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Conversion of Committed Effective Dose to Annual Organ Dose

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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
10/16/2023	00	New document to convert committed effective dose to annual organ doses. Added clarification to statements regarding bounding estimates, the application to unmonitored workers, and site-specific dose assignment. Incorporates formal internal and NIOSH review comments. Training is not required. Initiated by John M. Byrne and authored by Elizabeth M. Brackett.

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ACRONYMS AND ABBREVIATIONS

AWE	Atomic Weapons Employer
Bq	becquerel
CED	committed effective dose
C.F.R.	*Code of Federal Regulations*
DCF	dose conversion factor
DOE	U.S. Department of Energy
ICRP	International Commission on Radiological Protection
M	moderate
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
ORAUT	ORAU Team
RBM	red bone marrow
S	slow
SMT	stable metal tritide
SRDB Ref ID	Site Research Database Reference Identification (number)
Sv	sievert
TIB	technical information bulletin
ULI	upper large intestine
U.S.C.	*United States Code*
µm	micrometer
§	section or sections

1.0 INTRODUCTION

Technical information bulletins (TIBs) are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historical background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s), such as changing scientific understanding of operations, processes, or procedures involving radioactive materials. TIBs may be used to assist NIOSH staff in the completion of individual dose reconstructions.

In this document the word “facility” is used to refer to an area, building, or group of buildings that served a specific purpose at a U.S. Department of Energy (DOE) or Atomic Weapons Employer (AWE) facility. It does not mean, nor should it be equated to, an “AWE facility” or a “DOE facility.” The terms AWE and DOE facility are defined in 42 *United States Code* (U.S.C.) § 7384l(5) and (12) of the Energy Employees Occupational Illness Compensation Program Act of 2000, respectively.

1.1 PURPOSE

Promulgation of 10 *Code of Federal Regulations* (C.F.R.) Part 835, Occupational Radiation Protection, in the mid-1990s resulted in the institution of increased bioassay monitoring requirements at DOE facilities [DOE 1993]. Beginning in 1996, internal dose evaluation programs, including routine bioassay programs, were required for radiological workers who, under typical conditions, were likely to receive 0.1 rem or more committed effective dose equivalent in a year. In 2010, this requirement changed to 0.1-rem committed effective dose (CED). 10 C.F.R. 835, 2010. Note that the given years are the latest dates required by DOE for implementation of the regulations and that some sites were in compliance before these dates.

Given these requirements and how the site implemented them, the assignment of a 100-mrem CED in each year of potential exposure provides a bounding estimate of internal dose for unmonitored workers as determined and explained in the site-specific documentation. This document provides guidance on the conversion from a CED to annual organ doses.

1.2 SCOPE

The DOE monitoring requirement is based on a 50-year dose to the whole body, while dose reconstruction requires the assessment of annual organ dose. The relationship between the committed effective and annual organ doses is complex and does not allow direct conversion of one to the other. However, an intake quantity can be determined from the CED, which can then be used to calculate the annual organ dose. This value can be derived on a radionuclide-specific basis using the appropriate International Commission on Radiological Protection (ICRP) Publication 68 dose coefficient (dose conversion factor [DCF]) for CED [ICRP 1995]. In most cases, a potential intake of multiple nuclides could contribute to the 100-mrem monitoring requirement, many with multiple possible material types. All possibilities must be considered in the assessment. Applicability of this approach, including criteria defining which unmonitored workers are assigned this dose, is determined on a site-specific basis and is outside the scope of this document.

2.0 DETERMINATION OF INTAKE

Table 2-1 demonstrates the variability in the relationship between effective and organ doses. This will be further enhanced with the division into annual doses. The supporting data and calculations for Table 2-1 may be found in Oak Ridge Associated Universities (ORAU) Team (ORAUT) [2023].

