the eye from external sources	$H_p(3)$.
Equivalent dose to the extremity or skin from external sources	$H_p(0.07)$.

Where:

$H_p(d)$ is the personal dose equivalent at depth d in tissue

See ICRU Report 51 for the definition of $H_p(d)$

*Same as effective dose from external sources.

For doses resulting from intakes of radioactive materials operational quantities have been published in ICRP, IAEA and EU documents.

Relation between protection quantities and operational quantities for individual monitoring of doses from intakes of radioactive material

Protection quantity	Operational quantity
Committed effective dose	$\sum_j h_{j,eff,50,inh} I_{j,inh} + \sum_j h_{j,eff,50,ing} I_{j,ing}$
Committed equivalent dose	$\sum_j h_{j,T,50,inh} I_{j,inh} + \sum_j h_{j,T,50,ing} I_{j,ing}$

Where:

$h_{j,eff,50,inh}$ is the committed effective dose per unit of radioactivity intake by inhalation (inh)

$h_{j,eff,50,ing}$ is the committed effective dose per unit of radioactivity intake by ingestion (ing)

$h_{j,T,50,inh}$ is the committed equivalent dose to a tissue (T) per unit of radioactivity intake by inhalation

$h_{j,T,50,ing}$ is the committed equivalent dose to a tissue (T) per unit of radioactivity intake by ingestion

$I_{j,inh}$ is an intake by inhalation

$I_{j,inh}$ is an intake by ingestion

j is a radionuclide

For the total effective dose, the following operational quantity is suggested.

Protection quantity	Operational quantity
Total effective dose	$H_p(10) + \sum_j h_{j,eff,50,inh} I_{j,inh} + \sum_j h_{j,eff,50,ing} I_{j,ing}$

In addition to the operational quantities used for individual monitoring, the following table contains operational quantities that may be measured to characterize certain aspects of radiation fields in the workplace.

OPERATIONAL QUANTITIES FOR USE IN CHARACTERIZING WORKPLACE RADIATION FIELDS

Workplace measurement	Suggested operational quantity
Control of effective dose	H *(10).
Control of dose to the skin, the extremities and the lens of the eye	H ’(0.07, Ω).
Control of dose to the lens of the eye	H ’(3, Ω).

Where:

H*(10) is the ambient dose equivalent at a depth of 10 mm in tissue

H’(0.007, Ω) is the directional dose equivalent at a depth of 0.07mm in the ICRU sphere

H’(3, Ω) is the directional dose equivalent at a depth of 3 mm in the ICRU sphere

Ω defines the direction of the radiation field

See ICRU Report 51 for the definitions of ambient dose equivalent and directional dose equivalent.

To summarize the above discussion, protection quantities have been developed for use in radiation protection standards to establish dose limits and action levels that reflect the risk associated with radiation exposure and are directly applicable to all members of the population being protected. Measurable operational quantities have been selected that permit measurements which show compliance with protection quantities specified in 10 CFR part 835. Additional guidance will be provided in the implementation guide for 10 CFR part 835.

V. Regulatory Review

A. Review Under Executive Order 12866

Today’s final rule has been determined not to be a ‘‘significant regulatory action’’ within the scope of section 3(f) of Executive Order 12866, ‘‘Regulatory Planning and Review,’’ 58 FR 51735 (October 4, 1993), as amended by Executive Order 13258, 67 FR 9385 (February 26, 2002) and Executive Order 13422 (January 18, 2007). Accordingly, this rule was not reviewed under the Executive Order by the Office of Information and Regulatory Affairs (OIRA) in the Office of Management and Budget (OMB).

B. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3 of Executive Order 12988, ‘‘Civil Justice Reform,’’ 61 FR 4729 (February 7, 1996), imposes on Executive agencies the general duty to eliminate drafting errors and ambiguity, write regulations to minimize litigation, provide a clear legal standard for affected conduct rather than a general standard, and promote simplification and burden reduction. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in section 3(a) and section 3(b) to determine whether they are met. DOE has completed the required review and determined that, to the extent permitted by law, this final rule meets the relevant standards of Executive Order 12988.

C. Review Under Executive Order 13132

Executive Order 13132, ‘‘Federalism,’’ 64 FR 43255 (August 10, 1999), requires agencies to develop an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have ‘‘federalism implications.’’ Policies that have federalism implications are defined in the Executive Order to include regulations that have substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.

Today’s regulatory action has been determined not to be a ‘‘policy that has federalism implications;’’ that is, it does not have substantial direct effects on the States, on the relationship between the national government and the States, nor on the distribution of power and responsibilities among various levels of government under Executive Order 13132, 64 FR 43255 (August 10, 1999).

D. Reviews Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires that a federal agency prepare an initial regulatory flexibility analysis for any regulation for which a general NOPR is required, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities (5 U.S.C. 605(b)).

Today’s regulation establishes DOE amended requirements for nuclear safety and occupational radiation protection at DOE sites. The contractors who manage and operate DOE facilities are principally responsible for implementing the rule requirements. DOE considered whether these contractors are ’’small businesses,’’ as that term is defined in the Regulatory Flexibility Act (5 U.S.C. 601(3)). The Regulatory Flexibility Act’s definition incorporates the definition of ’’small business concern’’ in the Small Business Act, which the Small Business Administration (SBA) has developed through size standards in 13 CFR part 121. The DOE contractors subject to this rule exceed the SBA’s size standards for small businesses. In addition, DOE expects that any potential economic impact of this rule on small businesses would be minimal because DOE sites perform work under contracts to DOE or the prime contractor at the site. DOE contractors are reimbursed through their contracts with DOE for the costs of complying with DOE nuclear safety and radiation protection requirements. They would not, therefore, be adversely impacted by the requirements in this rule. For these reasons, DOE certifies that today’s regulatory action does not have a significant economic impact on a substantial number of small entities and, therefore, no regulatory flexibility analysis has been prepared. DOE’s certification and supporting statement of factual basis will be provided to the Chief Counsel of Advocacy of the SBA pursuant to 5 U.S.C. 605(b).

E. Review Under the Paperwork Reduction Act

The information collection provisions of this final rule are not substantially different from those contained in DOE contracts with DOE prime contractors covered by this rule. The information collection was previously approved by OMB and assigned OMB Control No. 1910–0300. Accordingly, no additional OMB clearance is required by the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 *et seq.*).

F. Review Under the National Environmental Policy Act

DOE has reviewed these amendments to 10 CFR parts 820 and 835 under the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 *et seq.*), the Council on Environmental Quality’s regulations (40 CFR parts 1500–08), and DOE’s implementing regulations (10 CFR part 1021). Categorical Exclusion A5 in appendix A to Subpart D of 10 CFR part 1021 (rulemaking that amends an existing rule without changing the environmental effect of the amended rule) applies to this rulemaking. Accordingly, DOE has not prepared an environmental impact statement or an

environmental assessment pursuant to NEPA.

G. Review Under the Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995, (2 U.S.C. 1531 *et seq.*), requires each Federal agency, to the extent permitted by law to prepare a written assessment of the effects of any Federal mandate in an agency rule that may result in the expenditure by State, tribal, or local governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. The Act also requires a Federal agency to develop an effective process to permit timely input by elected officials of State, tribal, or local governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity to provide timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. DOE has determined that today's final rule does not contain any Federal mandates affecting small governments, so these requirements do not apply.

H. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use,'' 66 FR 28355 (May 22, 2001) requires Federal agencies to prepare and submit to the OMB, a Statement of Energy Effects for any proposed significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgated or is expected to lead to promulgation of a final rule, and that: (1) Is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy, or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use. Today's regulatory action would not have a significant adverse effect on the supply, distribution, or use of energy and is, therefore, not a significant energy action. Accordingly, DOE has not prepared a Statement of Energy Effects.

I. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a ''Family Policymaking Assessment'' for any rule that may affect family well-being. Today's regulatory action has no impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has not prepared a Family Policymaking Assessment.

J. Review Under the Treasury and General Government Appropriations Act, 2001

The Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516, note) provides for agencies to review most dissemination of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). DOE has reviewed today's regulatory action under the OMB and DOE guidelines, and has concluded that it is consistent with applicable policies in those guidelines.

K. Congressional Notification

As required by 5 U.S.C. 801, DOE will submit to Congress a report regarding the issuance of today's regulatory action rule prior to the effective date set forth at the outset of this notice. The report will state that it has been determined that the rule is not a ''major rule'' as defined by 5 U.S.C. 804(2).

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

List of Subjects

10 CFR Part 820

Administrative practice and procedure, Federal buildings and facilities, Government contracts, Nuclear energy, Nuclear materials, Nuclear power plants and reactors, Nuclear safety, Penalties, Public health, and Radiation protection.

10 CFR Part 835

Federal buildings and facilities, Nuclear energy, Nuclear materials, Nuclear power plants and reactors, Nuclear safety, Occupational safety and health, Radiation protection, and Reporting and recordkeeping requirements.

Issued in Washington, DC on May 22, 2007.

Glenn Podonsky,

Chief, Office of Health, Safety and Security.

■ For the reasons set forth in the preamble, Parts 820 and 835 of Chapter III, Title 10, of the Code of Federal Regulations are amended as set forth below.

PART 820—PROCEDURAL RULES FOR DOE NUCLEAR ACTIVITIES

■ 1. The authority citation for part 820 is revised to read as follows:

Authority: 42 U.S.C. 2201; 2282(a); 7191; 28 U.S.C. 2461 note; 50 U.S.C. 2410.

■ 2. In § 820.2 add a new definition for ''NNSA'' to read as follows:

§ 820.2 Definitions.

* * * * *

NNSA means the National Nuclear Security Administration.

* * * * *

■ 3. Section 820.13 is added to read as follows:

§ 820.13 Direction to NNSA contractors.

(a) Notwithstanding any other provision of this part, and pursuant to section 3213 of Pub. L. 106–65, as amended (codified at 50 U.S.C. 2403), the NNSA, rather than the Director, signs, issues and serves the following actions that direct NNSA contractors:

(1) Subpoenas;

(2) Orders to compel attendance;

(3) Disclosures of information or documents obtained during an investigation or inspection;

(4) Preliminary notices of violations; and

(5) Final notices of violations.

(b) The NNSA Administrator shall act after consideration of the Director's recommendation.

■ 4. In § 820.21, paragraphs (g) and (h) are added to read as follows:

§ 820.21 Investigations.

* * * * *

(g) The Director may issue enforcement letters that communicate DOE's expectations with respect to any aspect of the requirements of DOE's Nuclear Safety Requirements, including identification and reporting of issues, corrective actions, and implementation of DOE's Nuclear Safety Requirements, provided that an enforcement letter may not create the basis for any legally enforceable requirement pursuant to this part.

(h) The Director may sign, issue and serve subpoenas.

■ 5. In Appendix A to part 820, revise sections IV and VIII to read as follows:

Appendix A to Part 820—General Statement of Enforcement Policy

* * * * *

IV. Responsibilities

(a) The Director, as the principal enforcement officer of DOE, has been delegated the authority to:

(1) Conduct enforcement inspections, investigations, and conferences;

(2) Issue Notices of Violations and proposed civil penalties, Enforcement Letters, Consent Orders, and subpoenas; and

(3) Issue orders to compel attendance and disclosure of information or documents obtained during an investigation or inspection.

(b) The NNSA Administrator, pursuant to section 3212 (b)(9) of Public Law 106–65 (codified at 50 U.S.C. 2402 (b)(9)), as amended, has authority over and responsibility for environment, safety and health operations within NNSA and is authorized to sign, issue and serve the following actions that direct NNSA contractors:

(1) Subpoenas;

(2) Orders to compel attendance;

(3) Disclosure of information or documents obtained during an investigation or inspection;

(4) Preliminary Notices of Violations; and

(5) Final Notices of Violations.

The NNSA Administrator acts after consideration of the Director's recommendation.

* * * * *

VIII. Enforcement Letter

(a) In cases where DOE has decided not to conduct an investigation or inspection or issue a Preliminary Notice of Violation (PNOV), DOE may send an Enforcement Letter to the contractor, signed by the Director. Enforcement Letters issued to NNSA contractors will be coordinated with the Principal Deputy Administrator of the NNSA prior to issuance. The Enforcement Letter is intended to communicate the basis of the decision not to pursue enforcement action for a noncompliance. The Enforcement Letter is intended to inform contractors of the desired level of nuclear safety performance. It may be used when DOE concludes the specific noncompliance at issue is not of the level of significance warranted to conduct an investigation or inspection or for issuance of a PNOV. Even where a noncompliance may be significant, the Enforcement Letter recognizes that the contractor's actions may have attenuated the need for enforcement action. The Enforcement Letter will typically recognize how the contractor handled the circumstances surrounding the noncompliance, address additional areas requiring the contractor's attention, and address DOE's expectations for corrective action.

(b) In general, Enforcement Letters communicate DOE's expectations with respect to any aspect of the requirements contained in the Department's nuclear safety rules, including identification and reporting of issues, corrective actions, and implementation of the contractor's nuclear safety program. DOE might, for example, wish to recognize some action of the contractor that is of particular benefit to nuclear safety performance that is a candidate for emulation by other contractors. On the other hand, DOE may wish to bring a program shortcoming to the attention of the contractor that, but for the lack of nuclear safety significance of the immediate issue, might have resulted in the issuance of a PNOV. An Enforcement Letter is not an enforcement action.

(c) With respect to many noncompliances, DOE may decide not to send an Enforcement Letter. When DOE decides that a contractor has appropriately corrected a noncompliance or that the significance of the noncompliance is sufficiently low, it may close out its review simply through an annotation in the DOE Noncompliance Tracking System (NTS). A closeout of a noncompliance with or without an Enforcement Letter may only take place after DOE has confirmed that corrective actions have been completed. Closeout of any NNSA contractor noncompliance will be coordinated with NNSA prior to closeout.

* * * * *

PART 835—OCCUPATIONAL RADIATION PROTECTION

■ 6. The authority citation for part 835 is revised to read as follows:

Authority: 42 U.S.C. 2201, 7191; 50 U.S.C. 2410.

