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October 30, 2007

PG&E Letter HBL-07-015

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555-0001

Docket No. 50-133
License No. DPR-7
Humboldt Bay Power Plant, Unit 3
Exemption Request From 10 CFR 20 Appendix B, Table 1 Values

Dear Commissioners and Staff:

In accordance with 10 CFR 20.2301, Pacific Gas and Electric Company (PG&E) is submitting a request for exemption from the values of the Inhalation Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) that appear in 10 CFR 20, Appendix B, Table 1, for use at Humboldt Bay Power Plant, Unit 3 (HBPP). PG&E proposes replacing the 10 CFR 20, Appendix B, Table 1 ALI and DAC values, derived using previous (1977) recommendations of the International Commission on Radiological Protection (ICRP), with ALI and DAC values derived using more recent (1995) ICRP recommendations.

Enclosure 1 to this letter describes how the ALIs and DACs were derived using the new ICRP recommendations and provides justification that the ICRP recommendations are appropriate for use at HBPP. Enclosure 2 to this letter is a technical report prepared by Radiation Safety & Control Services, Inc., that was used as the basis for the development of Enclosure 1. Both Enclosures 1 and 2 describe the methodology used to develop ALI and DAC values based on newer models that provide more accurate dose estimates than those used in 10 CFR 20, Appendix B, Table 1. In addition, Enclosure 2 identifies the specific ALI and DAC values proposed for use at HBPP.

Enclosures 1 and 2 provide justification, as required in 10 CFR 20.2301, that the exemption would not result in undue hazard to life or property. The information contained in the enclosures demonstrates that the criteria for granting an exemption have been met. In addition, 10 CFR 20.1204(c) allows licensees to adjust ALI and DAC values to reflect actual physical and chemical characteristics of airborne radioactive material, after obtaining prior NRC approval.

The change proposed in this exemption request is not required to address an immediate safety concern. However, the change will result in greater worker efficiency when performing decommissioning activities, thereby providing an overall reduction in worker dose. PG&E is currently performing preliminary decommissioning activities that are scheduled to increase in mid-2008 after

spent nuclear fuel assemblies and fuel fragment containers (hereafter referred to as "spent fuel") are transferred from the spent fuel pool to the Independent Spent Fuel Storage Installation. Therefore, PG&E requests the NRC process this exemption request within six months. Upon approval of this exemption request, PG&E intends to incorporate the revised inhalation ALIs and DACs from Enclosure 2 into the HBPP routine internal exposure control program.

PG&E's exemption request is similar to a recent revision to 10 CFR 835, "Occupational Radiation Protection," made by the Department of Energy (DOE) that implements the recent recommendations from ICRP regarding ALI and DAC values. Enclosure 1 provides more information on the DOE change.

Should you require further information or clarification, please contact John Albers at (707) 444-0877, or David Sokolsky at (707) 444-0801.

Sincerely,

John S. Keenan

cc: Gary W. Butner, Department of Public Health
Elmo E. Collins, Jr., NRC Region IV
John B. Hickman, NRC
PG Fossil Gen HBPP Humboldt Distribution

Enclosures

# EXEMPTION REQUEST EVALUATION

## 1.0 DESCRIPTION

In accordance with 10 CFR 20.2301, Pacific Gas and Electric Company (PG&E) is submitting a request for exemption from the values of the inhalation Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) that appear in Table 1, "Occupational Values," of 10 CFR 20, Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage," for use at Humboldt Bay Power Plant, Unit 3 (HBPP). PG&E proposes replacing the 10 CFR 20, Appendix B, Table 1 ALI and DAC values, derived using previous (1977) recommendations of the International Commission on Radiological Protection (ICRP), with ALI and DAC values derived using more recent (1995) ICRP recommendations. Regulation 10 CFR 20.1204(c) allows licensees to adjust ALI and DAC values to reflect actual physical and chemical characteristics of airborne radioactive material, after obtaining prior NRC approval.

This enclosure provides an explanation as to why the proposed exemption is appropriate for use at HBPP, a description of how the ALI and DAC values were derived using the more recent ICRP recommendations, and a justification that the exemption would not result in undue hazard to life or property. Upon approval of this exemption request, PG&E intends to incorporate the revised inhalation ALI and DAC values into the HBPP routine internal exposure control program.

## 2.0 BACKGROUND

The DAC and ALI values provided in Table 1 of Appendix B to 10 CFR 20 are based upon previous recommendations of the ICRP in Publication 30, "Limits for Intakes of Radionuclides by Workers," as listed below:

- ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers, Part 1," dated August 1979
- ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers, Part 2," dated November 1980
- ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers, Supplement to Part 2," dated December 1980

In those recommendations, highly conservative assumptions were made in order to simplify the calculations of dose limits. One significant assumption was that certain compounds were assumed to clear from the

lungs with a clearance half-life of only 500 days. This assumption resulted in a large fraction of these materials being translocated to bone surface where they were assumed to be retained for a biological half-life of 8,000 days.

The models used in the previous (1977) ICRP recommendations are not reflective of a realistic metabolism and result in a dose to the bone surface that is inappropriately high. More recent scientific data demonstrate that these materials are retained in the lung with a clearance half-life that is greatly in excess of 500 days. Additionally, newer metabolic information demonstrates that there is a significantly lower translocation of inhaled material to the bone.

The ICRP agreed with the more recent (1995) information and incorporated the information into newer recommendations, documented in ICRP Publications 67 through 72, as listed below:

- ICRP Publication 67, "Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 2 Ingestion Dose Coefficients," dated August 1994
- ICRP Publication 68, "Dose Coefficients for Intake of Radionuclides by Workers," dated July 1995
- ICRP Publication 69, "Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 3 Ingestion Dose Coefficients," dated July 1995
- ICRP Publication 70, "Basic Anatomical & Physiological Data for use in Radiological Protection: The Skeleton," dated January 1996
- ICRP Publication 71, "Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 4 Inhalation Dose Coefficients," dated May 1996
- ICRP Publication 72, "Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 5, Compilation of Ingestion and Inhalation Coefficients," dated September 1996

These publications include a comprehensive discussion of the updated models as well as a list of inhalation dose coefficients intended to replace those included in the previous ICRP recommendations. The updated models for occupational exposures are provided in ICRP Publication 68.

## 3.0 PROPOSED CHANGES

For the purposes of the HBPP internal exposure control program, PG&E wishes to replace the ALI and DAC values prescribed in Table 1 of 10 CFR 20, Appendix B, with those derived using the more recent ICRP

recommendations. The ALI values to be adopted are calculated as follows:

$$ALI(Bq) = \frac{D_L}{DCF}$$

where $D_L$ is the applicable dose limit and the DCF (dose conversation factor) is that from ICRP Publication 68, "Dose Coefficients for Intake of Radonuclides by Workers."

The DAC is defined as the concentration of a radionuclide in air, which if breathed by the Reference Man over a work year equal to 2000 hours under conditions of "light activity" (i.e., an inhalation rate of 1.2 $m^3$ per hour, where m=meters), would result in an intake equivalent to the applicable occupational dose limit for inhalation. Therefore, the DAC values to be adopted are calculated as follows:

$$DAC(\frac{Bq}{m^3}) = \frac{ALI}{\text{Volume of air}}$$

The specific ALI and DAC values proposed for use at HBPP are listed in Enclosure 2 to this letter, Radiation Safety & Control Services, Inc., Technical Support Document, TSD # 07-012, "Determination of ALIs and DACs Using ICRP 68 Dose Conversion Factors," Revision 00.

## 4.0 JUSTIFICATION

Fuel failures occurred at HBPP in the past when the reactor was operating, resulting in contamination due to alpha emitters. To protect plant workers from doses due to ingestion of alpha emitters, the HBPP internal exposure control program requires the use of respirators when performing certain activities. Using a respirator reduces worker efficiency and requires workers to remain in radiation areas longer than if respirators were not used. By remaining in a radiation area longer than necessary, workers receive higher external doses due to gamma radiation. At the present time, plant workers are actively performing preparatory decommissioning activities that are scheduled to increase in mid-2008 after spent nuclear fuel assemblies and fuel fragment containers (hereafter referred to as "spent fuel") are transferred from the spent fuel pool to the Independent Spent Fuel Storage Installation.

The more recent ALI and DAC values adopted by the ICRP reflect more accurate and realistic dose values from transuranic isotopes. Because transuranic isotopes are the major alpha emitters at HBPP, using the more accurate and realistic dose values will result in more accurate calculated alpha dose for workers. The more accurate alpha dose will require less

reliance on respirators, thereby allowing workers to perform activities in radiation areas much more efficiently resulting in reduced overall dose received.

