Department of Energy
Office of Worker Protection Programs and Hazards Management
Radiological Control Technical Position
RCTP 2000-01

Acceptable Approach for Controlling and Determining Individual Internal Exposures to Radioactive Material

Issue:

Title 10 Code of Federal Regulations, Part 835 (10 CFR 835), *Occupational Radiation Protection*, establishes occupational radiation protection requirements for Department of Energy (DOE) activities and includes requirements for the monitoring and control of individual exposures to various airborne radionuclides. These requirements are based on *Radiation Protection Guidance to Federal Agencies for Occupational Exposure*, which was issued by the President in January 1987. The Presidential guidance recommended use of weighting factors which were, at the time, consistent with the most current international and national recommendations.
Title 10 CFR 835.2(b) defines weighting factors consistent with the Presidential guidance and requires their use for determining dose. More current national and international recommendations now include tissue weighting factors that differ from those in 10 CFR 835.

Appendix A of 10 CFR 835, *Derived Air Concentrations (DAC) for Controlling Radiation Exposure to Workers at DOE Facilities*, provides DAC values for numerous radionuclides that are used to control individual internal doses, identify the need for air monitoring, and identify the need for posting. Use of more current national and international recommended internal dosimetry methodologies would result in much different DAC values.

Questions have been raised concerning DOE's position on the use of more current national and international scientific consensus recommendations as a source for tissue weighting factors and allowance to use these revised tissue weighting factors and other factors to revise the 10 CFR 835 appendix A DAC values.

Introduction:

The Office of Worker Protection Programs and Hazards Management (EH-52) received a request for exemption from the definitions of tissue weighting factors provided in 10 CFR 835.2(b).
The site requesting the exemption proposed to use the tissue weighting factors provided in the International Commission on Radiological Protection's (ICRP) Publication 60, *1990 Recommendations of the International Commission on Radiological Protection*. The National Council on Radiation Protection and Measurements (NCRP) in Report No. 116, *Limits of Exposure to Ionizing Radiation*, also recommends use of the ICRP Publication 60 tissue weighting factors.

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EH-52 also received requests for exemption to modify the 10 CFR 835 appendix A DAC values. These DAC values are consistent with internal dosimetry methodologies published in ICRP Publication 26, *Recommendations of the ICRP*, and ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers*. The requesting sites had requested allowance to develop site-specific DAC values based on more current internal dosimetry methodology, including the lung model described in ICRP Publication 66, *Human Respiratory Tract Model for Radiological Protection*.

Discussion:

Applicable Requirements (these requirements were published in the November 4, 1998, amendment to 10 CFR 835, 63 FR 59662 Federal Register Vol. 63, No. 213)

10 CFR 835

§ 835.2 Definitions.

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

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

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

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WEIGHTING FACTORS FOR VARIOUS ORGANS AND TISSUES

Organs or tissues, T	Weighting factor, w_T
Gonads	0.25
Breasts	0.15
Red bone marrow	0.12
Lungs	0.12
Thyroid	0.03
Bone surfaces	0.03
Remainder[1]	0.30
Whole body[2]	1.00

[1]"Remainder" means the five other organs or tissues, excluding the skin and lens of the eye, with the highest dose (e.g., liver, kidney, spleen, thymus, adrenal, pancreas, stomach, small intestine, and upper large intestine). The weighting factor for each remaining organ or tissue is 0.06.
[2]For the case of uniform external irradiation of the whole body, a weighting factor (w_T) equal to 1 may be used in determination of the effective dose equivalent.

§ 835.209 Concentrations of radioactive material in air.

(a) The derived air concentration (DAC) values given in appendices A and C of this part shall be used in the control of occupational exposures to airborne radioactive material.

(b) The estimation of internal dose shall be based on bioassay data rather than air concentration values unless bioassay data are:
- (1) unavailable;
- (2) inadequate; or
- (3) internal dose estimates based on air concentration values are demonstrated to be as or more accurate.

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Appendix A 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).

For situations where the particle size distribution is known to differ significantly from 1 micron, appropriate corrections can be made to both the estimated dose to workers and the DACs.