■ 7. Section 835.1 is amended:

■ a. In the introductory text of paragraph (b), remove the word ''discussed'' and insert in its place ''provided.''

■ b. Paragraph (b)(2) is revised.

■ c. Paragraph (b)(4) is removed.

■ d. Paragraph (b)(5) is redesignated as paragraph (b)(4) and the word ''or'' at the end of the paragraph is removed.

■ e. Paragraph (b)(6) is redesignated as paragraph (b)(5) and the punctuation at the end of the paragraph is replaced with the punctuation '';'' and the word ''or'' is added at the end of the paragraph.

■ f. A new paragraph (b)(6) is added.

■ g. A new paragraph (b)(7) is added.

■ h. Paragraph (c) is revised.

■ i. A new paragraph (d) is added.

The revisions and additions specified above read as follows:

§ 835.1 Scope.

* * * * *

(b) * * *

(2) Activities conducted under the authority of the Deputy Administrator for Naval Reactors, as described in Pub. L. 98–525 and 106–65;

* * * * *

(6) Radioactive material on or within material, equipment, and real property which is approved for release when the radiological conditions of the material, equipment, and real property have been documented to comply with the criteria for release set forth in a DOE authorized limit which has been approved by a Secretarial Officer in consultation with the Chief Health, Safety and Security Officer.

(7) Radioactive material transportation not performed by DOE or a DOE contractor.

(c) Occupational doses received as a result of excluded activities and radioactive material transportation listed in paragraphs (b)(1) through (b)(4) and (b)(7) of this section, shall be included to the extent practicable when determining compliance with the occupational dose limits at §§ 835.202 and 835.207, and with the limits for the embryo/fetus at § 835.206. Occupational doses resulting from authorized emergency exposures and planned special exposures shall not be considered when determining compliance with the dose limits at §§ 835.202 and 835.207.

(d) The requirements in subparts F and G of this part do not apply to radioactive material transportation by DOE or a DOE contractor conducted:

(1) Under the continuous observation and control of an individual who is knowledgeable of and implements required exposure control measures, or

(2) In accordance with Department of Transportation regulations or DOE orders that govern such movements.

■ 8. Section 835.2 is revised to read as follows:

§ 835.2 Definitions.

(a) As used in this part:

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

Activity Median Aerodynamic Diameter (AMAD) means a particle size in an aerosol where fifty percent of the activity in the aerosol is associated with particles of aerodynamic diameter greater than the AMAD.

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

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

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

(2) An individual present in the area without respiratory protection could

receive an intake exceeding 12 DAC-hours in a week.

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

Annual limit on intake (ALI) means the derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose of 5 rems (0.05 sieverts (Sv)) (1 rem = 0.01 Sv) or a committed equivalent dose of 50 rems (0.5 Sv) to any individual organ or tissue. ALI values for intake by ingestion and inhalation of selected radionuclides are based on International Commission on Radiological Protection Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, published July, 1994 (ISBN 0 08 042651 4). This document is available from Elsevier Science Inc., Tarrytown, NY.

Authorized limit means a limit on the concentration of residual radioactive material on the surfaces or within the property that has been derived consistent with DOE directives including the as low as is reasonably achievable (ALARA) process requirements, given the anticipated use of the property and has been authorized by DOE to permit the release of the property from DOE radiological control.

Background means radiation from:

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

(2) Cosmic sources;

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

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

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

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

Calibration means to adjust and/or determine either:

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

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

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

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

Declared pregnant worker means a woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo/fetus as provided in § 835.206. This declaration may be revoked, in writing, at any time by the declared pregnant worker.

Derived air concentration (DAC) means, for the radionuclides listed in appendix A of this part, the airborne concentration that equals the ALI divided by the volume of air breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400 m^3). For the radionuclides listed in appendix C of this part, the air immersion DACs were calculated for a continuous, non-shielded exposure via immersion in a semi-infinite cloud of radioactive material. Except as noted in the footnotes to appendix A of this part, the values are based on dose coefficients from International Commission on Radiological Protection Publication 68, *Dose Coefficients for Intakes of Radionuclides by Workers*, published July, 1994 (ISBN 0 08 042651 4) and the associated ICRP computer program, *The ICRP Database of Dose Coefficients: Workers and Members of the Public*, (ISBN 0 08 043 8768). These materials are available from Elsevier Science Inc., Tarrytown, NY.

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

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

DOE means the United States Department of Energy.

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

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

General employee means an individual who is either a DOE or DOE contractor employee; an employee of a subcontractor to a DOE contractor; or an individual who performs work for or in conjunction with DOE or utilizes DOE facilities.

High contamination area means any area, accessible to individuals, where removable surface contamination levels exceed or are likely to exceed 100 times the removable surface contamination values specified in appendix D of this part.

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

Individual means any human being.

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

Minor means an individual less than 18 years of age.

Monitoring means the measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.

Occupational dose means an individual's ionizing radiation dose (external and internal) as a result of that individual's work assignment. Occupational dose does not include doses received as a medical patient or doses resulting from background radiation or participation as a subject in medical research programs.

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

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

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

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

Radioactive material transportation means the movement of radioactive material by aircraft, rail, vessel, or highway vehicle. Radioactive material transportation does not include preparation of material or packagings for transportation, storage of material awaiting transportation, or application of markings and labels required for transportation.

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

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

Real property means land and anything permanently affixed to the land such as buildings, fences and those things attached to the buildings, such as light fixtures, plumbing and heating fixtures.

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

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

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

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

Special tritium compound (STC) means any compound, except for H_2O, that contains tritium, either intentionally (*e.g.*, by synthesis) or inadvertently (*e.g.*, by contamination mechanisms).

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

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

Week means a period of seven consecutive days.

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

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

Absorbed dose (D) means the average energy imparted by ionizing radiation to the matter in a volume element. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 grays).

Committed effective dose (E_{50}) means the sum of the committed equivalent doses to various tissues or organs in the body ($H_{T,50}$), each multiplied by the appropriate tissue weighting factor (w_T)—that is, $E_{50} = \Sigma w_T H_{T,50} + w_{Remainder} H_{Remainder,50}$. Where $w_{Remainder}$ is the tissue weighting factor assigned to the remainder organs and tissues and $H_{Remainder,50}$ is the committed equivalent dose to the remainder organs and tissues. Committed effective dose is expressed in units of rem (or Sv).

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

Cumulative total effective dose means the sum of all total effective dose values recorded for an individual plus, for occupational exposures received before the implementation date of this amendment, the cumulative total effective dose equivalent (as defined in the November 4, 1998 amendment to this rule) values recorded for an individual, where available, for each year occupational dose was received, beginning January 1, 1989.

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

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

Equivalent dose (H_T) means the product of average absorbed dose ($D_{T,R}$) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor (w_R). For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed

at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rem (or Sv).

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

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

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

Radiation weighting factor (w_R) means the modifying factor used to calculate the equivalent dose from the average tissue or organ absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate radiation weighting factor. The radiation weighting factors to be used for determining equivalent dose in rem are as follows:

RADIATION WEIGHTING FACTORS [1], W_R

Type and energy range	Radiation weighting factor
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	20

[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:

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

Tissue weighting factor (w_T) means the fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The equivalent dose to tissue, (H_T), is multiplied by the appropriate tissue weighting factor to obtain the effective dose (E) contribution from that tissue. The tissue weighting factors are as follows:

TISSUE WEIGHTING FACTORS FOR VARIOUS ORGANS AND TISSUES

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

[1] ''Remainder'' means the following additional tissues and organs and their masses, in grams, following parenthetically: adrenals (14), brain (1400), extrathoracic airways (15), small intestine (640), kidneys (310), muscle (28,000), pancreas (100), spleen (180), thymus (20), and uterus (80). The equivalent dose to the remainder tissues ($H_{remainder}$), is normally calculated as the mass-weighted mean dose to the preceeding 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.

Total effective dose (TED) means the sum of the effective dose (for external exposures) and the committed effective dose.

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

(c) Terms defined in the Atomic Energy Act of 1954 or in 10 CFR part 820 and not defined in this part are used consistent with their meanings given in the Atomic Energy Act of 1954 or in 10 CFR part 820.

■ 9. Section 835.4 is revised to read as follows:

§ 835.4 Radiological units.

Unless otherwise specified, the quantities used in the records required by this part shall be clearly indicated in special units of curie, rad, roentgen, or rem, including multiples and subdivisions of these units, or other conventional units, such as, dpm, dpm/100 cm^2 or mass units. The SI units, becquerel (Bq), gray (Gy), and sievert (Sv), may be provided parenthetically for reference with scientific standards.

■ 10. Section 835.101(f) is revised to read as follows:

§ 835.101 Radiation protection programs.

* * * * *

(f) The RPP shall include plans, schedules, and other measures for achieving compliance with regulations of this part. Unless otherwise specified in this part, compliance with the amendments to this part published on

June 8, 2007 shall be achieved no later than July 9, 2010.

* * * * *

■ 11. Section 835.202 is amended by revising paragraphs (a)(1) through (a)(4) to read as follows:

§ 835.202 Occupational dose limits for general employees.

(a) * * *

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

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

(3) An equivalent dose to the lens of the eye of 15 rems (0.15 Sv); and

(4) The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity of 50 rems (0.5 Sv).

* * * * *

■ 12. Section 835.203 is revised to read as follows:

§ 835.203 Combining internal and external equivalent doses.

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

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

■ 13. In § 835.205 paragraphs (b)(1), (b)(2), (b)(3) introductory text, and (b)(3)(ii) are revised to read as follows:

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

* * * * *

(b) * * *

(1) Area of skin irradiated is 100 cm ^{2} *or more.* The non-uniform equivalent dose received during the year shall be averaged over the 100 cm ^{2} of the skin receiving the maximum dose, added to any uniform equivalent dose also received by the skin, and recorded as the equivalent dose to any extremity or skin for the year.

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

(3) Area of skin irradiated is less than 10 cm^2. The non-uniform equivalent dose shall be averaged over the 1 cm^2 of skin receiving the maximum dose. This equivalent dose shall:

(i) * * *

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

■ 14. In § 835.206 paragraphs (a) and (c) are revised to read as follows:

§ 835.206 Limits for the embryo/fetus.

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

* * * * *

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

■ 15. Section 835.207 is revised to read as follows:

§ 835.207 Occupational dose limits for minors.

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

■ 16. Section 835.208 is revised to read as follows:

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

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

■ 17. In § 835.401, paragraph (a)(5) is revised to read as follows:

§ 835.401 General requirements.

(a) * * *

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

* * * * *

■ 18. Section 835.402 is amended:

■ a. Paragraphs (a)(1)(i), (ii), and (iii) are revised.

■ b. Paragraph (a)(2) is revised.

■ c. Paragraphs (c)(1) and (c)(2) are revised.

The revisions read as follows:

§ 835.402 Individual monitoring.

(a) * * *

(1) * * *

(i) An effective dose of 0.1 rem (0.001 Sv) or more in a year;

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

(iii) An equivalent dose to the lens of the eye of 1.5 rems (0.015 Sv) or more in a year;

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

* * * * *

(c) * * *

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

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

* * * * *

■ 19. Section 835.405 is amended by revising paragraph (c)(2) and adding paragraph (e) to read as follows:

§ 835.405 Receipt of packages containing radioactive material.

* * * * *

(c) * * *

(1) * * *

(2) Measurements of the radiation levels, if the package contains a Type B quantity (as defined at 10 CFR 71.4) of radioactive material.

(d) * * *

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

§ 835.502 [Amended]

■ 20. Section 835.502 is amended in paragraph (a)(2) by removing the words ''deep dose equivalent'' and replacing it with ''equivalent dose to the whole body'' and in introductory paragraph (b) by removing the words ''a deep dose equivalent'' and replacing it with ''an equivalent dose.''

§ 835.602 [Amended]

■ 21. Section 835.602 is amended in paragraph (a) by removing the word''equivalent.''

§ 835.606 [Amended]

■ 22. Section 835.606 is amended in paragraph (a)(2) by adding ''and less than 0.1 Ci'' after the word ''part'' and before the punctuation.

■ 23. Section 835.702 is amended:
■ a. Paragraph (a) is revised.
■ b. Paragraph (b) is revised.
■ c. Paragraph (c)(3) is revised.
■ d. Paragraphs (c)(4)(i) and (ii) are revised.
■ e. Paragraph (c)(5)(i), (ii) and (iii) are revised.
■ f. Paragraph (c)(6) is revised.

The revisions read as follows:

§ 835.702 Individual monitoring records.

(a) Except as authorized by § 835.702(b), records shall be maintained to document doses received by all individuals for whom monitoring was conducted and to document doses received during planned special exposures, unplanned doses exceeding the monitoring thresholds of § 835.402, and authorized emergency exposures.

(b) Recording of the non-uniform equivalent dose to the skin is not required if the dose is less than 2 percent of the limit specified for the skin at § 835.202(a)(4). Recording of internal dose (committed effective dose or committed equivalent dose) is not required for any monitoring result estimated to correspond to an individual receiving less than 0.01 rem (0.1 mSv) committed effective dose. The bioassay or air monitoring result used to make the estimate shall be maintained in accordance with § 835.703(b) and the unrecorded internal dose estimated for any individual in a year shall not exceed the applicable monitoring threshold at § 835.402(c).

(c) * * *

(3) Include the results of monitoring used to assess the following quantities for external dose received during the year:

(i) The effective dose from external sources of radiation (equivalent dose to the whole body may be used as effective dose for external exposure);

(ii) The equivalent dose to the lens of the eye;

(iii) The equivalent dose to the skin; and

(iv) The equivalent dose to the extremities.

(4) * * *

(i) Committed effective dose;

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

* * * * *

(5) * * *

(i) Total effective dose in a year;

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

(iii) Cumulative total effective dose.