Using the more recent ALI and DAC values will not result in undue hazard to life or property. To the contrary, not using the more recent ALI and DAC values could result in increased time in radiation areas causing increased external radiation dose due to gamma rays.

Further justification for the requested exemption is based on the fact that, effective July 9, 2007, the Department of Energy (DOE) revised 10 CFR 835, "Occupational Radiation Protection," to reflect the more recent ICRP recommendations and dose coefficients regarding ALI and DAC values. Part 835 of 10 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. The DOE consulted with the NRC and other federal agencies prior to making these changes.

Radiation Safety & Control Services, Inc.

Technical Support Document

TSD # 07-012

"Determination of ALIs and DACs
Using ICRP 68 Dose Conversion Factors"

Revision 00

15 Pages

RADIATION SAFETY & CONTROL SERVICES, INC.

Technical Support Document

# TSD # 07-012

# Determination of ALIs and DACs Using ICRP 68 Dose Conversion Factors

**Revision 00**

Originator: Harvey Farrar Date: 8/8/07
Originator Name

Reviewer: James P. Adams, CHP Date: 8/8/07
Reviewer Name

Approval: James P. Adams, CHP. Date: 8/8/07
Approver Name

# Determination of ALIs and DACs Using ICRP 68 Dose Conversion Factors

## 1.0 Introduction

The models used in the current version of 10 CFR Part 20 to regulate internal dose are those described in ICRP (International Commission on Radiation Protection) Reports 26 and 30. These reports were adopted by the ICRP in the late 1970s. Since that time the ICRP has published a major revision to its radiation protection recommendations (ICRP 60) and, in the years following the revision, published a series of reports in which it describes the components of an extensively revised internal dosimetry model.

National and international scientific communities agree that these newer models provide more accurate dose estimates than those used in the current 10 CFR Part 20. However, because of the inclusion of annual limits on intake (ALIs) and derived air concentrations (DACs) in Table 1 of Appendix B, Nuclear Regulatory Commission (NRC) licensees cannot implement the updated dose models for ALIs and DACs without requesting an exemption from the NRC.

This technical report develops new ALIs and DACs based upon the dose conversion factors of ICRP 68 to support submittal of an exemption request to the NRC in accordance with 20.2301, "Applications for Exemptions" (Reference 7.1). This provision allows the NRC to grant exemptions to the requirements of 10 CFR 20. In addition, 10 CFR 20.1204(c) allows licensees to adjust ALIs and DACs to reflect more accurate assessments of exposure with prior NRC approval.

## 2.0 Background

Ingestion and inhalation ALIs as well as inhalation DACs are provided in Table 1 of Appendix B to 10CFR20. These values are based upon the 1977 recommendations of the ICRP in Publication 30, "Limits for Intakes of Radionuclides by Workers." In those recommendations, highly conservative assumptions were made in order to simplify the calculations of dose limits. One significant assumption used in the calculation was that certain compounds were cleared from the lungs with a clearance half-life of only 500 days. This assumption resulted in a large fraction of these compounds being translocated to the bone surface, where they were assumed to be retained for a biological half-life of 8,000 days.

The models used in the 1977 ICRP recommendations are not reflective of a realistic metabolism and result in a dose to the bone surface that is unreasonably and inappropriately high. More recent scientific data demonstrate that these materials are retained in the lung with a clearance half-life that is greatly in excess of 500 days. Additionally, newer metabolic information demonstrates that there is a significantly lower translocation of inhaled material to the bone.

The ICRP recognized this information and incorporated it into its 1995 recommendations, and adopted the new models in ICRP Publications 66 through 72. These publications include a comprehensive discussion of the updated models as well as a list of inhalation and ingestion dose coefficients intended to replace those included in the 1977 ICRP recommendations. The updated models for occupational exposures are provided in ICRP 68.

## 3.0 Assumptions

N/A

## 4.0 Calculations

New ALIs and DACs were derived based upon the methodology in Regulatory Guide 8.34, "Monitoring Criteria and Methods to Calculate Occupational Radiation Doses" (Reference 7.2), using the dose conversion factors (DCFs) in ICRP 68 (Reference 7.6).

The ALIs to be adopted are calculated as follows:

$$ALI(\mu Ci) = \frac{D_L}{DCF}$$

where $D_L$ is the applicable dose limit, 5 rem for total effective dose equivalent or 50 rem total organ dose equivalent to any single organ or tissue (other than the eye), and the *DCF* (in μCi/rem) is that from ICRP Publication 68.

The DAC is defined in 10 CFR 20 Appendix B as the concentration of a radionuclide in air which, if breathed by Reference Man over a work year is equal to 2000 hours under conditions of "light activity" (i.e., 1.2 $m^3$ per hour or 2.4E9 cc/y), would result in an intake equivalent to the applicable occupational dose limit for inhalation. Therefore, the DACs to be adopted are calculated as follows:

$$DAC(\frac{\mu Ci}{cc}) = \frac{ALI}{\text{Volume of Air}}$$

Radiological Toolbox Version 2.0 (Reference 7.10) was used to obtain the DCFs for the various radionuclides and various organs.

## 5.0 Results

Attachments A and B provide the Ingestion and Inhalation stochastic (effective) ALI and the limiting stochastic or non-stochastic ALI based upon ICRP 68 DCFs for the radionuclides listed. The attachments also provide the ALIs from Table 1 of Appendix B to 10 CFR 20 and the ratio of the ICRP 68-based ALIs to the Part 20 ALIs. Bolded ratio values indicate radionuclides for which the ICRP 68-based ALIs are greater than their Part 20 counterparts. Attachment C provides the limiting DACs based upon the ICRP 68 DCFs.

## 6.0 Attachments

**Attachment A – Ingestion ALIs**

**Attachment B – Inhalation ALIs**

**Attachment C – Inhalation DACs**

## 7.0 References

7.1 Code of Federal Regulations, Title 10 Energy, Part 20, Standards for Protection Against Radiation

7.2 NRC Regulatory Guide 8.34, "Monitoring Criteria and Methods to Calculate Occupational Radiation Doses," dated July 1992.

7.3 International Commission on Radiological Protection. 1990 Recommendations of the International Commission on Radiological Protection, Elsevier Science, ICRP Publication No. 60 (1990).

7.4 International Commission on Radiological Protection. Human Respiratory Tract Model for Radiological Protection. Oxford: Pergamon Press; ICRP Publication No. 66; (1994).

7.5 International Commission on Radiological Protection. Age-Dependent Doses To Members Of The Public From Intake Of Radionuclides: Part 2 Ingestion Dose Coefficients, Oxford: Pergamon Press; ICRP Publication No. 67; (1994).

7.6 International Commission on Radiological Protection. Dose Coefficients for Intake of Radionuclides by Worker, Elsevier Science, ICRP Publication No. 68 (1995)..

7.7 International Commission on Radiological Protection. Age-Dependent Doses To Members Of The Public From Intake Of Radionuclides: Part 3 Ingestion Dose Coefficients, Elsevier Science, ICRP Publication No. 69 (1995)

7.8 International Commission on Radiological Protection. Basic Anatomical & Physiological Data For Use In Radiological Protection: The Skeleton, Elsevier Science, ICRP Publication No. 70 (1996)

7.9 International Commission on Radiological Protection. Age-Dependent Doses To The Members Of The Public From Intake Of Radionuclides Part 5, Compilation Of Ingestion And Inhalation Coefficients, ICRP Publication No. 72 (1996)

7.10 Radiological Toolbox Version 2.0. Eckerman, K.F. and Sjoreen, A.L. for the U.S. Nuclear Regulatory Commission, August 31, 2006