Technical Position:

Revised Tissue Weighting Factors

10 CFR 835.2(b) defines the tissue weighting factors to be used in determining effective dose equivalent and committed effective dose equivalent (CEDE). These tissue weighting factors are consistent with the methodology of ICRP Publications 26 and 30. ICRP Publication 60 recommends use of revised tissue weighting factors. A listing of the different tissue weighting factors is provided in Table 1.

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Table 1. Comparison of Tissue Weighting Factors

Tissue Weighting Factors

Organ or Tissue	10 CFR 835 (from ICRP 26)	ICRP Publication 60
Gonads	0.25	0.20
Breast	0.15	0.05
Red Bone Marrow	0.12	0.12
Lungs	0.12	0.12
Thyroid	0.03	0.05
Bone Surfaces	0.03	0.01
Colon		0.12
Stomach		0.12
Bladder		0.05
Liver		0.05
Oesophagus		0.05
Skin		0.01
Remainder	0.30	0.05
Whole Body	1.00	

With all other factors (particle size assumptions, lung model used etc.) being the same, the assessed CEDE from intakes of different radionuclides could vary significantly depending on which tissue weighting factors are used. Depending on the specific radionuclide and its chemical form, the assessed CEDE determined by using the ICRP Publication 60 tissue weighting factors could be either greater than, less than, or the same as that determined using the 10 CFR 835 tissue

weighting factors. For example, an intake of radioiodine would result in a greater CEDE using the ICRP Publication 60 tissue weighting factors rather than those in 10 CFR 835 due to the increase in the thyroid's tissue weighting factor. In contrast, the CEDE from an intake of plutonium would be less using the ICRP Publication 60 tissue weighting factors rather than those in 10 CFR 835 due to the decrease in the bone surface tissue weighting factor. See Table 2 for example results.

Table 2. Comparison of Dose Using Different Tissue Weighting Factors

Relative Committed Effective Dose Equivalent (rem)

Tissue Weighting Factor	**Pu-239 (Class Y)**	**I-131 (Class D)**
10 CFR 835	1.0	1.0
ICRP 60	0.8	1.7

As shown in Table 2, there are certain situations where the use of the 10 CFR 835 defined tissue weighting factors, as required by 10 CFR 835, results in an assessed dose significantly different than the assessed dose using the latest national and international consensus standards in their entirety. DOE is working on developing a DOE complex-wide resolution to this issue.

The tissue weighting factors are only one of the many factors affecting the assessment of internal doses. DOE encourages individual sites to evaluate the applicability of the specific factors affecting internal dose determinations that have a significant impact on assessed dose, including site-specific particle size differences, particle deposition rates, retention rates of radioactive material in the body and subsequent excretion rates and to use those factors that provide the most accurate practical assessment of the individual's dose. Some of these factors have a greater impact on the resultant assessed dose than the tissue weighting factors. DOE Guide G441.1-3, *Internal Dosimetry Program Guide,* states in section 4.4.3 that methods for evaluating the various doses from intakes "should be based on recommendations given in ICRP

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Publications, NCRP Reports, and ANSI standards that embody improvements and updates of the science of internal dosimetry." In addition, the Guide refers to DOE-STD-1121-98, *Internal Dosimetry*. This DOE standard discusses use of current internal dosimetry methodologies. However, keep in mind that the language in 10 CFR 835 requires the use of the tissue weighting factors defined in 10 CFR 835. Authority to use revised tissue weighting factors would need to be obtained by requesting and being granted an exemption from applicable 10 CFR 835 requirements. The Assistant Secretary for Environment, Safety and Health will evaluate each submitted exemption request on a case-by-case basis.

Revised DAC Values

The 10 CFR 835 DAC values were derived from an internal dosimetry methodology based on an individual receiving the more limiting of either 5 rem CEDE or 50 rem committed dose equivalent to any organ or tissue for a 2000 hour exposure. DAC values from 10 CFR 835 are required to be used for controlling individual internal doses, identifying the need for air monitoring, and identifying and posting airborne radioactivity areas. However, 10 CFR 835 does not require that these DAC values be used to determine individual internal doses. Air concentration values are not permitted to be used to estimate internal dose unless bioassay data are unavailable, inadequate, or internal dose estimates based on air concentration values are demonstrated to be as or more accurate than those based on bioassay data. Under such circumstances, 10 CFR 835.209 does not prohibit the use of air concentration values that differ from the 10 CFR 835 appendix A DAC values to estimate internal dose.