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

* * * * *

§ 835.1001 [Amended]

■ 24. Section 835.1001 is amended:
■ a. In paragraph (a), first sentence, remove ''physical design features and administrative control'' and add in its place ''engineered and administrative controls.''
■ b. In paragraph (b), remove ''physical design features'' and add in its place ''engineered controls.''

§ 835.1002 [Amended]

■ 25. In § 835.1002, in the first sentence of paragraph (b), remove ''0.5 mrem (5 microsieverts)'' and add in its place ''0.5 millirem (5 μSv).''

§ 835.1003 [Amended]

■ 26. Section 835.1003 is amended in the introductory text by removing ''physical design features and administrative controls'' and adding in its place ''engineered and administrative controls.''

§ 835.1202 [Amended]

■ 27. In § 835.1202, paragraph (b) is amended by removing ''microcurie'' and adding in its place ''μCi.''

§ 835.1301 [Amended]

■ 28. In § 835.1301, paragraph (d) is amended by removing ''after a dose was received'' and adding in its place ''which have been suspended as a result of a dose.''

■ 29. Appendix A of part 835 is revised to read as follows:

Appendix A to Part 835—Derived Air Concentrations (DAC) for Controlling Radiation Exposure to Workers at DOE Facilities

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

The DAC values are given for individual radionuclides. For known mixtures of radionuclides, determine the sum of the ratio of the observed concentration of a particular radionuclide and its corresponding DAC for all radionuclides in the mixture. If this sum exceeds unity (1), then the DAC has been exceeded. For unknown radionuclides, the most restrictive DAC (lowest value) for those isotopes not known to be absent shall be used. For any single radionuclide not listed in appendix A with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than two hours, the DAC value shall be 4 E-11 μCi/mL (1 Bq/m^3). For any single radionuclide not listed in appendix A that decays by alpha emission or spontaneous fission the DAC value shall be 2 E-13 μCi/mL (8 E-03 Bq/m^3).

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

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

The columns in this appendix contain the following information: (1) Radionuclide; (2) inhaled air DAC for type F (fast), type M (moderate), and type S (slow) materials in units of μCi/mL; (3) inhaled air DAC for type F (fast), type M (moderate), and type S (slow) materials in units of Bq/m^3; (4) an indication of whether or not the DAC for each class is controlled by the stochastic (effective dose) or deterministic (organ or tissue) dose. The absorption types (F, M, and S) have been established to describe the absorption type of the materials from the respiratory tract into the blood. The range of half-times for the absorption types correspond to: Type F, 100% at 10 minutes; Type M, 10% at 10 minutes and 90% at 140 days; and Type S 0.1% at 10 minutes and 99.9% at 7000 days. The DACs are listed by radionuclide, in order of increasing atomic mass, and are based on the assumption that the particle size distribution of 5 micrometers AMAD is used. For situations where the particle size distribution is known to differ significantly from 5 micrometers AMAD, appropriate corrections may be made to both the estimated dose to workers and the DACs.

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m^3			
	F	M	S	F	M	S	(F/M/S)
H-3 (Water) [2]	2 E−05	2 E−05	2 E−05	7 E+05	7 E+05	7 E+05	St/St/St

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
H-3 (Elemental) [2]	2 E−01	2 E−01	2 E−01	9 E+09	9 E+09	9 E+09	St/St/St
STCs (Insoluble) [4]	1 E−05	6 E−06	2 E−06	3 E+05	2 E+05	8 E+04	St/St/St
STCs (Soluble)	1 E−05	1 E−05	1 E−05	5 E+05	5 E+05	5 E+05	St/St/St
Be-7	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/St/St
Be-10	–	8 E−08	2 E−08	–	3 E+03	1 E+03	/St/St
C-11 (Vapor) [2]	–	1 E−04	–	–	6 E+06	–	/St/
C-11 (CO) [2]	4 E−04	4 E−04	4 E−04	1 E+07	1 E+07	1 E+07	St/St/St
C-11 (CO_2) [2]	2 E−04	2 E−04	2 E−04	9 E+06	9 E+06	9 E+06	St/St/St
C-14 (Vapor) [2]	–	9 E−07	–	–	3 E+04	–	/St/
C-14 (CO) [2]	7 E−04	7 E−04	7 E−04	2 E+07	2 E+07	2 E+07	St/St/St
C-14 (CO_2) [2]	8 E−05	8 E−05	8 E−05	3 E+06	3 E+06	3 E+06	St/St/St
F-18	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Na-22	2 E−07	–	–	1 E+04	–	–	E/ /
Na-24	4 E−07	–	–	1 E+04	–	–	ET/ /
Mg-28	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/St/
Al-26	4 E−08	4 E−08	–	1 E+03	1 E+03	–	St/St/
Si-31	9 E−06	5 E−06	5 E−06	3 E+05	1 E+05	1 E+05	ET/St/St
Si-32	1 E−07	5 E−08	1 E−08	5 E+03	2 E+03	3 E+02	St/St/St
P-32	5 E−07	1 E−07	–	1 E+04	7 E+03	–	St/St/
P-33	4 E−06	4 E−07	–	1 E+05	1 E+04	–	St/St/
S-35 (Vapor)	–	4 E−06	–	–	1 E+05	–	/St/
S-35	7 E−06	5 E−07	–	2 E+05	1 E+04	–	St/St/
Cl-36	1 E−06	1 E−07	–	4 E+04	4 E+03	–	St/St/
Cl-38	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Cl-39	2 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
K-40	1 E−07	–	–	6 E+03	–	–	St/ /
K-42	2 E−06	–	–	1 E+05	–	–	E/ /
K-43	9 E−07	–	–	3 E+04	–	–	ET/ /
K-44	8 E−06	–	–	2 E+05	–	–	ET/ /
K-45	9 E−06	–	–	3 E+05	–	–	ET/ /
Ca-41	–	2 E−06	–	–	8 E+04	–	/BS/
Ca-45	–	2 E−07	–	–	9 E+03	–	/St/
Ca-47	–	2 E−07	–	–	9 E+03	–	/St/
Sc-43	–	–	2 E−06	–	–	7 E+04	/ /ET
Sc-44m	–	–	2 E−07	–	–	1 E+04	/ /St
Sc-44	–	–	1 E−06	–	–	4 E+04	/ /ET
Sc-46	–	–	1 E−07	–	–	4 E+03	/ /St
Sc-47	–	–	7 E−07	–	–	2 E+04	/ /St
Sc-48	–	–	2 E−07	–	–	1 E+04	/ /ET
Sc-49	–	–	8 E−06	–	–	3 E+05	/ /ET
Ti-44	7 E−09	2 E−08	9 E−09	2 E+02	7 E+02	3 E+02	St/St/St
Ti-45	3 E−06	2 E−06	2 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
V-47	8 E−06	6 E−06	–	3 E+05	2 E+05	–	ET/ET/
V-48	2 E−07	2 E−07	–	9 E+03	7 E+03	–	ET/St/
V-49	1 E−05	2 E−05	–	7 E+05	9 E+05	–	BS/St/
Cr-48	2 E−06	2 E−06	2 E−06	8 E+04	8 E+04	8 E+04	ET/ET/ET
Cr-49	7 E−06	5 E−06	5 E−06	2 E+05	2 E+05	2 E+05	ET/ET/ET
Cr-51	1 E−05	1 E−05	1 E−05	6 E+05	6 E+05	5 E+05	St/St/St
Mn-51	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Mn-52m	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Mn-52	2 E−07	2 E−07	–	8 E+03	8 E+03	–	ET/ET/
Mn-53	5 E−06	1 E−05	–	2 E+05	5 E+05	–	BS/St/
Mn-54	5 E−07	4 E−07	–	1 E+04	1 E+04	–	St/St/
Mn-56	2 E−06	2 E−06	–	9 E+04	8 E+04	–	ET/ET/
Fe-52	6 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/E/
Fe-55	6 E−07	1 E−06	–	2 E+04	6 E+04	–	St/St/
Fe-59	1 E−07	1 E−07	–	6 E+03	6 E+03	–	St/St/
Fe-60	1 E−09	4 E−09	–	6 E+01	1 E+02	–	St/St/
Co-55	–	5 E−07	5 E−07	–	2 E+04	2 E+04	/ET/ET
Co-56	–	1 E−07	1 E−07	–	5 E+03	4 E+03	/St/St
Co-57	–	1 E−06	9 E−07	–	5 E+04	3 E+04	/St/St
Co-58m	–	3 E−05	3 E−05	–	1 E+06	1 E+06	/St/St
Co-58	–	4 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Co-60m	–	4 E−04	4 E−04	–	1 E+07	1 E+07	/St/St
Co-60	–	7 E−08	3 E−08	–	2 E+03	1 E+03	/St/St
Co-61	–	6 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Co-62m	–	7 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Ni-56 (Inorg)	4 E−07	4 E−07	–	1 E+04	1 E+04	–	ET/ET/
Ni-56 (Carbonyl)	–	4 E−07	–	–	1 E+04	–	/St/
Ni-57 (Inorg)	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Ni-57 (Carbonyl)	–	7 E−07	–	–	2 E+04	–	/ET/
Ni-59 (Inorg)	2 E−06	5 E−06	–	9 E+04	2 E+05	–	St/St/
Ni-59 (Carbonyl)	–	6 E−07	–	–	2 E+04	–	/St/
Ni-63 (Inorg)	1 E−06	1 E−06	–	4 E+04	6 E+04	–	St/St/
Ni-63 (Carbonyl)	–	2 E−07	–	–	1 E+04	–	/St/
Ni-65 (Inorg)	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Ni-65 (Carbonyl)	–	8 E−07	–	–	3 E+04	–	/ET/
Ni-66 (Inorg)	7 E−07	2 E−07	–	2 E+04	1 E+04	–	St/St/
Ni-66 (Carbonyl)	–	2 E−07	–	–	1 E+04	–	/ET/
Cu-60	5 E−06	4 E−06	4 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Cu-61	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Cu-64	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/E/E
Cu-67	2 E−06	1 E−06	9 E−07	8 E+04	3 E+04	3 E+04	ET/St/St
Zn-62	–	–	8 E−07	–	–	3 E+04	/ /St
Zn-63	–	–	5 E−06	–	–	2 E+05	/ /ET
Zn-65	–	–	2 E−07	–	–	7 E+03	/ /St
Zn-69m	–	–	1 E−06	–	–	6 E+04	/ /St
Zn-69	–	–	7 E−06	–	–	2 E+05	/ /ET
Zn-71m	–	–	1 E−06	–	–	5 E+04	/ /ET
Zn-72	–	–	3 E−07	–	–	1 E+04	/ /St
Ga-65	1 E−05	9 E−06	–	4 E+05	3 E+05	–	ET/ET/
Ga-66	8 E−07	7 E−07	–	3 E+04	2 E+04	–	ET/St/
Ga-67	3 E−06	2 E−06	–	1 E+05	7 E+04	–	ET/St/
Ga-68	6 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Ga-70	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Ga-72	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/
Ga-73	4 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/St/
Ge-66	2 E−06	2 E−06	–	9 E+04	9 E+04	–	ET/ET/
Ge-67	1 E−05	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Ge-68	6 E−07	7 E−08	–	2 E+04	2 E+03	–	ET/St/
Ge-69	1 E−06	1 E−06	–	3 E+04	3 E+04	–	ET/ET/
Ge-71	5 E−05	5 E−05	–	2 E+06	1 E+06	–	ET/E/
Ge-75	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Ge-77	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Ge-78	3 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
As-69	–	9 E−06	–	–	3 E+05	–	/ET/
As-70	–	2 E−06	–	–	8 E+04	–	/ET/
As-71	–	1 E−06	–	–	4 E+04	–	/St/
As-72	–	4 E−07	–	–	1 E+04	–	/St/
As-73	–	8 E−07	–	–	3 E+04	–	/St/
As-74	–	3 E−07	–	–	1 E+04	–	/St/
As-76	–	6 E−07	–	–	2 E+04	–	/St/
As-77	–	1 E−06	–	–	4 E+04	–	/St/
As-78	–	3 E−06	–	–	1 E+05	–	/ET/
Se-70	2 E−06	2 E−06	–	1 E+05	9 E+04	–	ET/ET/
Se-73m	1 E−05	1 E−05	–	5 E+05	4 E+05	–	ET/ET/
Se-73	1 E−06	1 E−06	–	6 E+04	5 E+04	–	ET/ET/
Se-75	4 E−07	3 E−07	–	1 E+04	1 E+04	–	St/St/
Se-79	3 E−07	1 E−07	–	1 E+04	6 E+03	–	K/St/
Se-81m	1 E−05	6 E−06	–	3 E+05	2 E+05	–	ET/ET/
Se-81	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Se-83	6 E−06	5 E−06	–	2 E+05	1 E+05	–	ET/ET/
Br-74m	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Br-74	4 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Br-75	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
Br-76	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/
Br-77	2 E−06	2 E−06	–	7 E+04	7 E+04	–	ET/ET/
Br-80m	6 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/St/
Br-80	3 E−05	2 E−05	–	1 E+06	7 E+05	–	ET/ET/
Br-82	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/ET/
Br-83	9 E−06	6 E−06	–	3 E+05	2 E+05	–	ET/ET/
Br-84	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
Rb-79	8 E−06	–	–	2 E+05	–	–	ET/ /
Rb-81m	1 E−05	–	–	6 E+05	–	–	ET/ /
Rb-81	2 E−06	–	–	1 E+05	–	–	ET/ /
Rb-82m	8 E−07	–	–	3 E+04	–	–	ET/ /
Rb-83	5 E−07	–	–	2 E+04	–	–	St/ /
Rb-84	3 E−07	–	–	1 E+04	–	–	St/ /
Rb-86	4 E−07	–	–	1 E+04	–	–	St/ /
Rb-87	7 E−07	–	–	2 E+04	–	–	St/ /