# ATTACHMENT A

## Ingestion ALIs

| Nuclide | Half Life | f1 | Ingestion ICRP 68 Effective ALI (µCi) | Ingestion ICRP 68 Limiting ALI (µCi) | Ingestion ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Ingestion Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|
| **Am-241** | 432.2y | 0.0005 | 6.75E+00 | 1.50E+00 | 1.50E+03 | Bone Surface | 8E-01 | Bone Surface | **1.9** |
| **Am-242** | 16.02h | 0.0005 | 4.50E+03 | 4.50E+03 | 4.50E+06 | Effective (ICRP 60) | 4E+03 | Effective (ICRP 30) | **1.1** |
| **Am-242m** | 152y | 0.0005 | 7.11E+00 | 1.53E+00 | 1.53E+03 | Bone Surface | 8E-01 | Bone Surface | **1.9** |
| **C-14** | 5730y | 1 | 2.33E+03 | 2.33E+03 | 2.33E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | **1.2** |
| **Cd-113m** | 13.6y | 0.05 | 5.87E+01 | 2.41E+01 | 2.41E+04 | Kidneys | 2E+01 | Kidneys | **1.2** |
| **Cl-36** | 3.01E5y | 1 | 1.45E+03 | 1.45E+03 | 1.45E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 0.7 |
| **Cm-242** | 162.8d | 0.0005 | 1.13E+02 | 7.11E+01 | 7.11E+04 | Bone Surface | 3E+01 | Bone Surface | **2.4** |
| **Cm-243** | 28.5y | 0.0005 | 9.00E+00 | 2.18E+00 | 2.18E+03 | Bone Surface | 1E+00 | Bone Surface | **2.2** |
| **Co-58** | 70.80d | 0.1 | 1.82E+03 | 1.82E+03 | 1.82E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 0.9 |
| **Co-58** | 70.80d | 0.05 | 1.93E+03 | 1.93E+03 | 1.93E+06 | Effective (ICRP 60) | 1E+03 | Effective (ICRP 30) | **1.9** |
| **Co-60** | 5.271y | 0.1 | 3.97E+02 | 3.97E+02 | 3.97E+05 | Effective (ICRP 60) | 5E+02 | Effective (ICRP 30) | 0.8 |
| **Co-60** | 5.271y | 0.05 | 5.40E+02 | 5.40E+02 | 5.40E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | **2.7** |
| **Cr-51** | 27.704d | 0.1 | 3.55E+04 | 3.55E+04 | 3.55E+07 | Effective (ICRP 60) | 4E+04 | Effective (ICRP 30) | 0.9 |
| **Cr-51** | 27.704d | 0.01 | 3.65E+04 | 3.65E+04 | 3.65E+07 | Effective (ICRP 60) | 4E+04 | Effective (ICRP 30) | 0.9 |
| **Cs-134** | 2.062y | 1 | 7.11E+01 | 7.11E+01 | 7.11E+04 | Effective (ICRP 60) | 7E+01 | Effective (ICRP 30) | **1.0** |
| **Cs-135** | 2.3E6y | 1 | 6.75E+02 | 6.75E+02 | 6.75E+05 | Effective (ICRP 60) | 7E+02 | Effective (ICRP 30) | 1.0 |
| **Cs-137** | 30.0y | 1 | 1.04E+02 | 1.04E+02 | 1.04E+05 | Effective (ICRP 60) | 1E+02 | Effective (ICRP 30) | **1.0** |
| **Eu-154** | 8.8y | 0.0005 | 6.75E+02 | 6.75E+02 | 6.75E+05 | Effective (ICRP 60) | 5E+02 | Effective (ICRP 30) | **1.4** |
| **Eu-155** | 4.96y | 0.0005 | 4.22E+03 | 3.86E+03 | 3.86E+06 | Lower Large Intestine | 4E+03 | Effective (ICRP 30) | 1.0 |
| **Fe-55** | 2.7y | 0.1 | 4.09E+03 | 4.09E+03 | 4.09E+06 | Effective (ICRP 60) | 9E+03 | Effective (ICRP 30) | 0.5 |
| **Fe-59** | 44.529d | 0.1 | 7.50E+02 | 7.50E+02 | 7.50E+05 | Effective (ICRP 60) | 8E+02 | Effective (ICRP 30) | 0.9 |
| **H-3** | 12.35y | 1OBT | 3.21E+04 | 3.21E+04 | 3.21E+07 | Effective (ICRP 60) | 8E+04 | Effective (ICRP 30) | 0.4 |
| **H-3** | 12.35y | 1 | 7.50E+04 | 7.50E+04 | 7.50E+07 | Effective (ICRP 60) | 8E+04 | Effective (ICRP 30) | 0.9 |
| **I-129** | 1.57E7y | 1 | 1.23E+01 | 6.43E+00 | 6.43E+03 | Thyroid | 5E+00 | Thyroid | **1.3** |
| **I-131** | 8.04d | 1 | 6.14E+01 | 3.14E+01 | 3.14E+04 | Thyroid | 3E+01 | Thyroid | **1.0** |
| **I-133** | 20.8h | 1 | 3.14E+02 | 1.65E+02 | 1.65E+05 | Thyroid | 1E+02 | Thyroid | **1.6** |
| **I-135** | 6.61h | 1 | 1.45E+03 | 8.44E+02 | 8.44E+05 | Thyroid | 8E+02 | Thyroid | **1.1** |

## ATTACHMENT A

## Ingestion ALIs

| Nuclide | Half Life | f1 | Ingestion ICRP 68 Effective ALI (µCi) | Ingestion ICRP 68 Limiting ALI (µCi) | Ingestion ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Ingestion Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|
| **Mn-54** | 312.5d | 0.1 | 1.90E+03 | 1.90E+03 | 1.90E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 1.0 |
| **Nb-93m** | 13.6y | 0.01 | 1.13E+04 | 9.00E+03 | 9.00E+06 | Lower Large Intestine | 9E+03 | LLI Wall | 1.0 |
| **Nb-94** | 2.03E4y | 0.01 | 7.94E+02 | 7.94E+02 | 7.94E+05 | Effective (ICRP 60) | 9E+02 | Effective (ICRP 30) | 0.9 |
| **Nb-95** | 35.15d | 0.01 | 2.33E+03 | 2.33E+03 | 2.33E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | **1.2** |
| **Ni-59** | 7.5E4y | 0.05 | 2.14E+04 | 2.14E+04 | 2.14E+07 | Effective (ICRP 60) | 2E+04 | Effective (ICRP 30) | **1.1** |
| **Ni-63** | 96y | 0.05 | 9.00E+03 | 9.00E+03 | 9.00E+06 | Effective (ICRP 60) | 9E+03 | Effective (ICRP 30) | 1.0 |
| **Np-237** | 2.14E6y | 0.0005 | 1.23E+01 | 2.50E+00 | 2.50E+03 | Bone Surface | 5E-01 | Bone Surface | 5.0 |
| **Pm-147** | 2.6234y | 0.0005 | 5.19E+03 | 4.22E+03 | 4.22E+06 | Lower Large Intestine | 4E+03 | LLI Wall | **1.1** |
| **Pu-238** | 87.74y | 0.0005 | 5.87E+00 | 1.82E+00 | 1.82E+03 | Bone Surface | 9E-01 | Bone Surface | **2.0** |
| **Pu-238** | 87.74y | 0.00001 | 1.53E+02 | 9.00E+01 | 9.00E+04 | Bone Surface | 9E-01 | Bone Surface | **100.0** |
| **Pu-238** | 87.74y | 0.0001 | 2.76E+01 | 9.00E+00 | 9.00E+03 | Bone Surface | 9E-01 | Bone Surface | **10.0** |
| **Pu-239** | 24065y | 0.0005 | 5.40E+00 | 1.65E+00 | 1.65E+03 | Bone Surface | 8E-01 | Bone Surface | **2.1** |
| **Pu-239** | 24065y | 0.00001 | 1.50E+02 | 8.44E+01 | 8.44E+04 | Bone Surface | 8E-01 | Bone Surface | **105.5** |
| **Pu-239** | 24065y | 0.0001 | 2.55E+01 | 8.44E+00 | 8.44E+03 | Bone Surface | 8E-01 | Bone Surface | **10.5** |
| **Pu-240** | 6537y | 0.0005 | 5.40E+00 | 1.65E+00 | 1.65E+03 | Bone Surface | 8E-01 | Bone Surface | **2.1** |
| **Pu-240** | 6537y | 0.00001 | 1.50E+02 | 8.44E+01 | 8.44E+04 | Bone Surface | 8E-01 | Bone Surface | **105.5** |
| **Pu-240** | 6537y | 0.0001 | 2.55E+01 | 8.44E+00 | 8.44E+03 | Bone Surface | 8E-01 | Bone Surface | **10.5** |
| **Pu-241** | 14.4y | 0.0005 | 2.87E+02 | 8.44E+01 | 8.44E+04 | Bone Surface | 4E+01 | Bone Surface | **2.1** |
| **Pu-241** | 14.4y | 0.00001 | 1.23E+04 | 4.09E+03 | 4.09E+06 | Bone Surface | 4E+01 | Bone Surface | **102.3** |
| **Pu-241** | 14.4y | 0.0001 | 1.41E+03 | 4.09E+02 | 4.09E+05 | Bone Surface | 4E+01 | Bone Surface | **10.2** |
| **Pu-242** | 3.763E5y | 0.0005 | 5.63E+00 | 1.73E+00 | 1.73E+03 | Bone Surface | 8E-01 | Bone Surface | **2.2** |
| **Pu-242** | 3.763E5y | 0.00001 | 1.57E+02 | 8.44E+01 | 8.44E+04 | Bone Surface | 8E-01 | Bone Surface | **105.5** |
| **Pu-242** | 3.763E5y | 0.0001 | 2.70E+01 | 8.44E+00 | 8.44E+03 | Bone Surface | 8E-01 | Bone Surface | **10.5** |
| **Ru-103** | 39.28d | 0.05 | 1.85E+03 | 1.85E+03 | 1.85E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 0.9 |
| **Ru-106** | 368.2d | 0.05 | 1.93E+02 | 1.90E+02 | 1.90E+05 | Lower Large Intestine | 2E+02 | LLI Wall | 1.0 |
| **Sb-124** | 60.20d | 0.1 | 5.40E+02 | 5.40E+02 | 5.40E+05 | Effective (ICRP 60) | 5E+02 | Effective (ICRP 30) | **1.1** |
| **Sb-125** | 2.77y | 0.1 | 1.23E+03 | 1.23E+03 | 1.23E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 0.6 |