Table 2-1. Committed organ doses (mrem) from ^{239}Pu intakes resulting in a 100-mrem CED.[a]

Organ[b]	Type M: 31.3 Bq	Type S: 120.5 Bq
Adrenals	5.3	1.8
Bone surface	3,100	1,100
ULI	5.6	1.9
Liver	660	230
RBM	150	54
Lungs	66	570
CED	100	100

a. Source: ORAUT [2023].
b. ULI = upper large intestine; RBM = red bone marrow.

For the general case, the intake activity for a given isotope of a radionuclide that results in a 100-mrem CED is derived from the corresponding ICRP [1995] DCF. Given that 100 mrem is equal to 0.001 Sv, an intake that would result in a CED of 100 mrem is:

$$\textit{Intake}\ (\text{Bq}) = 0.001\ \text{Sv}/\textit{DCF}\ (\text{Sv/Bq}) \qquad (2\text{-}1)$$

For consistency in calculating values, use the DCFs from the spreadsheet [ICRP 2012a] the ICRP provided with Publication 119, *Compendium of Dose Coefficients Based on ICRP Publication 60* [ICRP 2012b]. The spreadsheet tab labeled “Table A.1.” lists the DCFs, and column F contains the applicable values (i.e., worker 5-µm inhalation DCFs) in units of Sv/Bq. Note that “e” is used to denote the effective DCF. The tab “Table B.1.” lists DCFs for soluble gases in column C if the dose came from the vapor form of a material.

DCFs for special forms of several radionuclides are not included in ICRP Publication 119. The following Project documents are to be used in such cases:

- Stable metal tritides (SMTs): ORAUT-OTIB-0066, *Calculation of Dose from Intakes of Special Tritium Compounds* [ORAUT 2020a].
- Super S materials: ORAUT-OTIB-0049, *Estimating Doses for Plutonium Strongly Retained in the Lung* [ORAUT 2020b].
- Insoluble ^{238}Pu: DCAS-RPT-005, *Alternative Dissolution Models for Insoluble Pu-238* [NIOSH 2018].

3.0 APPLICATION OF INTAKE

Use the intake calculated in Section 2.0 to calculate the appropriate annual organ doses.

Applicability of this approach is on a site-specific basis. Refer to the site-specific documentation for details on timeframes, radionuclides, and dose assignment details.

REFERENCES

10 C.F.R. 835, [2010]. Occupational radiation protection. [SRDB Ref ID: 165861]

DOE [1993]. Federal Register Vol. 58 No. 238 December 14, 1993 Occupational radiation protection. Final rule. Fed Regist *58*(238):65458. [SRDB Ref ID: 165855]

ICRP [1995]. ICRP 68 - Dose coefficients for intakes of radionuclides by workers. ICRP Publication 68. Ann ICRP *24*(4). [SRDB Ref ID: 22731]

ICRP [2012a]. ICRP 119 - Spreadsheet versions of Annexes A-K of ICRP Publication 119, corrected version. Spreadsheet. Ottawa, Ontario, Canada: International Commission on Radiological Protection. [SRDB Ref ID: 127250]

ICRP [2012b]. ICRP 119 - Compendium of dose coefficients based on ICRP Publication 60. ICRP Publication 119. Ann ICRP *41*(S1). [SRDB Ref ID: 127106]

NIOSH [2018]. Alternative dissolution models for insoluble Pu-238. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. DCAS-RPT-005 Rev. 01, August 17. [SRDB Ref ID: 175415]

ORAUT [2020a]. Calculation of dose from intakes of special tritium compounds. Oak Ridge, TN: Oak Ridge Associated Universities Team. ORAUT-OTIB-0066 Rev. 01, October 15. [SRDB Ref ID: 183483]

ORAUT [2020b]. Estimating doses for plutonium strongly retained in the lung. Oak Ridge, TN: Oak Ridge Associated Universities Team. ORAUT-OTIB-0049 Rev. 02, September 1. [SRDB Ref ID: 178329]

ORAUT [2023]. ORAUT-OTIB-0093 Rev 00 supporting calculations. Spreadsheet. Oak Ridge, TN: Oak Ridge Associated Universities Team. June 5. [SRDB Ref ID: 197739]