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Rb-88	1 E−05	–	–	5 E+05	–	–	ET/ /
Rb-89	1 E−05	–	–	3 E+05	–	–	ET/ /
Sr-80	3 E−06	–	2 E−06	1 E+05	–	9 E+04	ET/ /St
Sr-81	7 E−06	–	5 E−06	2 E+05	–	2 E+05	ET/ /ET
Sr-82	1 E−07	–	7 E−08	6 E+03	–	2 E+03	St/ /St
Sr-83	1 E−06	–	9 E−07	3 E+04	–	3 E+04	ET/ /ET
Sr-85m	4 E−05	–	3 E−05	1 E+06	–	1 E+06	ET/ /ET
Sr-85	1 E−06	–	8 E−07	3 E+04	–	3 E+04	St/ /St
Sr-87m	1 E−05	–	9 E−06	4 E+05	–	3 E+05	ET/ /ET
Sr-89	4 E−07	–	1 E−07	1 E+04	–	3 E+03	St/ /St
Sr-90	1 E−08	–	7 E−09	4 E+02	–	2 E+02	BS/ /St
Sr-91	1 E−06	–	9 E−07	5 E+04	–	3 E+04	ET/ /St
Sr-92	2 E−06	–	1 E−06	8 E+04	–	6 E+04	ET/ /St
Y-86m	–	7 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Y-86	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/ET/ET
Y-87	–	9 E−07	8 E−07	–	3 E+04	3 E+04	/ET/ET
Y-88	–	1 E−07	1 E−07	–	6 E+03	6 E+03	/St/St
Y-90m	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/St/St
Y-90	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Y-91m	–	2 E−05	2 E−05	–	7 E+05	7 E+05	/ET/ET
Y-91	–	1 E−07	9 E−08	–	4 E+03	3 E+03	/St/St
Y-92	–	2 E−06	2 E−06	–	7 E+04	7 E+04	/St/St
Y-93	–	9 E−07	9 E−07	–	3 E+04	3 E+04	/St/St
Y-94	–	8 E−06	8 E−06	–	3 E+05	3 E+05	/ET/ET
Y-95	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/ET/ET
Zr-86	5 E−07	5 E−07	5 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Zr-88	1 E−07	3 E−07	3 E−07	5 E+03	1 E+04	1 E+04	St/St/St
Zr-89	6 E−07	6 E−07	6 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Zr-93	3 E−09	1 E−08	1 E−07	1 E+02	6 E+02	5 E+03	BS/BS/BS
Zr-95	9 E−08	1 E−07	1 E−07	3 E+03	5 E+03	4 E+03	BS/St/St
Zr-97	7 E−07	4 E−07	4 E−07	2 E+04	1 E+04	1 E+04	ET/St/St
Nb-88	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/ET
Nb-89 (66 min)	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/ET/ET
Nb-89 (122 min)	–	2 E−06	2 E−06	–	1 E+05	1 E+05	/ET/ET
Nb-90	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/ET/ET
Nb-93m	–	1 E−06	6 E−07	–	7 E+04	2 E+04	/St/St
Nb-94	–	7 E−08	2 E−08	–	2 E+03	8 E+02	/St/St
Nb-95m	–	7 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Nb-95	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/St/St
Nb-96	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/ET/ET
Nb-97	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/ET
Nb-98	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/ET/ET
Mo-90	8 E−07	–	7 E−07	3 E+04	–	2 E+04	ET/ /ET
Mo-93m	1 E−06	–	1 E−06	3 E+04	–	3 E+04	ET/ /ET
Mo-93	2 E−07	–	4 E−07	7 E+03	–	1 E+04	BS/ /St
Mo-99	1 E−06	–	5 E−07	5 E+04	–	1 E+04	E/ /St
Mo-101	8 E−06	–	6 E−06	3 E+05	–	2 E+05	ET/ /ET
Tc-93m	8 E−06	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Tc-93	3 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
Tc-94m	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Tc-94	1 E−06	1 E−06	–	4 E+04	3 E+04	–	ET/ET/
Tc-95m	8 E−07	6 E−07	–	3 E+04	2 E+04	–	ET/St/
Tc-95	1 E−06	1 E−06	–	5 E+04	5 E+04	–	ET/ET/
Tc-96m	2 E−05	2 E−05	–	1 E+06	1 E+06	–	ET/ET/
Tc-96	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/ET/
Tc-97m	1 E−06	2 E−07	–	5 E+04	7 E+03	–	St/St/
Tc-97	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/St/
Tc-98	3 E−07	9 E−08	–	1 E+04	3 E+03	–	St/St/
Tc-99m	1 E−05	1 E−05	–	5 E+05	4 E+05	–	ET/ET/
Tc-99	1 E−06	1 E−07	–	5 E+04	6 E+03	–	St/St/
Tc-101	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Tc-104	9 E−06	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Ru-94	5 E−06	5 E−06	5 E−06	2 E+05	1 E+05	1 E+05	ET/ET/ET
Ru-97	2 E−06	2 E−06	2 E−06	8 E+04	8 E+04	8 E+04	ET/ET/ET
Ru-103	8 E−07	2 E−07	2 E−07	3 E+04	1 E+04	9 E+03	St/St/St
Ru-105	2 E−06	2 E−06	2 E−06	9 E+04	8 E+04	8 E+04	ET/ET/ET
Ru-106	5 E−08	3 E−08	1 E−08	2 E+03	1 E+03	5 E+02	St/St/St
Rh-99m	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Rh-99	8 E−07	6 E−07	6 E−07	3 E+04	2 E+04	2 E+04	ET/St/St
Rh-100	5 E−07	5 E−07	5 E−07	1 E+04	1 E+04	1 E+04	ET/ET/ET

Radionuclide	Absorption type [3] μCi/mL			Absorption type [3] Bq/m [3]			Stochastic or organ or tissue [1]
	F	M	S	F	M	S	(F/M/S)
Rh-101m	1 E−06	1 E−06	1 E−06	6 E+04	6 E+04	6 E+04	ET/ET/ET
Rh-101	3 E−07	3 E−07	1 E−07	1 E+04	1 E+04	6 E+03	St/St/St
Rh-102m	2 E−07	2 E−07	1 E−07	1 E+04	7 E+03	4 E+03	St/St/St
Rh-102	6 E−08	1 E−07	6 E−08	2 E+03	4 E+03	2 E+03	St/St/St
Rh-103m	4 E−04	2 E−04	2 E−04	1 E+07	8 E+06	8 E+06	St/St/St
Rh-105	3 E−06	1 E−06	1 E−06	1 E+05	5 E+04	4 E+04	ET/St/St
Rh-106m	1 E−06	1 E−06	1 E−06	6 E+04	5 E+04	5 E+04	ET/ET/ET
Rh-107	1 E−05	9 E−06	9 E−06	5 E+05	3 E+05	3 E+05	ET/ET/ET
Pd-100	5 E−07	5 E−07	5 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Pd-101	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Pd-103	4 E−06	1 E−06	1 E−06	1 E+05	6 E+04	7 E+04	E/St/St
Pd-107	1 E−05	1 E−05	1 E−06	5 E+05	4 E+05	7 E+04	K/St/St
Pd-109	2 E−06	1 E−06	1 E−06	9 E+04	4 E+04	4 E+04	St/St/St
Ag-102	9 E−06	7 E−06	7 E−06	3 E+05	2 E+05	2 E+05	ET/ET/ET
Ag-103	8 E−06	7 E−06	7 E−06	3 E+05	2 E+05	2 E+05	ET/ET/ET
Ag-104m	8 E−06	6 E−06	6 E−06	2 E+05	2 E+05	2 E+05	ET/ET/ET
Ag-104	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Ag-105	7 E−07	8 E−07	7 E−07	2 E+04	2 E+04	2 E+04	St/St/St
Ag-106m	2 E−07	2 E−07	2 E−07	9 E+03	9 E+03	9 E+03	ET/ET/ET
Ag-106	1 E−05	1 E−05	1 E−05	5 E+05	4 E+05	4 E+05	ET/ET/ET
Ag-108m	7 E−08	1 E−07	2 E−08	2 E+03	4 E+03	1 E+03	St/St/St
Ag-110m	8 E−08	9 E−08	7 E−08	3 E+03	3 E+03	2 E+03	St/St/St
Ag-111	9 E−07	3 E−07	3 E−07	3 E+04	1 E+04	1 E+04	St/St/St
Ag-112	4 E−06	2 E−06	2 E−06	1 E+05	8 E+04	8 E+04	E/St/St
Ag-115	1 E−05	8 E−06	8 E−06	4 E+05	3 E+05	3 E+05	ET/ET/ET
Cd-104	4 E−06	4 E−06	4 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Cd-107	5 E−06	5 E−06	4 E−06	2 E+05	1 E+05	1 E+05	ET/ET/ET
Cd-109	2 E−08	9 E−08	1 E−07	9 E+02	3 E+03	4 E+03	K/K/St
Cd-113m	1 E−09	6 E−09	1 E−08	6 E+01	2 E+02	6 E+02	K/K/K
Cd-113	1 E−09	5 E−09	1 E−08	5 E+01	2 E+02	5 E+02	K/K/K
Cd-115m	3 E−08	1 E−07	1 E−07	1 E+03	3 E+03	3 E+03	K/St/St
Cd-115	9 E−07	4 E−07	4 E−07	3 E+04	1 E+04	1 E+04	K/St/St
Cd-117m	1 E−06	1 E−06	1 E−06	4 E+04	4 E+04	4 E+04	ET/ET/ET
Cd-117	2 E−06	2 E−06	2 E−06	8 E+04	7 E+04	7 E+04	ET/ET/ET
In-109	4 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
In-110 (69 min)	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
In-110 (5 h)	9 E−07	9 E−07	–	3 E+04	3 E+04	–	ET/ET/
In-111	1 E−06	1 E−06	–	5 E+04	5 E+04	–	ET/ET/
In-112	2 E−05	1 E−05	–	9 E+05	6 E+05	–	ET/ET/
In-113m	1 E−05	1 E−05	–	4 E+05	3 E+05	–	ET/ET/
In-114m	5 E−08	9 E−08	–	1 E+03	3 E+03	–	St/St/
In-115m	6 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
In-115	1 E−09	5 E−09	–	4 E+01	1 E+02	–	St/St/
In-116m	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
In-117m	5 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
In-117	7 E−06	5 E−06	–	2 E+05	2 E+05	–	ET/ET/
In-119m	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Sn-110	1 E−06	1 E−06	–	6 E+04	6 E+04	–	ET/ET/
Sn-111	1 E−05	1 E−05	–	6 E+05	5 E+05	–	ET/ET/
Sn-113	7 E−07	2 E−07	–	2 E+04	1 E+04	–	St/St/
Sn-117m	8 E−07	2 E−07	–	3 E+04	9 E+03	–	BS/St/
Sn-119m	1 E−06	3 E−07	–	5 E+04	1 E+04	–	St/St/
Sn-121m	5 E−07	1 E−07	–	2 E+04	6 E+03	–	St/St/
Sn-121	4 E−06	2 E−06	–	1 E+05	7 E+04	–	ET/St/
Sn-123m	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Sn-123	3 E−07	1 E−07	–	1 E+04	3 E+03	–	St/St/
Sn-125	4 E−07	2 E−07	–	1 E+04	7 E+03	–	St/St/
Sn-126	4 E−08	3 E−08	–	1 E+03	1 E+03	–	St/St/
Sn-127	2 E−06	2 E−06	–	9 E+04	7 E+04	–	ET/ET/
Sn-128	2 E−06	2 E−06	–	1 E+05	8 E+04	–	ET/ET/
Sb-115	1 E−05	1 E−05	–	5 E+05	4 E+05	–	ET/ET/
Sb-116m	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Sb-116	1 E−05	1 E−05	–	4 E+05	3 E+05	–	ET/ET/
Sb-117	1 E−05	1 E−05	–	4 E+05	3 E+05	–	ET/ET/
Sb-118m	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Sb-119	6 E−06	6 E−06	–	2 E+05	2 E+05	–	ET/ET/
Sb-120 (16 min)	2 E−05	2 E−05	–	1 E+06	7 E+05	–	ET/ET/
Sb-120 (6 d)	3 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/ET/
Sb-122	8 E−07	4 E−07	–	3 E+04	1 E+04	–	St/St/
Sb-124m	4 E−05	3 E−05	–	1 E+06	1 E+06	–	ET/ET/