# ATTACHMENT A

## Ingestion ALIs

| Nuclide | Half Life | f1 | Ingestion ICRP 68 Effective ALI (µCi) | Ingestion ICRP 68 Limiting ALI (µCi) | Ingestion ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Ingestion Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|
| **Sm-151** | 90y | 0.0005 | 1.38E+04 | 1.35E+04 | 1.35E+07 | Lower Large Intestine | 1E+04 | LLI Wall | **1.4** |
| **Sn-121** | 27.06h | 0.02 | 5.87E+03 | 5.63E+03 | 5.63E+06 | Lower Large Intestine | 6E+03 | LLI Wall | 0.9 |
| **Sn-121m** | 55y | 0.02 | 3.55E+03 | 3.00E+03 | 3.00E+06 | Lower Large Intestine | 3E+03 | LLI Wall | 1.0 |
| **Sr-89** | 50.5d | 0.3 | 5.19E+02 | 5.19E+02 | 5.19E+05 | Effective (ICRP 60) | 6E+02 | LLI Wall | 0.9 |
| **Sr-89** | 50.5d | 0.01 | 5.87E+02 | 4.66E+02 | 4.66E+05 | Lower Large Intestine | 5E+02 | Effective (ICRP 30) | 0.9 |
| **Sr-90** | 29.12y | 0.3 | 4.82E+01 | 3.29E+01 | 3.29E+04 | Bone Surface | 3E+01 | Bone Surface | **1.1** |
| **Sr-90** | 29.12y | 0.01 | 5.00E+02 | 5.00E+02 | 5.00E+05 | Effective (ICRP 60) | 3E+01 | Bone Surface | **16.7** |
| **Tc-99** | 2.13E5y | 0.8 | 1.73E+03 | 1.73E+03 | 1.73E+06 | Effective (ICRP 60) | 4E+03 | Effective (ICRP 30) | 0.4 |
| **Te-125m** | 58d | 0.3 | 1.55E+03 | 6.75E+02 | 6.75E+05 | Bone Surface | 1E+03 | Bone Surface | 0.7 |
| **Th-232** | 1.405E10y | 0.0005 | 6.14E+00 | 1.13E+00 | 1.13E+03 | Bone Surface | 7E-01 | Bone Surface | **1.6** |
| **Th-232** | 1.405E10y | 0.0002 | 1.47E+01 | 2.87E+00 | 2.87E+03 | Bone Surface | 7E-01 | Bone Surface | **4.1** |
| **Th-234** | 24.10d | 0.0005 | 3.97E+02 | 3.14E+02 | 3.14E+05 | Lower Large Intestine | 3E+02 | LLI Wall | **1.0** |
| **Th-234** | 24.10d | 0.0002 | 3.97E+02 | 3.14E+02 | 3.14E+05 | Lower Large Intestine | 3E+02 | LLI Wall | **1.0** |
| **U-233** | 1.585E5y | 0.02 | 2.70E+01 | 1.63E+01 | 1.63E+04 | Bone Surface | 1E+01 | Bone Surface | **1.6** |
| **U-233** | 1.585E5y | 0.002 | 1.59E+02 | 1.59E+02 | 1.59E+05 | Effective (ICRP 60) | 1E+01 | Bone Surface | **15.9** |
| **U-234** | 2.445E5y | 0.02 | 2.76E+01 | 1.73E+01 | 1.73E+04 | Bone Surface | 1E+01 | Bone Surface | **1.7** |
| **U-234** | 2.445E5y | 0.002 | 1.63E+02 | 1.63E+02 | 1.63E+05 | Effective (ICRP 60) | 1E+01 | Bone Surface | **16.3** |
| **U-235** | 703.8E6y | 0.02 | 2.93E+01 | 1.82E+01 | 1.82E+04 | Bone Surface | 1E+01 | Bone Surface | **1.8** |
| **U-235** | 703.8E6y | 0.002 | 1.63E+02 | 1.63E+02 | 1.63E+05 | Effective (ICRP 60) | 1E+01 | Bone Surface | **16.3** |
| **U-236** | 2.3415E7y | 0.02 | 2.93E+01 | 1.82E+01 | 1.82E+04 | Bone Surface | 1E+01 | Bone Surface | **1.8** |
| **U-236** | 2.3415E7y | 0.002 | 1.71E+02 | 1.71E+02 | 1.71E+05 | Effective (ICRP 60) | 1E+01 | Bone Surface | **17.1** |
| **U-238** | 4.468E9y | 0.02 | 3.07E+01 | 1.90E+01 | 1.90E+04 | Bone Surface | 1E+01 | Bone Surface | **1.9** |
| **U-238** | 4.468E9y | 0.002 | 1.78E+02 | 1.78E+02 | 1.78E+05 | Effective (ICRP 60) | 1E+01 | Effective (ICRP 30) | |
| **Y-90** | 64.0h | 0.0001 | 5.00E+02 | 4.35E+02 | 4.35E+05 | Lower Large Intestine | 4E+02 | LLI Wall | **1.1** |
| **Zr-93** | 1.53E6y | 0.002 | 4.82E+03 | 1.23E+03 | 1.23E+06 | Bone Surface | 1E+03 | Bone Surface | **1.2** |
| **Zr-95** | 63.98d | 0.002 | 1.53E+03 | 1.53E+03 | 1.53E+06 | Effective (ICRP 60) | 1E+03 | Effective (ICRP 30) | **1.5** |