There are situations where the use of a newer internal dosimetry methodology, such as the use of ICRP Publication 66 lung model, would indicate that the 10 CFR 835 appendix A DAC values should be significantly reduced to ensure compliance with the regulatory limit. While 10 CFR 835 only allows particle size corrections or revisions to the DAC values, the regulations do not prohibit individual sites from implementing more restrictive radiological controls than those specified in 10 CFR 835. These controls would need to be consistent with the "as low as reasonably achievable" process.

For example, if a site determined that, using newer internal dosimetry methodologies, an individual receiving the equivalent of a 2000 DAC-hour exposure (based on 10 CFR 835 appendix A DAC values) would receive a dose above the regulatory limit, the site could implement internal exposure controls (e.g., airborne radioactivity monitoring, use of respiratory protection devices, stay time evaluations, and posting) at lower thresholds than those controls that are required in 10 CFR 835.

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This position is consistent with 10 CFR 835.3(d) which states that "Nothing in this part shall be construed as limiting actions as may be necessary to protect health and safety." Sites may implement radiation protection program elements and controls that are more restrictive than those required by 10 CFR 835 to ensure that the regulatory requirements in 10 CFR 835 are met.

In addition, making appropriate particle size corrections to the DAC values, in many situations, results in revised DAC values that are closer to those developed using newer internal dosimetry methodologies. Title 10 CFR 835 appendix A values are derived using a methodology that assumes a 1 micron particle size. Dose coefficients from newer internal dosimetry methodologies are derived using methodology that assumes a 5 micron particle size. For some situations, when an appropriate correction for particle size is made, the 10 CFR 835 appendix A DAC value is close to a DAC value determined using newer internal dosimetry methodologies.

Summary:

Title 10 CFR 835 requires the use of the 10 CFR 835 defined tissue weighting factors in assessing dose. DOE recognizes the limitation this requirement imposes on adopting the latest international and national recommendations for assessing internal dose and is working on developing a DOE complex-wide resolution. Excluding revisions to tissue weighting factors, DOE does allow individual sites to evaluate and use site specific particle size corrections and newer internal dosimetry models to best assess dose.

DAC values from 10 CFR 835 are required to be used for controlling individual internal doses, identifying the need for air monitoring, and identifying and posting airborne radioactivity areas. 10 CFR 835 does not require that these DAC values be used to determine individual internal doses. The use of a newer internal dosimetry methodology could result in situations with significantly different DAC values. While 10 CFR 835 only allows appropriate particle size corrections to be made to the 10 CFR 835 DAC values, the regulations do not prevent individual sites from implementing more restrictive internal exposure controls than those specified in
10 CFR 835. As necessary, sites may implement radiation protection program elements and controls that are more restrictive than those required by 10 CFR 835.

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References:

Presidential Documents, *Radiation Protection Guidance to Federal Agencies for Occupational Exposure*, 52 FR 2822, *Federal Register*, Vol. 52, No. 17, January 27, 1987

10 CFR 835, *Occupational Radiation Protection*, 63 FR 59662, *Federal Register*, Vol. 63, No. 213, November 4, 1998

DOE Guide G441.1-3 *Internal Dosimetry Program Guide*, U.S. Department of Energy, March 1999

DOE-STD-1121-98, *Internal Dosimetry*, U. S. Department of Energy, September 1999

ICRP Publication 26, *Recommendations of the ICRP*, International Commission on Radiological Protection, January 1977

ICRP Publication 30, *Limits for Intakes of Radionuclides by Workers*, International Commission on Radiological Protection, July 1978

ICRP Publication 60, *1990 Recommendations of the International Commission on Radiological* Protection, International Commission on Radiological Protection, November 1990

ICRP Publication 66, *Human Respiratory Tract Model for Radiological Protection*, International Commission on Radiological Protection, September 1995

NCRP Report No. 116, *Limits of Exposure to Ionizing Radiation*, National Council on Radiation Protection and Measurements, March 1993