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Sb-124	2 E−07	1 E−07	–	1 E+04	4 E+03	–	St/St/
Sb-125	2 E−07	1 E−07	–	7 E+03	6 E+03	–	BS/St/
Sb-126m	1 E−05	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Sb-126	2 E−07	1 E−07	–	9 E+03	6 E+03	–	ET/St/
Sb-127	7 E−07	3 E−07	–	2 E+04	1 E+04	–	E/St/
Sb-128 (9 h)	5 E−07	5 E−07	–	2 E+04	2 E+04	–	ET/ET/
Sb-128 (10 min)	1 E−05	9 E−06	–	4 E+05	3 E+05	–	ET/ET/
Sb-129	1 E−06	1 E−06	–	6 E+04	5 E+04	–	ET/ET/
Sb-130	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Sb-131	6 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Te-116 (Vapor)	–	6 E−06	–	–	2 E+05	–	/St /
Te-116	2 E−06	2 E−06	–	8 E+04	7 E+04	–	ET/ET/
Te-121m (Vapor)	–	4 E−08	–	–	1 E+03	–	/BS/
Te-121m	1 E−07	1 E−07	–	4 E+03	5 E+03	–	BS/St/
Te-121 (Vapor)	–	1 E−06	–	–	4 E+04	–	/St /
Te-121	1 E−06	1 E−06	–	3 E+04	3 E+04	–	ET/ET/
Te-123m (Vapor)	–	5 E−08	–	–	2 E+03	–	/BS/
Te-123m	1 E−07	1 E−07	–	4 E+03	6 E+03	–	BS/St/
Te-123 (Vapor)	–	1 E−08	–	–	4 E+02	–	/BS/
Te-123	2 E−08	5 E−08	–	1 E+03	1 E+03	–	BS/BS/
Te-125m (Vapor)	–	1 E−07	–	–	3 E+03	–	/BS/
Te-125m	2 E−07	1 E−07	–	9 E+03	7 E+03	–	BS/St/
Te-127m (Vapor)	–	6 E−08	–	–	2 E+03	–	/BS/
Te-127m	1 E−07	9 E−08	–	5 E+03	3 E+03	–	BS/St/
Te-127 (Vapor)	–	7 E−06	–	–	2 E+05	–	/St/
Te-127	5 E−06	3 E−06	–	2 E+05	1 E+05	–	ET/St/
Te-129m (Vapor)	–	1 E−07	–	–	5 E+03	–	/St/
Te-129m	3 E−07	1 E−07	–	1 E+04	3 E+03	–	St/St/
Te-129 (Vapor)	–	1 E−05	–	–	5 E+05	–	/St/
Te-129	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Te-131m (Vapor)	–	1 E−07	–	–	5 E+03	–	/T/
Te-131m	3 E−07	3 E−07	–	1 E+04	1 E+04	–	T/St/
Te-131 (Vapor)	–	6 E−06	–	–	2 E+05	–	/T/
Te-131	1 E−05	7 E−06	–	4 E+05	2 E+05	–	ET/ET/
Te-132 (Vapor)	–	7 E−08	–	–	2 E+03	–	/T/
Te-132	1 E−07	1 E−07	–	6 E+03	6 E+03	–	T/St/
Te-133m (Vapor)	–	1 E−06	–	–	6 E+04	–	/T/
Te-133m	3 E−06	2 E−06	–	1 E+05	1 E+05	–	T/ET/
Te-133 (Vapor)	–	7 E−06	–	–	2 E+05	–	/T/
Te-133	1 E−05	9 E−06	–	4 E+05	3 E+05	–	ET/ET/
Te-134 (Vapor)	–	6 E−06	–	–	2 E+05	–	/St/
Te-134	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
I-120m (Methyl)	4 E−06	–	–	1 E+05	–	–	T/ /
I-120m (Vapor)	–	3 E−06	–	–	1 E+05	–	/St /
I-120m	2 E−06	–	–	8 E+04	–	–	ET/ /
I-120 (Methyl)	1 E−06	–	–	6 E+04	–	–	T/ /
I-120 (Vapor)	–	1 E−06	–	–	5 E+04	–	/T/
I-120	2 E−06	–	–	1 E+05	–	–	E/ /
I-121 (Methyl)	5 E−06	–	–	2 E+05	–	–	T/ /
I-121 (Vapor)	–	4 E−06	–	–	1 E+05	–	/T/
I-121	8 E−06	–	–	3 E+05	–	–	T/ /
I-123 (Methyl)	1 E−06	–	–	7 E+04	–	–	T/ /
I-123 (Vapor)	–	1 E−06	–	–	5 E+04	–	/T/
I-123	2 E−06	–	–	1 E+05	–	–	T/ /
I-124 (Methyl)	3 E−08	–	–	1 E+03	–	–	T/ /
I-124 (Vapor)	–	2 E−08	–	–	9 E+02	–	/T/
I-124	4 E−08	–	–	1 E+03	–	–	T/ /
I-125 (Methyl)	2 E−08	–	–	9 E+02	–	–	T/ /
I-125 (Vapor)	–	2 E−08	–	–	7 E+02	–	/T/
I-125	3 E−08	–	–	1 E+03	–	–	T/ /
I-126 (Methyl)	1 E−08	–	–	5 E+02	–	–	T/ /
I-126 (Vapor)	–	1 E−08	–	–	4 E+02	–	/T/
I-126	2 E−08	–	–	7 E+02	–	–	T/ /
I-128 (Methyl)	3 E−05	–	–	1 E+06	–	–	T/ /
I-128 (Vapor)	–	8 E−06	–	–	3 E+05	–	/St/
I-128	1 E−05	–	–	6 E+05	–	–	ET/ /
I-129 (Methyl)	3 E−09	–	–	1 E+02	–	–	T/ /
I-129 (Vapor)	–	2 E−09	–	–	1 E+02	–	/T/
I-129	5 E−09	–	–	2 E+02	–	–	T/ /
I-130 (Methyl)	2 E−07	–	–	7 E+03	–	–	T/ /

Radionuclide	Absorption type [3] μCi/mL			Absorption type [3] Bq/m [3]			Stochastic or organ or tissue [1]
	F	M	S	F	M	S	(F/M/S)
I-130 (Vapor)	–	1 E−07	–	–	6 E+03	–	/T/
I-130	3 E−07	–	–	1 E+04	–	–	T/ /
I-131 (Methyl)	1 E−08	–	–	6 E+02	–	–	T/ /
I-131 (Vapor)	–	1 E−08	–	–	5 E+02	–	/T/
I-131	2 E−08	–	–	9 E+02	–	–	T/ /
I-132m (Methyl)	1 E−06	–	–	7 E+04	–	–	T/ /
I-132m (Vapor)	–	1 E−06	–	–	6 E+04	–	/T/
I-132m	3 E−06	–	–	1 E+05	–	–	T/ /
I-132 (Methyl)	1 E−06	–	–	6 E+04	–	–	T/ /
I-132 (Vapor)	–	1 E−06	–	–	5 E+04	–	/T/
I-132	2 E−06	–	–	7 E+04	–	–	T/ /
I-133 (Methyl)	9 E−08	–	–	3 E+03	–	–	T/ /
I-133 (Vapor)	–	7 E−08	–	–	2 E+03	–	/T/
I-133	1 E−07	–	–	5 E+03	–	–	T/ /
I-134 (Methyl)	8 E−06	–	–	2 E+05	–	–	T/ /
I-134 (Vapor)	–	3 E−06	–	–	1 E+05	–	/St/
I-134	3 E−06	–	–	1 E+05	–	–	ET/ /
I-135 (Methyl)	4 E−07	–	–	1 E+04	–	–	T/ /
I-135 (Vapor)	–	3 E−07	–	–	1 E+04	–	/T/
I-135	6 E−07	–	–	2 E+04	–	–	T/ /
Cs-125	1 E−05	–	–	4 E+05	–	–	ET/ /
Cs-127	4 E−06	–	–	1 E+05	–	–	ET/ /
Cs-129	2 E−06	–	–	9 E+04	–	–	ET/ /
Cs-130	1 E−05	–	–	6 E+05	–	–	ET/ /
Cs-131	7 E−06	–	–	2 E+05	–	–	ET/ /
Cs-132	9 E−07	–	–	3 E+04	–	–	ET/ /
Cs-134m	8 E−06	–	–	2 E+05	–	–	ET/ /
Cs-134	5 E−08	–	–	2 E+03	–	–	St/ /
Cs-135m	8 E−06	–	–	2 E+05	–	–	ET/ /
Cs-135	5 E−07	–	–	2 E+04	–	–	St/ /
Cs-136	2 E−07	–	–	1 E+04	–	–	E/ /
Cs-137	8 E−08	–	–	3 E+03	–	–	St/ /
Cs-138	5 E−06	–	–	2 E+05	–	–	ET/ /
Ba-126	4 E−06	–	–	1 E+05	–	–	ET/ /
Ba-128	4 E−07	–	–	1 E+04	–	–	St/ /
Ba-131m	4 E−05	–	–	1 E+06	–	–	ET/ /
Ba-131	1 E−06	–	–	4 E+04	–	–	ET/ /
Ba-133m	2 E−06	–	–	7 E+04	–	–	St/ /
Ba-133	3 E−07	–	–	1 E+04	–	–	St/ /
Ba-135m	2 E−06	–	–	9 E+04	–	–	St/ /
Ba-139	1 E−05	–	–	3 E+05	–	–	St/ /
Ba-140	3 E−07	–	–	1 E+04	–	–	St/ /
Ba-141	1 E−05	–	–	4 E+05	–	–	ET/ /
Ba-142	9 E−06	–	–	3 E+05	–	–	ET/ /
La-131	1 E−05	8 E−06	–	4 E+05	3 E+05	–	ET/ET/
La-132	1 E−06	1 E−06	–	5 E+04	5 E+04	–	ET/ET/
La-135	1 E−05	1 E−05	–	4 E+05	4 E+05	–	ET/ET/
La-137	4 E−08	2 E−07	–	1 E+03	8 E+03	–	L/L/
La-138	3 E−09	1 E−08	–	1 E+02	4 E+02	–	St/St/
La-140	4 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/St/
La-141	5 E−06	2 E−06	–	1 E+05	9 E+04	–	St/St/
La-142	2 E−06	2 E−06	–	9 E+04	8 E+04	–	ET/ET/
La-143	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Ce-134	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Ce-135	–	5 E−07	5 E−07	–	2 E+04	2 E+04	/ET/ET
Ce-137m	–	1 E−06	9 E−07	–	3 E+04	3 E+04	/St/St
Ce-137	–	1 E−05	1 E−05	–	7 E+05	7 E+05	/ET/ET
Ce-139	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/St/St
Ce-141	–	2 E−07	1 E−07	–	7 E+03	6 E+03	/St/St
Ce-143	–	5 E−07	5 E−07	–	2 E+04	2 E+04	/St/St
Ce-144	–	2 E−08	1 E−08	–	9 E+02	7 E+02	/St/St
Pr-136	–	1 E−05	1 E−05	–	3 E+05	3 E+05	/ET/ET
Pr-137	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/ET/ET
Pr-138m	–	2 E−06	2 E−06	–	7 E+04	7 E+04	/ET/ET
Pr-139	–	1 E−05	1 E−05	–	5 E+05	5 E+05	/ET/ET
Pr-142m	–	6 E−05	5 E−05	–	2 E+06	2 E+06	/St/St
Pr-142	–	8 E−07	7 E−07	–	2 E+04	2 E+04	/St/St
Pr-143	–	2 E−07	2 E−07	–	1 E+04	9 E+03	/St/St
Pr-144	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/ET/ET
Pr-145	–	2 E−06	2 E−06	–	8 E+04	8 E+04	/St/St

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Pr-147	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/ET/ET
Nd-136	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/ET/ET
Nd-138	–	1 E−06	1 E−06	–	5 E+04	5 E+04	/St/St
Nd-139m	–	1 E−06	1 E−06	–	5 E+04	5 E+04	/ET/ET
Nd-139	–	1 E−05	1 E−05	–	6 E+05	6 E+05	/ET/ET
Nd-141	–	3 E−05	3 E−05	–	1 E+06	1 E+06	/ET/ET
Nd-147	–	2 E−07	2 E−07	–	1 E+04	9 E+03	/St/St
Nd-149	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/ET/ET
Nd-151	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/ET/ET
Pm-141	–	1 E−05	1 E−05	–	4 E+05	4 E+05	/ET/ET
Pm-143	–	5 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Pm-144	–	1 E−07	1 E−07	–	3 E+03	5 E+03	/St/St
Pm-145	–	1 E−07	4 E−07	–	5 E+03	1 E+04	/BS/St
Pm-146	–	4 E−08	6 E−08	–	1 E+03	2 E+03	/St/St
Pm-147	–	1 E−07	1 E−07	–	4 E+03	6 E+03	/BS/St
Pm-148m	–	1 E−07	1 E−07	–	5 E+03	4 E+03	/St/St
Pm-148	–	2 E−07	2 E−07	–	9 E+03	9 E+03	/St/St
Pm-149	–	7 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Pm-150	–	2 E−06	2 E−06	–	8 E+04	8 E+04	/ET/ET
Pm-151	–	9 E−07	8 E−07	–	3 E+04	3 E+04	/St/St
Sm-141m	–	5 E−06	–	–	2 E+05	–	/ET/
Sm-141	–	1 E−05	–	–	4 E+05	–	/ET/
Sm-142	–	4 E−06	–	–	1 E+05	–	/ET/
Sm-145	–	4 E−07	–	–	1 E+04	–	/BS/
Sm-146	–	2 E−11	–	–	1 E+00	–	/BS/
Sm-147	–	2 E−11	–	–	1 E+00	–	/BS/
Sm-151	–	7 E−08	–	–	2 E+03	–	/BS/
Sm-153	–	8 E−07	–	–	3 E+04	–	/St/
Sm-155	–	1 E−05	–	–	3 E+05	–	/ET/
Sm-156	–	2 E−06	–	–	7 E+04	–	/St/
Eu-145	–	5 E−07	–	–	2 E+04	–	/ET/
Eu-146	–	3 E−07	–	–	1 E+04	–	/ET/
Eu-147	–	5 E−07	–	–	2 E+04	–	/St/
Eu-148	–	2 E−07	–	–	9 E+03	–	/St/
Eu-149	–	2 E−06	–	–	9 E+04	–	/St/
Eu-150 (12 h)	–	2 E−06	–	–	7 E+04	–	/St/
Eu-150 (34 yr)	–	1 E−08	–	–	6 E+02	–	/St/
Eu-152m	–	1 E−06	–	–	6 E+04	–	/St/
Eu-152	–	2 E−08	–	–	7 E+02	–	/St/
Eu-154	–	1 E−08	–	–	5 E+02	–	/St/
Eu-155	–	7 E−08	–	–	2 E+03	–	/BS/
Eu-156	–	1 E−07	–	–	6 E+03	–	/St/
Eu-157	–	1 E−06	–	–	4 E+04	–	/St/
Eu-158	–	5 E−6	–	–	1 E+05	–	/ET/
Gd-145	9 E−06	7 E−06	–	3 E+05	2 E+05	–	ET/ET/
Gd-146	1 E−07	1 E−07	–	4 E+03	4 E+03	–	St/St/
Gd-147	7 E−07	6 E−07	–	2 E+04	2 E+04	–	ET/ET/
Gd-148	5 E−12	2 E−11	–	2 E−01	9 E−01	–	BS/BS/
Gd-149	1 E−06	7 E−07	–	4 E+04	2 E+04	–	St/St/
Gd-151	2 E−07	8 E−07	–	9 E+03	3 E+04	–	BS/St/
Gd-152	7 E−12	3 E−11	–	2 E−01	1 E+00	–	BS/BS/
Gd-153	9 E−08	4 E−07	–	3 E+03	1 E+04	–	BS/St/
Gd-159	3 E−06	1 E−06	–	1 E+05	5 E+04	–	St/St/
Tb-147	–	2 E−06	–	–	1 E+05	–	/ET/
Tb-149	–	1 E−07	–	–	6 E+03	–	/St/
Tb-150	–	2 E−06	–	–	8 E+04	–	/ET/
Tb-151	–	1 E−06	–	–	4 E+04	–	/ET/
Tb-153	–	2 E−06	–	–	8 E+04	–	/St/
Tb-154	–	5 E−07	–	–	2 E+04	–	/ET/
Tb-155	–	2 E−06	–	–	8 E+04	–	/St/
Tb-156m (24 h)	–	2 E−06	–	–	9 E+04	–	/St/
Tb-156m (5 h)	–	4 E−06	–	–	1 E+05	–	/St/
Tb-156	–	4 E−07	–	–	1 E+04	–	/E/
Tb-157	–	2 E−07	–	–	8 E+03	–	/BS/
Tb-158	–	1 E−08	–	–	6 E+02	–	/BS/
Tb-160	–	1 E−07	–	–	3 E+03	–	/St/
Tb-161	–	4 E−07	–	–	1 E+04	–	/St/
Dy-155	–	2 E−06	–	–	1 E+05	–	/ET/
Dy-157	–	5 E−06	–	–	1 E+05	–	/ET/
Dy-159	–	2 E−06	–	–	8 E+04	–	/BS/