## ATTACHMENT B

## Inhalation ALIs

| Nuclide | Half Life | Type | AMAD | f1 | Inhalation ICRP 68 Effective ALI (µCi) | Inhalation ICRP 68 Limiting ALI (µCi) | Inhalation ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Inhalation Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Am-241** | 432.2y | M | 5 | 0.0005 | 5.00E-02 | 1.2E-02 | 1.23E+01 | Bone Surface | 6E-03 | Bone Surface | **2.0** |
| **Am-242** | 16.02h | M | 5 | 0.0005 | 1.13E+02 | 1.1E+02 | 1.13E+05 | Effective (ICRP 60) | 8E+01 | Bone Surface | **1.4** |
| **Am-242m** | 152y | M | 5 | 0.0005 | 5.63E-02 | 1.2E-02 | 1.23E+01 | Bone Surface | 6E-03 | Bone Surface | **2.0** |
| **Am-243** | 7380y | M | 5 | 0.0005 | 5.00E-02 | 1.2E-02 | 1.23E+01 | Bone Surface | 6E-03 | Bone Surface | **2.0** |
| **C-14** | 5730y | V | 5 | 1 CO2 | 2.08E+05 | 2.1E+05 | 2.08E+08 | Effective (ICRP 60) | 2E+05 | Effective (ICRP 30) | **1.0** |
| **C-14** | 5730y | V | 5 | 1 CO | 1.69E+06 | 1.7E+06 | 1.69E+09 | Effective (ICRP 60) | 2E+06 | Effective (ICRP 30) | 0.8 |
| **C-14** | 5730y | V | 5 | 1 CH4 | 4.66E+05 | 4.7E+05 | 4.66E+08 | Effective (ICRP 60) | 2E+05 | Effective (ICRP 30) | **2.3** |
| **C-14** | 5730y | V | 5 | 1 | 2.33E+03 | 2.3E+03 | 2.33E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | **1.2** |
| **Cd-113m** | 13.6y | F | 5 | 0.05 | 1.04E+01 | 4.1E+00 | 4.09E+03 | Kidneys | 2E+00 | Kidneys | **2.0** |
| **Cd-113m** | 13.6y | M | 5 | 0.05 | 3.38E+01 | 1.5E+01 | 1.47E+04 | Kidneys | 8E+00 | Kidneys | **1.8** |
| **Cd-113m** | 13.6y | S | 5 | 0.05 | 5.63E+01 | 4.2E+01 | 4.22E+04 | Kidneys | 1E+01 | Effective (ICRP 30) | **4.2** |
| **Cl-36** | 3.01E5y | F | 5 | 1 | 2.76E+03 | 2.8E+03 | 2.76E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | **1.4** |
| **Cl-36** | 3.01E5y | M | 5 | 1 | 2.65E+02 | 2.6E+02 | 2.65E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | **1.3** |
| **Cm-242** | 162.8d | M | 5 | 0.0005 | 3.65E-01 | 3.6E-01 | 3.65E+02 | Effective (ICRP 60) | 3E-01 | Bone Surface | **1.2** |
| **Cm-243** | 28.5y | M | 5 | 0.0005 | 6.75E-02 | 1.8E-02 | 1.80E+01 | Bone Surface | 9E-03 | Bone Surface | **2.0** |
| **Cm-244** | 18.11y | M | 5 | 0.0005 | 7.94E-02 | 2.3E-02 | 2.25E+01 | Bone Surface | 1E-02 | Bone Surface | **2.3** |
| **Co-58** | 70.80d | M | 5 | 0.1 | 9.64E+02 | 9.6E+02 | 9.64E+05 | Effective (ICRP 60) | 1E+03 | Effective (ICRP 30) | 1.0 |
| **Co-58** | 70.80d | S | 5 | 0.05 | 7.94E+02 | 7.9E+02 | 7.94E+05 | Effective (ICRP 60) | 7E+02 | Effective (ICRP 30) | **1.1** |
| **Co-60** | 5.271y | M | 5 | 0.1 | 1.90E+02 | 1.9E+02 | 1.90E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | 1.0 |
| **Co-60** | 5.271y | S | 5 | 0.05 | 7.94E+01 | 7.9E+01 | 7.94E+04 | Effective (ICRP 60) | 3E+01 | Effective (ICRP 30) | **2.6** |
| **Cr-51** | 27.704d | F | 5 | 0.1 | 4.50E+04 | 4.5E+04 | 4.50E+07 | Effective (ICRP 60) | 5E+04 | Effective (ICRP 30) | 0.9 |
| **Cr-51** | 27.704d | M | 5 | 0.1 | 3.97E+04 | 4.0E+04 | 3.97E+07 | Effective (ICRP 60) | 2E+04 | Effective (ICRP 30) | **2.0** |
| **Cr-51** | 27.704d | S | 5 | 0.1 | 3.75E+04 | 3.8E+04 | 3.75E+07 | Effective (ICRP 60) | 2E+04 | Effective (ICRP 30) | **1.9** |
| **Cs-134** | 2.062y | F | 5 | 1 | 1.41E+02 | 1.4E+02 | 1.41E+05 | Effective (ICRP 60) | 1E+02 | Effective (ICRP 30) | **1.4** |
| **Cs-135** | 2.3E6y | F | 5 | 1 | 1.36E+03 | 1.4E+03 | 1.36E+06 | Effective (ICRP 60) | 1E+03 | Effective (ICRP 30) | **1.4** |
| **Cs-137** | 30.0y | F | 5 | 1 | 2.01E+02 | 2.0E+02 | 2.01E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | **1.0** |
| **Eu-154** | 8.8y | M | 5 | 0.0005 | 3.86E+01 | 3.9E+01 | 3.86E+04 | Effective (ICRP 60) | 2E+01 | Effective (ICRP 30) | **1.9** |

## ATTACHMENT B

# Inhalation ALIs

| Nuclide | Half Life | Type | AMAD | f1 | Inhalation ICRP 68 Effective ALI (µCi) | Inhalation ICRP 68 Limiting ALI (µCi) | Inhalation ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Inhalation Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Eu-155** | 4.96y | M | 5 | 0.0005 | 2.87E+02 | 1.8E+02 | 1.75E+05 | Bone Surface | 9E+01 | Bone Surface | **1.9** |
| **Fe-55** | 2.7y | F | 5 | 0.1 | 1.47E+03 | 1.5E+03 | 1.47E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 0.7 |
| **Fe-55** | 2.7y | M | 5 | 0.1 | 4.09E+03 | 4.1E+03 | 4.09E+06 | Effective (ICRP 60) | 4E+03 | Effective (ICRP 30) | **1.0** |
| **Fe-59** | 44.529d | F | 5 | 0.1 | 4.50E+02 | 4.5E+02 | 4.50E+05 | Effective (ICRP 60) | 3E+02 | Effective (ICRP 30) | **1.5** |
| **Fe-59** | 44.529d | M | 5 | 0.1 | 4.22E+02 | 4.2E+02 | 4.22E+05 | Effective (ICRP 60) | 5E+02 | Effective (ICRP 30) | 0.8 |
| **H-3** | 12.35y | V | 5 | 1 OBT | 3.29E+04 | 3.3E+04 | 3.29E+07 | Effective (ICRP 60) | 8E+04 | Effective (ICRP 30) | 0.4 |
| **H-3** | 12.35y | V | 5 | 1 HT | 7.50E+08 | 7.5E+08 | 7.50E+11 | Effective (ICRP 60) | 8E+04 | Effective (ICRP 30) | **9375.0** |
| **H-3** | 12.35y | V | 5 | 1 CH3T | 7.50E+06 | 7.5E+06 | 7.50E+09 | Effective (ICRP 60) | 8E+04 | Effective (ICRP 30) | **93.8** |
| **H-3** | 12.35y | V | 5 | 1 HTO | 7.50E+04 | 7.5E+04 | 7.50E+07 | Effective (ICRP 60) | 8E+04 | Effective (ICRP 30) | 0.9 |
| **I-129** | 1.57E7y | V | 5 | 1 CH3I | 1.82E+01 | 9.0E+00 | 9.00E+03 | Thyroid | 9E+00 | Thyroid | 1.0 |
| **I-129** | 1.57E7y | V | 5 | 1 I2 | 1.41E+01 | 7.1E+00 | 7.11E+03 | Thyroid | 9E+00 | Thyroid | 0.8 |
| **I-129** | 1.57E7y | F | 5 | 1 | 2.65E+01 | 1.4E+01 | 1.35E+04 | Thyroid | 9E+00 | Thyroid | **1.5** |
| **I-131** | 8.04d | V | 5 | 1 CH3I | 9.00E+01 | 4.4E+01 | 4.35E+04 | Thyroid | 5E+01 | Thyroid | 0.9 |
| **I-131** | 8.04d | V | 5 | 1 I2 | 6.75E+01 | 3.5E+01 | 3.46E+04 | Thyroid | 5E+01 | Thyroid | 0.7 |
| **I-131** | 8.04d | F | 5 | 1 | 1.23E+02 | 6.4E+01 | 6.43E+04 | Thyroid | 5E+01 | Thyroid | **1.3** |
| **I-133** | 20.8h | V | 5 | 1 CH3I | 4.35E+02 | 2.3E+02 | 2.25E+05 | Thyroid | 3E+02 | Thyroid | 0.8 |
| **I-133** | 20.8h | V | 5 | 1 I2 | 3.38E+02 | 1.8E+02 | 1.78E+05 | Thyroid | 3E+02 | Thyroid | 0.6 |
| **I-133** | 20.8h | F | 5 | 1 | 6.43E+02 | 3.4E+02 | 3.38E+05 | Thyroid | 3E+02 | Thyroid | **1.1** |
| **I-135** | 6.61h | V | 5 | 1 CH3I | 1.99E+03 | 1.0E+03 | 1.04E+06 | Thyroid | 2E+03 | Thyroid | 0.5 |
| **I-135** | 6.61h | V | 5 | 1 I2 | 1.47E+03 | 9.0E+02 | 9.00E+05 | Thyroid | 2E+03 | Thyroid | 0.5 |
| **I-135** | 6.61h | F | 5 | 1 | 2.93E+03 | 1.7E+03 | 1.67E+06 | Thyroid | 2E+03 | Thyroid | 0.8 |
| **Mn-54** | 312.5d | F | 5 | 0.1 | 1.23E+03 | 1.2E+03 | 1.23E+06 | Effective (ICRP 60) | 9E+02 | Effective (ICRP 30) | **1.4** |
| **Mn-54** | 312.5d | M | 5 | 0.1 | 1.13E+03 | 1.1E+03 | 1.13E+06 | Effective (ICRP 60) | 8E+02 | Effective (ICRP 30) | **1.4** |
| **Nb-93m** | 13.6y | M | 5 | 0.01 | 4.66E+03 | 4.7E+03 | 4.66E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | **2.3** |
| **Nb-93m** | 13.6y | S | 5 | 0.01 | 1.57E+03 | 1.6E+03 | 1.57E+06 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | **7.8** |
| **Nb-94** | 2.03E4y | M | 5 | 0.01 | 1.88E+02 | 1.9E+02 | 1.88E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | 0.9 |
| **Nb-94** | 2.03E4y | S | 5 | 0.01 | 5.40E+01 | 5.4E+01 | 5.40E+04 | Effective (ICRP 60) | 2E+01 | Effective (ICRP 30) | **2.7** |

## ATTACHMENT B

## Inhalation ALIs

| Nuclide | Half Life | Type | AMAD | f1 | Inhalation ICRP 68 Effective ALI (µCi) | Inhalation ICRP 68 Limiting ALI (µCi) | Inhalation ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Inhalation Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Nb-95** | 35.15d | M | 5 | 0.01 | 1.04E+03 | 1.0E+03 | 1.04E+06 | Effective (ICRP 60) | 1E+03 | Effective (ICRP 30) | **1.0** |
| **Nb-95** | 35.15d | S | 5 | 0.01 | 1.04E+03 | 1.0E+03 | 1.04E+06 | Effective (ICRP 60) | 1E+03 | Effective (ICRP 30) | **1.0** |
| **Ni-59** | 7.5E4y | V | 5 | 0.05 | 1.63E+03 | 1.6E+03 | 1.63E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 0.8 |
| **Ni-59** | 7.5E4y | F | 5 | 0.05 | 6.14E+03 | 6.1E+03 | 6.14E+06 | Effective (ICRP 60) | 4E+03 | Effective (ICRP 30) | **1.5** |
| **Ni-59** | 7.5E4y | M | 5 | 0.05 | 1.44E+04 | 1.4E+04 | 1.44E+07 | Effective (ICRP 60) | 7E+03 | Effective (ICRP 30) | **2.1** |
| **Ni-63** | 96y | V | 5 | 0.05 | 6.75E+02 | 6.8E+02 | 6.75E+05 | Effective (ICRP 60) | 8E+02 | Effective (ICRP 30) | 0.8 |
| **Ni-63** | 96y | F | 5 | 0.05 | 2.60E+03 | 2.6E+03 | 2.60E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | **1.3** |
| **Ni-63** | 96y | M | 5 | 0.05 | 4.35E+03 | 4.4E+03 | 4.35E+06 | Effective (ICRP 60) | 3E+03 | Effective (ICRP 30) | **1.5** |
| **Np-237** | 2.14E6y | M | 5 | 0.0005 | 9.00E-02 | 2.0E-02 | 2.01E+01 | Bone Surface | 4E-03 | Bone Surface | **5.0** |
| **Pm-147** | 2.6234y | M | 5 | 0.0005 | 3.86E+02 | 2.6E+02 | 2.65E+05 | Bone Surface | 1E+02 | Bone Surface | **2.6** |
| **Pm-147** | 2.6234y | S | 5 | 0.0005 | 4.22E+02 | 4.2E+02 | 4.22E+05 | Effective (ICRP 60) | 1E+02 | Effective (ICRP 30) | **4.2** |
| **Pu-238** | 87.74y | M | 5 | 0.0005 | 4.50E-02 | 1.5E-02 | 1.48E+01 | Bone Surface | 7E-03 | Bone Surface | **2.1** |
| **Pu-238** | 87.74y | S | 5 | 1E-05 | 1.23E-01 | 1.2E-01 | 1.23E+02 | Effective (ICRP 60) | 2E-02 | Effective (ICRP 30) | **6.1** |
| **Pu-239** | 24065y | M | 5 | 0.0005 | 4.22E-02 | 1.4E-02 | 1.35E+01 | Bone Surface | 6E-03 | Bone Surface | **2.3** |
| **Pu-239** | 24065y | S | 5 | 1E-05 | 1.63E-01 | 1.5E-01 | 1.48E+02 | Bone Surface | 2E-02 | Bone Surface | **7.4** |
| **Pu-240** | 6537y | M | 5 | 0.0005 | 4.22E-02 | 1.4E-02 | 1.35E+01 | Bone Surface | 6E-03 | Bone Surface | **2.3** |
| **Pu-240** | 6537y | S | 5 | 1E-05 | 1.63E-01 | 1.5E-01 | 1.48E+02 | Bone Surface | 2E-02 | Bone Surface | **7.4** |
| **Pu-241** | 14.4y | M | 5 | 0.0005 | 2.33E+00 | 6.8E-01 | 6.75E+02 | Bone Surface | 3E-01 | Bone Surface | **2.3** |
| **Pu-241** | 14.4y | S | 5 | 1E-05 | 1.61E+01 | 6.8E+00 | 6.75E+03 | Bone Surface | 8E-01 | Bone Surface | **8.4** |
| **Pu-242** | 3.763E5y | M | 5 | 0.0005 | 4.35E-02 | 1.4E-02 | 1.41E+01 | Bone Surface | 7E-03 | Bone Surface | **2.0** |
| **Pu-242** | 3.763E5y | S | 5 | 1E-05 | 1.75E-01 | 1.6E-01 | 1.57E+02 | Bone Surface | 2E-02 | Bone Surface | **7.8** |
| **Ru-103** | 39.28d | V | 5 | 0.05 | 1.23E+03 | 1.2E+03 | 1.23E+06 | Effective (ICRP 60) | 6E+02 | Effective (ICRP 30) | **2.0** |
| **Ru-103** | 39.28d | F | 5 | 0.05 | 1.99E+03 | 2.0E+03 | 1.99E+06 | Effective (ICRP 60) | 2E+03 | Effective (ICRP 30) | 1.0 |
| **Ru-103** | 39.28d | M | 5 | 0.05 | 7.11E+02 | 7.1E+02 | 7.11E+05 | Effective (ICRP 60) | 1E+03 | Effective (ICRP 30) | 0.7 |
| **Ru-103** | 39.28d | S | 5 | 0.05 | 6.14E+02 | 6.1E+02 | 6.14E+05 | Effective (ICRP 60) | 6E+02 | Effective (ICRP 30) | **1.0** |
| **Ru-106** | 368.2d | V | 5 | 0.05 | 7.50E+01 | 7.5E+01 | 7.50E+04 | Effective (ICRP 60) | 1E+01 | Effective (ICRP 30) | **7.5** |
| **Ru-106** | 368.2d | F | 5 | 0.05 | 1.38E+02 | 1.4E+02 | 1.38E+05 | Effective (ICRP 60) | 9E+01 | Effective (ICRP 30) | **1.5** |