Radionuclide	Absorption type [3] μCi/mL			Absorption type [3] Bq/m [3]			Stochastic or organ or tissue [1]
	F	M	S	F	M	S	(F/M/S)
Dy-165	–	6 E−06	–	–	2 E+05	–	/ET/
Dy-166	–	3 E−07	–	–	1 E+04	–	/St/
Ho-155	–	1 E−05	–	–	4 E+05	–	/ET/
Ho-157	–	2 E−05	–	–	1 E+06	–	/ET/
Ho-159	–	2 E−05	–	–	9 E+05	–	/ET/
Ho-161	–	3 E−05	–	–	1 E+06	–	/ET/
Ho-162m	–	9 E−06	–	–	3 E+05	–	/ET/
Ho-162	–	5 E−05	–	–	2 E+06	–	/ET/
Ho-164m	–	3 E−05	–	–	1 E+06	–	/St/
Ho-164	–	2 E−05	–	–	8 E+05	–	/ET/
Ho-166m	–	7 E−09	–	–	2 E+02	–	/St/
Ho-166	–	6 E−07	–	–	2 E+04	–	/St/
Ho-167	–	4 E−06	–	–	1 E+05	–	/ET/
Er-161	–	3 E−06	–	–	1 E+05	–	/ET/
Er-165	–	2 E−05	–	–	1 E+06	–	/ET/
Er-169	–	6 E−07	–	–	2 E+04	–	/St/
Er-171	–	1 E−06	–	–	6 E+04	–	/St/
Er-172	–	4 E−07	–	–	1 E+04	–	/St/
Tm-162	–	9 E−06	–	–	3E+05	–	/ET/
Tm-166	–	1 E−06	–	–	4 E+04	–	/ET/
Tm-167	–	5 E−07	–	–	2 E+04	–	/St/
Tm-170	–	1 E−07	–	–	4 E+03	–	/St/
Tm-171	–	2 E−07	–	–	9 E+03	–	/BS/
Tm-172	–	4 E−07	–	–	1 E+04	–	/St/
Tm-173	–	2 E−06	–	–	8 E+04	–	/St/
Tm-175	–	8 E−06	–	–	2 E+05	–	/ET/
Yb-162	–	1 E−05	1 E−05	–	5 E+05	5 E+05	/ET/ET
Yb-166	–	6 E−07	5 E−07	–	2 E+04	2 E+04	/St/St
Yb-167	–	3 E−05	3 E−05	–	1 E+06	1 E+06	/ET/ET
Yb-169	–	2 E−07	2 E−07	–	9 E+03	8 E+03	/St/St
Yb-175	–	8 E−07	8 E−07	–	3 E+04	2 E+04	/St/St
Yb-177	–	6 E−06	5 E−06	–	2 E+05	2 E+05	/ET/ET
Yb-178	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/E
Lu-169	–	9 E−07	9 E−07	–	3 E+04	3 E+04	/ET/ET
Lu-170	–	4 E−07	4 E−07	–	1 E+04	1 E+04	/ET/ET
Lu-171	–	6 E−07	6 E−07	–	2 E+04	2 E+04	/St/St
Lu-172	–	3 E−07	3 E−07	–	1 E+04	1 E+04	/St/St
Lu-173	–	2 E−07	4 E−07	–	8 E+03	1 E+04	/BS/St
Lu-174m	–	2 E−07	2 E−07	–	7 E+03	8 E+03	/BS/St
Lu-174	–	9 E−08	2 E−07	–	3 E+03	8 E+03	/BS/St
Lu-176m	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/St/St
Lu-176	–	3 E−09	1 E−08	–	1 E+02	6 E+02	/BS/St
Lu-177m	–	5 E−08	4 E−08	–	2 E+03	1 E+03	/St/St
Lu-177	–	5 E−07	5 E−07	–	2 E+04	1 E+04	/St/St
Lu-178m	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/ET/ET
Lu-178	–	8 E−06	8 E−06	–	3 E+05	3 E+05	/ET/ET
Lu-179	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/St/St
Hf-170	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Hf-172	6 E−09	3 E−08	–	2 E+02	1 E+03	–	BS/BS/
Hf-173	2 E−06	2 E−06	–	9 E+04	8 E+04	–	ET/ET/
Hf-175	5 E−07	6 E−07	–	2 E+04	2 E+04	–	BS/St/
Hf-177m	2 E−06	1 E−06	–	9 E+04	6 E+04	–	ET/ET/
Hf-178m	8 E−10	4 E−09	–	3 E+01	1 E+02	–	BS/BS/
Hf-179m	2 E−07	1 E−07	–	8 E+03	6 E+03	–	BS/St/
Hf-180m	2 E−06	1 E−06	–	7 E+04	6 E+04	–	ET/ET/
Hf-181	1 E−07	1 E−07	–	4 E+03	5 E+03	–	BS/St/
Hf-182m	5 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Hf-182	5 E−10	2 E−09	–	2 E+01	9 E+01	–	BS/BS/
Hf-183	6 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Hf-184	1 E−06	1 E−06	–	5 E+04	4 E+04	–	ET/St/
Ta-172	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/ET/ET
Ta-173	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/E/E
Ta-174	–	5 E−06	5 E−06	–	2 E+05	2 E+05	/ET/ET
Ta-175	–	1 E−06	1 E−06	–	6 E+04	6 E+04	/ET/ET
Ta-176	–	1 E−06	1 E−06	–	3 E+04	3 E+04	/ET/ET
Ta-177	–	4 E−06	4 E−06	–	1 E+05	1 E+05	/St/St
Ta-178	–	3 E−06	3 E−06	–	1 E+05	1 E+05	/ET/ET
Ta-179	–	4 E−06	1 E−06	–	1 E+05	7 E+04	/St/St
Ta-180m	–	9 E−06	9 E−06	–	3 E+05	3 E+05	/St/St
Ta-180	–	1 E−07	4 E−08	–	4 E+03	1 E+03	/St/St

Radionuclide	Absorption type [3]			Absorption type [3]			Stochastic or organ or tissue [1]
	μCi/mL			Bq/m [3]			
	F	M	S	F	M	S	(F/M/S)
Ta-182m	–	6 E−06	6 E−06	–	2 E+05	2 E+05	/ET/ET
Ta-182	–	9 E−08	7 E−08	–	3 E+03	2 E+03	/St/St
Ta-183	–	3 E−07	2 E−07	–	1 E+04	1 E+04	/St/St
Ta-184	–	8 E−07	8 E−07	–	3 E+04	3 E+04	/ET/ET
Ta-185	–	5 E−06	5 E−06	–	2 E+05	1 E+05	/ET/ET
Ta-186	–	7 E−06	7 E−06	–	2 E+05	2 E+05	/ET/ET
W-176	3 E−06	–	–	1 E+05	–	–	ET/ /
W-177	5 E−06	–	–	2 E+05	–	–	ET/ /
W-178	3 E−06	–	–	1 E+05	–	–	ET/ /
W-179	1 E−04	–	–	5 E+06	–	–	ET/ /
W-181	1 E−05	–	–	4 E+05	–	–	ET/ /
W-185	2 E−06	–	–	9 E+04	–	–	St/ /
W-187	1 E−06	–	–	5 E+04	–	–	ET/ /
W-188	6 E−07	–	–	2 E+04	–	–	St/ /
Re-177	1 E−05	1 E−05	–	6 E+05	4 E+05	–	ET/ET/
Re-178	1 E−05	1 E−05	–	5 E+05	3 E+05	–	ET/ET/
Re-181	1 E−06	1 E−06	–	5 E+04	4 E+04	–	ET/ET/
Re-182 (64 h)	4 E−07	3 E−07	–	1 E+04	1 E+04	–	ET/St/
Re-182 (12 h)	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Re-184m	6 E−07	1 E−07	–	2 E+04	4 E+03	–	St/St/
Re-184	7 E−07	3 E−07	–	2 E+04	1 E+04	–	ET/St/
Re-186m	4 E−7	7 E−08	–	1 E+04	2 E+03	–	St/St/
Re-186	7 E−07	4 E−07	–	2 E+04	1 E+04	–	St/St/
Re-187	2 E−04	1 E−04	–	8 E+06	4 E+06	–	St/St/
Re-188m	3 E−05	2 E−05	–	1 E+06	1 E+06	–	St/St/
Re-188	8 E−07	7 E−07	–	3 E+04	2 E+04	–	St/St/
Re-189	1 E−06	9 E−07	–	4 E+04	3 E+04	–	St/St/
Os-180	1 E−05	1 E−05	1 E−05	5 E+05	3 E+05	3 E+05	ET/ET/ET
Os-181	3 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Os-182	1 E−06	9 E−07	9 E−07	3 E+04	3 E+04	3 E+04	ET/ET/ET
Os-185	4 E−07	5 E−07	5 E−07	1 E+04	2 E+04	1 E+04	St/St/St
Os-189m	1 E−04	7 E−05	7 E−05	4 E+06	2 E+06	2 E+06	St/St/St
Os-191m	1 E−05	4 E−06	4 E−06	5 E+05	1 E+05	1 E+05	St/St/St
Os-191	1 E−06	4 E−07	3 E−07	5 E+04	1 E+04	1 E+04	St/St/St
Os-193	2 E−06	8 E−07	8 E−07	7 E+04	3 E+04	3 E+04	St/St/St
Os-194	4 E−08	4 E−08	1 E−08	1 E+03	1 E+03	4 E+02	St/St/St
Ir-182	9 E−06	7 E−06	7 E−06	3 E+05	2 E+05	2 E+05	ET/ET/ET
Ir-184	1 E−06	1 E−06	1 E−06	7 E+04	6 E+04	7 E+04	ET/ET/ET
Ir-185	2 E−06	1 E−06	1 E−06	7 E+04	7 E+04	7 E+04	ET/ET/ET
Ir-186 (16 h)	8 E−07	7 E−07	7 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Ir-186 (2 h)	5 E−06	4 E−06	4 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Ir-187	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/ET/ET
Ir-188	6 E−07	6 E−07	6 E−07	2 E+04	2 E+04	2 E+04	ET/ET/ET
Ir-189	3 E−06	1 E−06	1 E−06	1 E+05	5 E+04	4 E+04	St/St/St
Ir-190m (3 h)	2 E−06	2 E−06	2 E−06	8 E+04	8 E+04	7 E+04	ET/ET/ET
Ir-190m (1 h)	9 E−05	5 E−05	5 E−05	3 E+06	2 E+06	1 E+06	ET/St/St
Ir-190	4 E−07	2 E−07	2 E−07	1 E+04	9 E+03	8 E+03	ET/St/St
Ir-192m	1 E−07	1 E−07	2 E−08	3 E+03	6 E+03	1 E+03	St/St/St
Ir-192	2 E−07	1 E−07	1 E−07	9 E+03	5 E+03	4 E+03	St/St/St
Ir-194m	8 E−08	8 E−08	6 E−08	3 E+03	3 E+03	2 E+03	St/St/St
Ir-194	1 E−06	7 E−07	7 E−07	5 E+04	2 E+04	2 E+04	St/St/St
Ir-195m	2 E−06	2 E−06	2 E−06	9 E+04	7 E+04	7 E+04	ET/ET/ET
Ir-195	7 E−06	5 E−06	4 E−06	2 E+05	1 E+05	1 E+05	ET/ET/ET
Pt-186	3 E−06	–	–	1 E+05	–	–	ET/ /
Pt-188	8 E−07	–	–	3 E+04	–	–	E/ /
Pt-189	3 E−06	–	–	1 E+05	–	–	ET/ /
Pt-191	1 E−06	–	–	7 E+04	–	–	ET/ /
Pt-193m	2 E−06	–	–	8 E+04	–	–	ET/ /
Pt-193	2 E−05	–	–	7 E+05	–	–	ET/ /
Pt-195m	1 E−06	–	–	5 E+04	–	–	ET/ /
Pt-197m	7 E−06	–	–	2 E+05	–	–	ET/ /
Pt-197	3 E−06	–	–	1 E+05	–	–	ET/ /
Pt-199	1 E−05	–	–	4 E+05	–	–	ET/ /
Pt-200	1 E−06	–	–	5 E+04	–	–	St/ /
Au-193	4 E−06	3 E−06	3 E−06	1 E+05	1 E+05	1 E+05	ET/E/St
Au-194	9 E−07	9 E−07	9 E−07	3 E+04	3 E+04	3 E+04	ET/ET/ET
Au-195	3 E−06	7 E−07	4 E−07	1 E+05	2 E+04	1 E+04	ET/St/St
Au-198m	6 E−07	2 E−07	2 E−07	2 E+04	1 E+04	1 E+04	ET/St/St
Au-198	1 E−06	5 E−07	5 E−07	4 E+04	2 E+04	1 E+04	ET/St/St
Au-199	2 E−06	8 E−07	7 E−07	7 E+04	3 E+04	2 E+04	ET/St/St