## ATTACHMENT B

# Inhalation ALIs

| Nuclide | Half Life | Type | AMAD | f1 | Inhalation ICRP 68 Effective ALI (µCi) | Inhalation ICRP 68 Limiting ALI (µCi) | Inhalation ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Inhalation Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ru-106** | 368.2d | M | 5 | 0.05 | 7.94E+01 | 7.9E+01 | 7.94E+04 | Effective (ICRP 60) | 5E+01 | Effective (ICRP 30) | **1.6** |
| **Ru-106** | 368.2d | S | 5 | 0.05 | 3.86E+01 | 3.9E+01 | 3.86E+04 | Effective (ICRP 60) | 1E+01 | Effective (ICRP 30) | **3.9** |
| **Sb-124** | 60.20d | F | 5 | 0.1 | 7.11E+02 | 7.1E+02 | 7.11E+05 | Effective (ICRP 60) | 9E+02 | Effective (ICRP 30) | **0.8** |
| **Sb-124** | 60.20d | M | 5 | 0.01 | 2.87E+02 | 2.9E+02 | 2.87E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | **1.4** |
| **Sb-125** | 2.77y | F | 5 | 0.1 | 7.94E+02 | 5.0E+02 | 5.00E+05 | Bone Surface | 2E+03 | Effective (ICRP 30) | 0.3 |
| **Sb-125** | 2.77y | M | 5 | 0.01 | 4.09E+02 | 4.1E+02 | 4.09E+05 | Effective (ICRP 60) | 5E+02 | Effective (ICRP 30) | 0.8 |
| **Sm-151** | 90y | M | 5 | 0.0005 | 5.19E+02 | 1.9E+02 | 1.90E+05 | Bone Surface | 1E+02 | Bone Surface | **1.9** |
| **Sn-121** | 27.06h | F | 5 | 0.02 | 1.35E+04 | 1.1E+04 | 1.13E+07 | Extrathoracic Airways | 2E+04 | Effective (ICRP 30) | 0.6 |
| **Sn-121** | 27.06h | M | 5 | 0.02 | 4.82E+03 | 4.8E+03 | 4.82E+06 | Effective (ICRP 60) | 1E+04 | Effective (ICRP 30) | 0.5 |
| **Sn-121m** | 55y | F | 5 | 0.02 | 1.39E+03 | 1.4E+03 | 1.39E+06 | Effective (ICRP 60) | 9E+02 | Effective (ICRP 30) | **1.5** |
| **Sn-121m** | 55y | M | 5 | 0.02 | 4.09E+02 | 4.1E+02 | 4.09E+05 | Effective (ICRP 60) | 5E+02 | Effective (ICRP 30) | 0.8 |
| **Sr-89** | 50.5d | F | 5 | 0.3 | 9.64E+02 | 9.6E+02 | 9.64E+05 | Effective (ICRP 60) | 8E+02 | Effective (ICRP 30) | **1.2** |
| **Sr-89** | 50.5d | S | 5 | 0.01 | 2.41E+02 | 2.4E+02 | 2.41E+05 | Effective (ICRP 60) | 1E+02 | Effective (ICRP 30) | **2.4** |
| **Sr-90** | 29.12y | F | 5 | 0.3 | 4.50E+01 | 2.9E+01 | 2.93E+04 | Bone Surface | 2E+01 | Bone Surface | **1.5** |
| **Sr-90** | 29.12y | S | 5 | 0.01 | 1.75E+01 | 1.8E+01 | 1.75E+04 | Effective (ICRP 60) | 4E+00 | Effective (ICRP 30) | **4.4** |
| **Tc-99** | 2.13E5y | F | 5 | 0.8 | 3.38E+03 | 3.4E+03 | 3.38E+06 | Effective (ICRP 60) | 5E+03 | Stomach Wall | 0.7 |
| **Tc-99** | 2.13E5y | M | 5 | 0.8 | 4.22E+02 | 4.2E+02 | 4.22E+05 | Effective (ICRP 60) | 7E+02 | Effective (ICRP 30) | 0.6 |
| **Te-125m** | 58d | V | 5 | 0.3 | 9.00E+02 | 2.5E+02 | 2.50E+05 | Bone Surface | 7E+02 | Bone Surface | 0.4 |
| **Te-125m** | 58d | F | 5 | 0.3 | 2.01E+03 | 6.1E+02 | 6.14E+05 | Bone Surface | 4E+02 | Bone Surface | **1.5** |
| **Te-125m** | 58d | M | 5 | 0.3 | 4.66E+02 | 4.7E+02 | 4.66E+05 | Effective (ICRP 60) | 7E+02 | Effective (ICRP 30) | 0.7 |
| **Th-232** | 1.405E10y | M | 5 | 0.0005 | 4.66E-02 | 9.0E-03 | 9.00E+00 | Bone Surface | 1E-03 | Bone Surface | **9.0** |
| **Th-232** | 1.405E10y | S | 5 | 0.0002 | 1.13E-01 | 9.6E-02 | 9.64E+01 | Bone Surface | 3E-03 | Bone Surface | **32.1** |
| **Th-234** | 24.10d | M | 5 | 0.0005 | 2.55E+02 | 2.5E+02 | 2.55E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | **1.3** |
| **Th-234** | 24.10d | S | 5 | 0.0002 | 2.33E+02 | 2.3E+02 | 2.33E+05 | Effective (ICRP 60) | 2E+02 | Effective (ICRP 30) | **1.2** |
| **U-233** | 1.585E5y | F | 5 | 0.02 | 2.05E+00 | 1.1E+00 | 1.13E+03 | Bone Surface | 1E+00 | Bone Surface | **1.1** |
| **U-233** | 1.585E5y | M | 5 | 0.02 | 6.14E-01 | 6.1E-01 | 6.14E+02 | Effective (ICRP 60) | 7E-01 | Effective (ICRP 30) | 0.9 |

## ATTACHMENT B

# Inhalation ALIs

| Nuclide | Half Life | Type | AMAD | f1 | Inhalation ICRP 68 Effective ALI (µCi) | Inhalation ICRP 68 Limiting ALI (µCi) | Inhalation ICRP 68 ALI (nCi) | ICRP 68 Applicable Organ | ICRP 30 10 CFR 20 Inhalation Limiting ALI (µCi) | ICRP 30 Applicable Organ | ICRP 68/30 Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **U-233** | 1.585E5y | S | 5 | 0.002 | 1.96E-01 | 1.8E-01 | 1.78E+02 | Extrathoracic Airways | 4E-02 | Effective (ICRP 30) | **4.4** |
| **U-234** | 2.445E5y | F | 5 | 0.02 | 2.11E+00 | 1.2E+00 | 1.23E+03 | Bone Surface | 1E+00 | Bone Surface | **1.2** |
| **U-234** | 2.445E5y | M | 5 | 0.02 | 6.43E-01 | 6.4E-01 | 6.43E+02 | Effective (ICRP 60) | 7E-01 | Effective (ICRP 30) | 0.9 |
| **U-234** | 2.445E5y | S | 5 | 0.002 | 1.99E-01 | 1.8E-01 | 1.80E+02 | Extrathoracic Airways | 4E-02 | Effective (ICRP 30) | **4.5** |
| **U-235** | 703.8E6y | F | 5 | 0.02 | 2.25E+00 | 1.2E+00 | 1.23E+03 | Bone Surface | 1E+00 | Bone Surface | **1.2** |
| **U-235** | 703.8E6y | M | 5 | 0.02 | 7.50E-01 | 7.5E-01 | 7.50E+02 | Effective (ICRP 60) | 8E-01 | Effective (ICRP 30) | 0.9 |
| **U-235** | 703.8E6y | S | 5 | 0.002 | 2.21E-01 | 2.0E-01 | 1.96E+02 | Extrathoracic Airways | 4E-02 | Effective (ICRP 30) | **4.9** |
| **U-236** | 2.3415E7y | F | 5 | 0.02 | 2.21E+00 | 1.2E+00 | 1.23E+03 | Bone Surface | 1E+00 | Bone Surface | **1.2** |
| **U-236** | 2.3415E7y | M | 5 | 0.02 | 7.11E-01 | 7.1E-01 | 7.11E+02 | Effective (ICRP 60) | 8E-01 | Effective (ICRP 30) | 0.9 |
| **U-236** | 2.3415E7y | S | 5 | 0.002 | 2.14E-01 | 1.9E-01 | 1.90E+02 | Extrathoracic Airways | 4E-02 | Effective (ICRP 30) | **4.8** |
| **U-238** | 4.468E9y | F | 5 | 0.02 | 2.33E+00 | 1.4E+00 | 1.35E+03 | Bone Surface | 1E+00 | Bone Surface | **1.4** |
| **U-238** | 4.468E9y | M | 5 | 0.02 | 8.44E-01 | 8.4E-01 | 8.44E+02 | Effective (ICRP 60) | 8E-01 | Effective (ICRP 30) | **1.1** |
| **U-238** | 4.468E9y | S | 5 | 0.002 | 2.37E-01 | 2.1E-01 | 2.08E+02 | Extrathoracic Airways | 4E-02 | Effective (ICRP 30) | **5.2** |
| **Y-90** | 64.0h | M | 5 | 0.0001 | 8.44E+02 | 8.4E+02 | 8.44E+05 | Effective (ICRP 60) | 7E+02 | Effective (ICRP 30) | **1.2** |
| **Y-90** | 64.0h | S | 5 | 0.0001 | 7.94E+02 | 7.9E+02 | 7.94E+05 | Effective (ICRP 60) | 6E+02 | Effective (ICRP 30) | **1.3** |
| **Zr-93** | 1.53E6y | F | 5 | 0.002 | 4.66E+01 | 9.0E+00 | 9.00E+03 | Bone Surface | 6E+00 | Bone Surface | **1.5** |
| **Zr-93** | 1.53E6y | M | 5 | 0.002 | 2.05E+02 | 4.1E+01 | 4.09E+04 | Bone Surface | 2E+01 | Bone Surface | **2.0** |
| **Zr-93** | 1.53E6y | S | 5 | 0.002 | 7.94E+02 | 3.6E+02 | 3.65E+05 | Bone Surface | 6E+01 | Bone Surface | **6.1** |
| **Zr-95** | 63.98d | F | 5 | 0.002 | 4.50E+02 | 2.2E+02 | 2.18E+05 | Bone Surface | 1E+02 | Bone Surface | **2.2** |
| **Zr-95** | 63.98d | M | 5 | 0.002 | 3.75E+02 | 3.8E+02 | 3.75E+05 | Effective (ICRP 60) | 4E+02 | Effective (ICRP 30) | 0.9 |
| **Zr-95** | 63.98d | S | 5 | 0.002 | 3.21E+02 | 3.2E+02 | 3.21E+05 | Effective (ICRP 60) | 3E+02 | Effective (ICRP 30) | **1.1** |