Radionuclide	Absorption type [3] μCi/mL			Absorption type [3] Bq/m [3]			Stochastic or organ or tissue [1]
	F	M	S	F	M	S	(F/M/S)
Au-200m	5 E−07	4 E−07	4 E−07	1 E+04	1 E+04	1 E+04	ET/ET/ET
Au-200	1 E−05	7 E−06	7 E−06	4 E+05	2 E+05	2 E+05	ET/ET/ET
Au-201	1 E−05	1 E−05	9 E−06	5 E+05	3 E+05	3 E+05	ET/ET/ET
Hg-193m (Org)	1 E−06	–	–	4 E+04	–	–	ET/ /
Hg-193m	1 E−06	1 E−06	–	4 E+04	4 E+04	–	ET/ET/
Hg-193m (Vapor)	–	1 E−07	–	–	6 E+03	–	/St/
Hg-193 (Org)	5 E−06	–	–	1 E+05	–	–	ET/ /
Hg-193	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Hg-193 (Vapor)	–	5 E−07	–	–	1 E+04	–	/St/
Hg-194 (Org)	2 E−08	–	–	1 E+03	–	–	St/ /
Hg-194	3 E−08	1 E−07	–	1 E+03	3 E+03	–	St/St/
Hg-194 (Vapor)	–	1 E−08	–	–	5 E+02	–	/St/
Hg-195m (Org)	1 E−06	–	–	5 E+04	–	–	ET/ /
Hg-195m	1 E−06	8 E−07	–	5 E+04	3 E+04	–	ET/St/
Hg-195m (Vapor)	–	6 E−08	–	–	2 E+03	–	/St/
Hg-195 (Org)	6 E−06	–	–	2 E+05	–	–	ET/ /
Hg-195	6 E−06	6 E−06	–	2 E+05	2 E+05	–	ET/ET/
Hg-195 (Vapor)	–	4 E−07	–	–	1 E+04	–	/St/
Hg-197m (Org)	1 E−06	–	–	5 E+04	–	–	ET/ /
Hg-197m	1 E−06	8 E−07	–	5 E+04	3 E+04	–	ET/St/
Hg-197m (Vapor)	–	9 E−08	–	–	3 E+03	–	/St/
Hg-197 (Org)	4 E−06	–	–	1 E+05	–	–	ET/ /
Hg-197	4 E−06	2 E−06	–	1 E+05	7 E+04	–	ET/St/
Hg-197 (Vapor)	–	1 E−07	–	–	4 E+03	–	/St/
Hg-199m (Org)	8 E−06	–	–	3 E+05	–	–	ET/ /
Hg-199m	8 E−06	5 E−06	–	3 E+05	1 E+05	–	ET/ET/
Hg-199m (Vapor)	–	3 E−06	–	–	1 E+05	–	/St/
Hg-203 (Org)	7 E−07	–	–	2 E+04	–	–	St/ /
Hg-203	9 E−07	2 E−07	–	3 E+04	1 E+04	–	St/St/
Hg-203 (Vapor)	–	8 E−08	–	–	2 E+03	–	/St/
Tl-194m	5 E−06	–	–	2 E+05	–	–	ET/ /
Tl-194	2 E−05	–	–	8 E+05	–	–	ET/ /
Tl-195	6 E−06	–	–	2 E+05	–	–	ET/ /
Tl-197	8 E−06	–	–	2 E+05	–	–	ET/ /
Tl-198m	2 E−06	–	–	9 E+04	–	–	ET/ /
Tl-198	1 E−06	–	–	5 E+04	–	–	ET/ /
Tl-199	5 E−06	–	–	2 E+05	–	–	ET/ /
Tl-200	8 E−07	–	–	3 E+04	–	–	ET/ /
Tl-201	4 E−06	–	–	1 E+05	–	–	ET/ /
Tl-202	1 E−06	–	–	5 E+04	–	–	ET/ /
Tl-204	9 E−07	–	–	3 E+04	–	–	St/ /
Pb-195m	7 E−06	–	–	2 E+05	–	–	ET/ /
Pb-198	2 E−06	–	–	9 E+04	–	–	ET/ /
Pb-199	4 E−06	–	–	1 E+05	–	–	ET/ /
Pb-200	1 E−06	–	–	4 E+04	–	–	ET/ /
Pb-201	2 E−06	–	–	7 E+04	–	–	ET/ /
Pb-202m	1 E−06	–	–	6 E+04	–	–	ET/ /
Pb-202	4 E−08	–	–	1 E+03	–	–	St/ /
Pb-203	2 E−06	–	–	7 E+04	–	–	ET/ /
Pb-205	9 E−07	–	–	3 E+04	–	–	BS/ /
Pb-209	9 E−06	–	–	3 E+05	–	–	ET/ /
Pb-210	1 E−10	–	–	5 E+00	–	–	BS/ /
Pb-211	4 E−08	–	–	1 E+03	–	–	ET/ /
Pb-212	5 E−09	–	–	2 E+02	–	–	ET/ /
Pb-214	4 E−08	–	–	1 E+03	–	–	ET/ /
Bi-200	5 E−06	4 E−06	–	2 E+05	1 E+05	–	ET/ET/
Bi-201	3 E−06	2 E−06	–	1 E+05	1 E+05	–	ET/ET/
Bi-202	2 E−06	2 E−06	–	9 E+04	9 E+04	–	ET/ET/
Bi-203	7 E−07	7 E−07	–	2 E+04	2 E+04	–	ET/ET/
Bi-205	4 E−07	4 E−07	–	1 E+04	1 E+04	–	ET/ET/
Bi-206	2 E−07	2 E−07	–	9 E+03	8 E+03	–	ET/ET/
Bi-207	4 E−07	1 E−07	–	1 E+04	6 E+03	–	ET/St/
Bi-210m	3 E−09	2 E−10	–	1 E+02	9 E+00	–	K/St/
Bi-210	1 E−07	9 E−09	–	6 E+03	3 E+02	–	K/St/
Bi-212	1 E−08	8 E−09	–	4 E+02	3 E+02	–	ET/ET/
Bi-213	1 E−08	7 E−09	–	4 E+02	2 E+02	–	ET/ET/
Bi-214	1 E−08	1 E−08	–	6 E+02	4 E+02	–	ET/ET/
Po-203	5 E−06	4 E−06	–	1 E+05	1 E+05	–	ET/ET/
Po-205	4 E−06	3 E−06	–	1 E+05	1 E+05	–	ET/ET/
Po-207	1 E−06	1 E−06	–	7 E+04	6 E+04	–	ET/ET/

Radionuclide	Absorption type [3] μCi/mL			Absorption type [3] Bq/m [3]			Stochastic or organ or tissue [1]
	F	M	S	F	M	S	(F/M/S)
Po-210	7 E−10	2 E−10	–	2 E+01	9 E+00	–	K/St/
At-207	1 E−06	2 E−07	–	4 E+04	1 E+04	–	St/St/
At-211	7 E−09	5 E−09	–	2 E+02	1 E+02	–	ET/St/
Rn-220 [5]	1 E−08	–	–	6 E+02	–	–	–
Rn-222 [5]	8 E−08	–	–	3 E+03	–	–	–
Fr-222	1 E−08	–	–	3 E+02	–	–	ET/ /
Fr-223	4 E−07	–	–	1 E+04	–	–	St/ /
Ra-223	–	9 E−11	–	–	3 E+00	–	/St/
Ra-224	–	2 E−10	–	–	8 E+00	–	/St/
Ra-225	–	1 E−10	–	–	4 E+00	–	/St/
Ra-226	–	2 E−10	–	–	9 E+00	–	/St/
Ra-227	–	8 E−07	–	–	3 E+04	–	/BS/
Ra-228	–	1 E−10	–	–	5 E+00	–	/BS/
Ac-224	1 E−08	6 E−09	5 E−09	6 E+02	2 E+02	2 E+02	BS/St/St
Ac-225	2 E−10	9 E−11	8 E−11	7 E+00	3 E+00	3 E+00	BS/St/St
Ac-226	1 E−09	6 E−10	5 E−10	4 E+01	2 E+01	2 E+01	ET/St/St
Ac-227	2 E−13	1 E−12	1 E−11	1 E−02	5 E−02	4 E−01	BS/BS/St
Ac-228	6 E−09	3 E−08	4 E−08	2 E+02	1 E+03	1 E+03	BS/BS/St
Th-226	–	4 E−09	4 E−09	–	1 E+02	1 E+02	/ET/ET
Th-227	–	9 E−11	7 E−11	–	3 E+00	2 E+00	/St/St
Th-228	–	2 E−11	2 E−11	–	7 E−01	8 E−01	/BS/St
Th-229	–	2 E−12	1 E−11	–	7 E−02	4 E−01	/BS/St
Th-230	–	3 E−12	4 E−11	–	1 E−01	1 E+00	/BS/BS
Th-231	–	1 E−06	1 E−06	–	5 E+04	5 E+04	/St/St
Th-232	–	3 E−12	4 E−11	–	1 E−01	1 E+00	/BS/BS
Th-234	–	1 E−07	9 E−08	–	3 E+03	3 E+03	/St/St
Pa-227	–	4 E−09	4 E−09	–	1 E+02	1 E+02	/ET/ET
Pa-228	–	1 E−08	1 E−08	–	3 E+02	4 E+02	/BS/St
Pa-230	–	1 E−09	9 E−10	–	4 E+01	3 E+01	/St/St
Pa-231	–	1 E−12	1 E−11	–	4 E−02	4 E−01	/BS/BS
Pa-232	–	1 E−08	1 E−07	–	6 E+02	7 E+03	/BS/BS
Pa-233	–	2 E−07	1 E−07	–	7 E+03	6 E+03	/St/St
Pa-234	–	7 E−07	7 E−07	–	2 E+04	2 E+04	/ET/ET
U-230	6 E−10	5 E−11	4 E−11	2 E+01	2 E+00	1 E+00	K/St/St
U-231	2 E−06	1 E−06	1 E−06	8 E+04	4 E+04	4 E+04	ET/St/St
U-232	5 E−11	1 E−10	2 E−11	2 E+00	4 E+00	7 E−01	BS/St/ET
U-233	4 E−10	2 E−10	7 E−11	1 E+01	9 E+00	2 E+00	BS/St/ET
U-234	5 E−10	2 E−10	7 E−11	1 E+01	9 E+00	2 E+00	BS/St/ET
U-235	5 E−10	3 E−10	8 E−11	1 E+01	1 E+01	3 E+00	BS/St/ET
U-236	5 E−10	2 E−10	7 E−11	1 E+01	1 E+01	2 E+00	BS/St/ET
U-237	1 E−06	3 E−07	3 E−07	4 E+04	1 E+04	1 E+04	ET/St/St
U-238	5 E−10	3 E−10	8 E−11	2 E+01	1 E+01	3 E+00	BS/St/ET
U-239	1 E−05	9 E−06	9 E−06	5 E+05	3 E+05	3 E+05	ET/ET/ET
U-240	1 E−06	7 E−07	6 E−07	5 E+04	2 E+04	2 E+04	ET/St/St
Np-232	–	3 E−06	–	–	1 E+05	–	/BS/
Np-233	–	7 E−05	–	–	2 E+06	–	/ET/
Np-234	–	5 E−07	–	–	2 E+04	–	/ET/
Np-235	–	1 E−06	–	–	4 E+04	–	/BS/
Np-236 (1 E+05 yr)	–	4 E−11	–	–	1 E+00	–	/BS/
Np-236 (22 h)	–	5 E−08	–	–	1 E+03	–	/BS/
Np-237	–	8 E−12	–	–	3 E−01	–	/BS/
Np-238	–	1 E−07	–	–	4 E+03	–	/BS/
Np-239	–	5 E−07	–	–	1 E+04	–	/St/
Np-240	–	2 E−06	–	–	8 E+04	–	/ET/
Pu-234	–	3 E−08	3 E−08	–	1 E+03	1 E+03	/St/St
Pu-235	–	9 E−05	8 E−05	–	3 E+06	3 E+06	/ET/ET
Pu-236	–	1 E−11	7 E−11	–	6 E−01	2 E+00	/BS/St
Pu-237	–	1 E−06	1 E−06	–	7 E+04	6 E+04	/St/St
Pu-238	–	6 E−12	5 E−11	–	2 E−01	1 E+00	/BS/St
Pu-239	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-240	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-241	–	2 E−10	2 E−09	–	1 E+01	1 E+02	/BS/BS
Pu-242	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-243	–	5 E−06	5 E−06	–	1 E+05	1 E+05	/E/E
Pu-244	–	5 E−12	6 E−11	–	2 E−01	2 E+00	/BS/BS
Pu-245	–	9 E−07	8 E−07	–	3 E+04	3 E+04	/St/St
Pu-246	–	8 E−08	8 E−08	–	3 E+03	2 E+03	/St/St
Am-237	–	8 E−06	–	–	3 E+05	–	/ET/
Am-238	–	2 E−06	–	–	9 E+04	–	/BS/
Am-239	–	1 E−06	–	–	6 E+04	–	/ET/

Radionuclide	Absorption type [3] µCi/mL			Absorption type [3] Bq/m [3]			Stochastic or organ or tissue [1]
	F	M	S	F	M	S	(F/M/S)
Am-240	–	7 E−07	–	–	2 E+04	–	/ET/
Am-241	–	5 E−12	–	–	1 E−01	–	/BS/
Am-242m	–	5 E−12	–	–	1 E−01	–	/BS/
Am-242	–	4 E−08	–	–	1 E+03	–	/St/
Am-243	–	5 E−12	–	–	1 E−01	–	/BS/
Am-244m	–	3 E−06	–	–	1 E+05	–	/BS/
Am-244	–	1 E−07	–	–	5 E+03	–	/BS/
Am-245	–	5 E−06	–	–	2 E+05	–	/ET/
Am-246m	–	6 E−06	–	–	2 E+05	–	/ET/
Am-246	–	2 E−06	–	–	9 E+04	–	/ET/
Cm-238	–	1 E−07	–	–	4 E+03	–	/St/
Cm-240	–	2 E−10	–	–	7 E+00	–	/St/
Cm-241	–	2 E−08	–	–	8 E+02	–	/St/
Cm-242	–	1 E−10	–	–	5 E+00	–	/St/
Cm-243	–	7 E−12	–	–	2 E−01	–	/BS/
Cm-244	–	9 E−12	–	–	3 E−01	–	/BS/
Cm-245	–	5 E−12	–	–	1 E−01	–	/BS/
Cm-246	–	5 E−12	–	–	1 E−01	–	/BS/
Cm-247	–	5 E−12	–	–	2 E−01	–	/BS/
Cm-248	–	1 E−12	–	–	5 E−02	–	/BS/
Cm-249	–	8 E−06	–	–	3 E+05	–	/ET/
Cm-250	–	2 E−13	–	–	8 E−03	–	/BS/
Bk-245	–	3 E−07	–	–	1 E+04	–	/St/
Bk-246	–	8 E−07	–	–	3 E+04	–	/ET/
Bk-247	–	3 E−12	–	–	1 E−01	–	/BS/
Bk-249	–	1 E−09	–	–	5 E+01	–	/BS/
Bk-250	–	2 E−07	–	–	9 E+03	–	/BS/
Cf-244	–	1 E−08	–	–	5 E+02	–	/ET/
Cf-246	–	1 E−09	–	–	5 E+01	–	/St/
Cf-248	–	5 E−11	–	–	2 E+00	–	/BS/
Cf-249	–	3 E−12	–	–	1 E−01	–	/BS/
Cf-250	–	7 E−12	–	–	2 E−01	–	/BS/
Cf-251	–	3 E−12	–	–	1 E−01	–	/BS/
Cf-252	–	1 E−11	–	–	6 E−01	–	/BS/
Cf-253	–	5 E−10	–	–	2 E+01	–	/St/
Cf-254	–	2 E−11	–	–	8 E−01	–	/BS/
Es-250	–	4 E−07	–	–	1 E+04	–	/BS/
Es-251	–	3 E−07	–	–	1 E+04	–	/St/
Es-253	–	2 E−10	–	–	9 E+00	–	/St/
Es-254m	–	1 E−09	–	–	5 E+01	–	/St/
Es-254	–	6 E−11	–	–	2 E+00	–	/BS/
Fm-252	–	2 E−09	–	–	8 E+01	–	/St/
Fm-253	–	1 E−09	–	–	6 E+01	–	/St/
Fm-254	–	6 E−09	–	–	2 E+02	–	/ET/
Fm-255	–	2 E−09	–	–	8 E+01	–	/St/
Fm-257	–	1 E−10	–	–	4 E+00	–	/St/
Md-257	–	2 E−08	–	–	1 E+03	–	/St/
Md-258	–	1 E−10	–	–	4 E+00	–	/St/

Footnotes for Appendix A

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

[2] The ICRP identifies these materials as soluble or reactive gases and vapors or highly soluble or reactive gases and vapors. For tritiated water, the inhalation DAC values allow for an additional 50% absorption through the skin, as described in ICRP Publication No. 68, Dose Coefficients for Intakes of Radionuclides by Workers. For elemental tritium, the DAC values include a factor that irradiation from gas within the lungs might increase the dose by 20%.

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

[4] DAC values derived using hafnium tritide particle and are based on ''observed activity'' (i.e, only radiation emitted from the particle is considered). DAC values derived using methodology found in Radiological Control Programs for Special Tritium Compounds, DOE–HDBK–1184–2004.

[5] These values are appropriate for protection from radon combined with its short-lived decay products and are based on information given in ICRP Publication 65: Protection Against Radon-222 at Home and at Work and in DOE–STD–1121–98: Internal Dosimetry. The values given are for 100% equilibrium concentration conditions of the short-lived radon decay products with the parent. To allow for an actual measured equilibrium concentration or a demonstrated equilibrium concentration, the values given in this table should be multiplied by the ratio (100%/actual %) or (100%/demonstrated %), respectively. Alternatively, the DAC values for Rn-220 and Rn-222 may be replaced by 2.5 working level (WL) and 0.83 WL, respectively, for appropriate limiting of decay product concentrations. A WL is any combination of short-lived radon decay products, in one liter of air without regard to the degree of equilibrium, that will result in the ultimate emission of 1.3 E+05 MeV of alpha energy.

■ 30. Appendix C of part 835 is revised to read as follows:

Appendix C to Part 835—Derived Air Concentration (DAC) for Workers From External Exposure During Immersion in a Cloud of Airborne Radioactive Material

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

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

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

		Air immersion DAC	
Radionuclide	Half-Life	(μCi/mL)	(Bq/m^3)
Ar-37	35.02 d	1 E+00	4 E+10
Ar-39	269 yr	4 E–04	1 E+07
Ar-41	1.827 h	1 E–06	3 E+04
Kr-74	11.5 min	1 E–06	4 E+04
Kr-76	14.8 h	3 E–06	1 E+05
Kr-77	74.7 h	1 E–06	5 E+04
Kr-79	35.04 h	5 E–06	2 E+05
Kr-81	2.1E+05 yr	2 E–04	9 E+06
Kr-83m	1.83 h	2 E–02	9 E+08
Kr-85	10.72 yr	2 E–04	9 E+06
Kr-85m	4.48 h	9 E–06	3 E+05
Kr-87	76.3 min	1 E–06	5 E+04
Kr-88	2.84 h	6 E–07	2 E+04
Xe-120	40.0 min	3 E–06	1 E+05
Xe-121	40.1 min	7 E–07	2 E+04
Xe-122	20.1 h	2 E–05	1 E+06
Xe-123	2.14 h	2 E–06	8 E+04
Xe-125	16.8 h	5 E–06	2 E+05
Xe-127	36.406 d	5 E–06	2 E+05
Xe-129m	8.89 d	6 E–05	2 E+06
Xe-131m	11.84 d	1 E–04	6 E+06
Xe-133	5.245 d	4 E–05	1 E+06
Xe-133m	2.19 d	4 E–05	1 E+06
Xe-135	9.11 h	5 E–06	2 E+05
Xe-135m	15.36 min	3 E–06	1 E+05
Xe-138	14.13 min	1 E–06	4 E+04

For any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life less than two hours, the DAC value shall be 6 E–06 μCi/mL (2 E+04 Bq/m^3).

Appendix E to Part 835—[Amended]

■ 31. Appendix D is amended in the last row of the first column by revising the words ''Tritium and tritiated compounds [6]'' to read ''Tritium and STCs [6].'' The last row of column three is revised by replacing the term ''N/A'' with the words ''See Footnote 6.'' Footnote 6 is revised by appending the following to the end of the footnote ''In certain cases, a ''Total'' value of 10,000 dpm/100 cm^2 may be applicable either to metals, of the types which form insoluble special tritium compounds that have been exposed to tritium; or to bulk materials to which particles of insoluble special tritium compound are fixed to a surface.'' Footnote 7 is revised to read ''These limits only apply to the alpha emitters within the respective decay series.''

■ 32. Appendix E of part 835 is revised to read as follows:

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

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

Nuclide	Activity (μCi)
H-3	1.5E+08
Be-7	3.1E+03
Be-10	1.4E+05
C-14	4.6E+06
Na-22	1.9E+01
Al-26	1.5E+01
Si-32	4.9E+04
S-35	2.4E+06
Cl-36	5.2E+05
K-40	2.7E+02
Ca-41	9.3E+06
Ca-45	1.1E+06
Sc-46	6.2E+01
Ti-44	1.5E+02
V-49	1.0E+08
Mn-53	7.5E+07
Mn-54	6.5E+01
Fe-55	2.9E+06
Fe-59	1.9E+02
Fe-60	8.1E+03
Co-56	3.9E+01
Co-57	2.3E+02
Co-58	1.3E+02
Co-60	1.7E+01
Ni-59	3.2E+06
Ni-63	1.3E+06

Nuclide	Activity (μCi)
Zn-65	1.1E+02
Ge-68	5.6E+02
As-73	5.3E+02
Se-75	6.3E+01
Se-79	8.7E+05
Rb-83	9.1E+01
Rb-84	2.0E+02
Sr-85	1.2E+02
Sr-89	4.8E+05
Sr-90	3.5E+04
Y-88	3.3E+01
Y-91	5.0E+04
Zr-88	1.1E+02
Zr-93	9.3E+04
Zr-95	1.9E+02
Nb-91	6.9E+01
Nb-91m	3.6E+02
Nb-92	1.8E+01
Nb-93m	4.4E+02
Nb-94	2.3E+01
Nb-95	3.4E+02
Mo-93	7.7E+01
Tc-95m	1.3E+02
Tc-97	8.1E+01
Tc-97m	3.5E+02
Tc-98	2.5E+01
Tc-99	8.4E+05
Ru-103	4.4E+02
Ru-106	2.5E+02
Rh-101	8.7E+05
Rh-102	3.0E+05
Rh-102m	6.4E+05
Pd-107	9.3E+06
Ag-105	3.3E+06
Ag-108m	1.8E+01
Ag-110m	2.2E+01
Cd-109	1.6E+02
Cd-113m	2.0E+04
Cd-115m	1.0E+04
In-114m	7.7E+02
Sn-113	3.1E+02
Sn-119m	3.3E+02
Sn-121m	8.1E+05
Sn-123	1.3E+04
Sn-126	1.8E+02
Sb-124	9.1E+01
Sb-125	6.7E+01
Te-121m	1.8E+02
Te-123m	2.8E+02
Te-125m	4.4E+02
Te-127m	8.0E+02
Te-129m	2.3E+03
I-125	3.5E+02
I-129	1.8E+02
Cs-134	2.6E+01
Cs-135	1.3E+06
Cs-137	6.0E+01
Ba-133	5.1E+01
La-137	2.7E+05
Ce-139	2.4E+02
Ce-141	2.4E+03
Ce-144	1.4E+03
Pm-143	1.3E+02
Pm-144	2.9E+01
Pm-145	2.6E+02
Pm-146	4.4E+01
Pm-147	7.7E+05
Pm-148m	1.0E+02
Sm-145	2.4E+06
Sm-146	4.0E+02
Sm-151	2.5E+05
Eu-148	1.1E+06
Eu-149	1.1E+07
Eu-152	3.1E+01
Eu-154	3.1E+01
Eu-155	3.6E+02
Gd-146	5.1E+05
Gd-148	9.0E+01
Gd-151	2.9E+06
Gd-153	2.1E+02
Tb-157	2.5E+03
Tb-158	9.0E+04
Tb-160	1.2E+02
Dy-159	1.0E+07
Ho-166m	2.1E+01
Tm-170	8.4E+03
Tm-171	2.8E+04
Yb-169	5.5E+02
Lu-173	1.8E+06
Lu-174	9.3E+05
Lu-174m	1.0E+06
Lu-177m	5.8E+01
Hf-172	7.3E+04
Hf-175	3.0E+06
Hf-178m	8.7E+03
Hf-181	3.4E+02
Hf-182	7.5E+03
Ta-179	9.3E+06
Ta-182	7.3E+01
W-181	1.0E+03
W-185	3.9E+06
W-188	6.3E+04
Re-183	5.3E+02
Re-184	2.6E+02
Re-184m	1.5E+02
Re-186m	3.4E+05
Os-185	1.3E+02
Os-194	6.4E+04
Ir-192	1.3E+02
Ir-192m	1.4E+05
Ir-194m	2.7E+01
Pt-193	8.7E+07
Au-195	4.8E+02
Hg-194	5.2E+04
Hg-203	4.9E+02
Tl-204	2.2E+04
Pb-202	1.9E+05
Pb-205	9.0E+01
Pb-210	9.2E+01
Bi-207	1.7E+01
Bi-208	1.5E+01
Bi-210m	1.2E+03
Po-209	6.3E+03
Po-210	1.2E+03
Ra-226	2.2E+02
Ra-228	1.5E+03
Ac-227	4.2E+00
Th-228	8.4E+01
Th-229	3.1E+01
Th-230	5.4E+00
Th-232	9.3E+01
Pa-231	3.0E+01
U-232	1.0E+02
U-233	3.9E+02
U-234	2.9E+02
U-235	6.7E+01
U-236	3.1E+02
U-238	3.5E+02
Np-235	1.1E+02
Np-236	2.1E+01
Np-237	4.9E+01
Pu-236	2.0E+02
Pu-237	3.3E+02
Pu-238	9.0E+01
Pu-239	8.4E+01
Pu-240	8.4E+01
Pu-241	4.6E+03
Pu-242	8.7E+01
Pu-244	9.0E+01
Am-241	7.2E+01
Am-242m	1.1E+02
Am-243	7.3E+01
Cm-241	1.0E+05
Cm-242	6.2E+02
Cm-243	4.8E+01
Cm-244	1.5E+02
Cm-245	5.0E+01
Cm-246	1.0E+02
Cm-247	8.5E+01
Cm-248	2.8E+01
Cm-250	5.4E+00
Bk-247	6.0E+01
Bk-249	2.7E+04
Cf-248	4.4E+02
Cf-249	5.5E+01
Cf-250	1.2E+02
Cf-251	5.3E+01
Cf-252	5.2E+00
Cf-254	1.2E+02
Es-254	6.3E+01
Es-255	8.8E+03
Fm-257	5.1E+02
Md-258	6.1E+02

Any alpha emitting radionuclide not listed in appendix E and mixtures of alpha emitters of unknown composition have a value of 10 μCi.

With the exception that any type of STC has a value of 10 Ci, any radionuclide other than alpha emitting radionuclides not listed in appendix E and mixtures of beta emitters of unknown composition have a value of 100 μCi.

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

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