## ATTACHMENT C

# Inhalation DACs

| Nuclide | Half Life | Type | AMAD | f1 | Limiting DAC (µCi/cc) |
|---|---|---|---|---|---|
| Am-241 | 432.2y | M | 5 | 0.0005 | 5.11E-12 |
| Am-242 | 16.02h | M | 5 | 0.0005 | 4.69E-08 |
| Am-242m | 152y | M | 5 | 0.0005 | 5.11E-12 |
| Am-243 | 7380y | M | 5 | 0.0005 | 5.11E-12 |
| C-14 | 5730y | V | 5 | 1 CO2 | 8.65E-05 |
| C-14 | 5730y | V | 5 | 1 CO | 7.03E-04 |
| C-14 | 5730y | V | 5 | 1 CH4 | 1.94E-04 |
| C-14 | 5730y | V | 5 | 1 | 9.70E-07 |
| Cd-113m | 13.6y | F | 5 | 0.05 | 1.70E-09 |
| Cd-113m | 13.6y | M | 5 | 0.05 | 6.11E-09 |
| Cd-113m | 13.6y | S | 5 | 0.05 | 1.76E-08 |
| Cl-36 | 3.01E5y | F | 5 | 1 | 1.15E-06 |
| Cl-36 | 3.01E5y | M | 5 | 1 | 1.10E-07 |
| Cm-242 | 162.8d | M | 5 | 0.0005 | 1.52E-10 |
| Cm-243 | 28.5y | M | 5 | 0.0005 | 7.50E-12 |
| Cm-244 | 18.11y | M | 5 | 0.0005 | 9.38E-12 |
| Co-58 | 70.80d | M | 5 | 0.1 | 4.02E-07 |
| Co-58 | 70.80d | S | 5 | 0.05 | 3.31E-07 |
| Co-60 | 5.271y | M | 5 | 0.1 | 7.92E-08 |
| Co-60 | 5.271y | S | 5 | 0.05 | 3.31E-08 |
| Cr-51 | 27.704d | F | 5 | 0.1 | 1.88E-05 |
| Cr-51 | 27.704d | M | 5 | 0.1 | 1.65E-05 |
| Cr-51 | 27.704d | S | 5 | 0.1 | 1.56E-05 |
| Cs-134 | 2.062y | F | 5 | 1 | 5.86E-08 |
| Cs-135 | 2.3E6y | F | 5 | 1 | 5.68E-07 |
| Cs-137 | 30.0y | F | 5 | 1 | 8.40E-08 |
| Eu-154 | 8.8y | M | 5 | 0.0005 | 1.61E-08 |
| Eu-155 | 4.96y | M | 5 | 0.0005 | 7.31E-08 |
| Fe-55 | 2.7y | F | 5 | 0.1 | 6.11E-07 |
| Fe-55 | 2.7y | M | 5 | 0.1 | 1.70E-06 |
| Fe-59 | 44.529d | F | 5 | 0.1 | 1.88E-07 |
| Fe-59 | 44.529d | M | 5 | 0.1 | 1.76E-07 |
| H-3 | 12.35y | V | 5 | 1 OBT | 1.37E-05 |
| H-3 | 12.35y | V | 5 | 1 HT | 3.13E-01 |
| H-3 | 12.35y | V | 5 | 1 CH3T | 3.13E-03 |
| H-3 | 12.35y | V | 5 | 1 HTO | 3.13E-05 |
| I-129 | 1.57E7y | V | 5 | 1 CH3I | 3.75E-09 |
| I-129 | 1.57E7y | V | 5 | 1 I2 | 2.96E-09 |
| I-129 | 1.57E7y | F | 5 | 1 | 5.63E-09 |
| I-131 | 8.04d | V | 5 | 1 CH3I | 1.81E-08 |
| I-131 | 8.04d | V | 5 | 1 I2 | 1.44E-08 |
| I-131 | 8.04d | F | 5 | 1 | 2.68E-08 |
| I-133 | 20.8h | V | 5 | 1 CH3I | 9.38E-08 |

## ATTACHMENT C

# Inhalation DACs

| Nuclide | Half Life | Type | AMAD | f1 | Limiting DAC (µCi/cc) |
|---|---|---|---|---|---|
| I-133 | 20.8h | V | 5 | 1 I2 | 7.40E-08 |
| I-133 | 20.8h | F | 5 | 1 | 1.41E-07 |
| I-135 | 6.61h | V | 5 | 1 CH3I | 4.33E-07 |
| I-135 | 6.61h | V | 5 | 1 I2 | 3.75E-07 |
| I-135 | 6.61h | F | 5 | 1 | 6.94E-07 |
| Mn-54 | 312.5d | F | 5 | 0.1 | 5.11E-07 |
| Mn-54 | 312.5d | M | 5 | 0.1 | 4.69E-07 |
| Nb-93m | 13.6y | M | 5 | 0.01 | 1.94E-06 |
| Nb-93m | 13.6y | S | 5 | 0.01 | 6.54E-07 |
| Nb-94 | 2.03E4y | M | 5 | 0.01 | 7.81E-08 |
| Nb-94 | 2.03E4y | S | 5 | 0.01 | 2.25E-08 |
| Nb-95 | 35.15d | M | 5 | 0.01 | 4.33E-07 |
| Nb-95 | 35.15d | S | 5 | 0.01 | 4.33E-07 |
| Ni-59 | 7.5E4y | V | 5 | 0.05 | 6.78E-07 |
| Ni-59 | 7.5E4y | F | 5 | 0.05 | 2.56E-06 |
| Ni-59 | 7.5E4y | M | 5 | 0.05 | 5.98E-06 |
| Ni-63 | 96y | V | 5 | 0.05 | 2.81E-07 |
| Ni-63 | 96y | F | 5 | 0.05 | 1.08E-06 |
| Ni-63 | 96y | M | 5 | 0.05 | 1.81E-06 |
| Np-237 | 2.14E6y | M | 5 | 0.0005 | 8.40E-12 |
| Pm-147 | 2.6234y | M | 5 | 0.0005 | 1.10E-07 |
| Pm-147 | 2.6234y | S | 5 | 0.0005 | 1.76E-07 |
| Pu-238 | 87.74y | M | 5 | 0.0005 | 6.18E-12 |
| Pu-238 | 87.74y | S | 5 | 0.00001 | 5.11E-11 |
| Pu-239 | 24065y | M | 5 | 0.0005 | 5.63E-12 |
| Pu-239 | 24065y | S | 5 | 0.00001 | 6.18E-11 |
| Pu-240 | 6537y | M | 5 | 0.0005 | 5.63E-12 |
| Pu-240 | 6537y | S | 5 | 0.00001 | 6.18E-11 |
| Pu-241 | 14.4y | M | 5 | 0.0005 | 2.81E-10 |
| Pu-241 | 14.4y | S | 5 | 0.00001 | 2.81E-09 |
| Pu-242 | 3.763E5y | M | 5 | 0.0005 | 5.86E-12 |
| Pu-242 | 3.763E5y | S | 5 | 0.00001 | 6.54E-11 |
| Ru-103 | 39.28d | V | 5 | 0.05 | 5.11E-07 |
| Ru-103 | 39.28d | F | 5 | 0.05 | 8.27E-07 |
| Ru-103 | 39.28d | M | 5 | 0.05 | 2.96E-07 |
| Ru-103 | 39.28d | S | 5 | 0.05 | 2.56E-07 |
| Ru-106 | 368.2d | V | 5 | 0.05 | 3.13E-08 |
| Ru-106 | 368.2d | F | 5 | 0.05 | 5.74E-08 |
| Ru-106 | 368.2d | M | 5 | 0.05 | 3.31E-08 |
| Ru-106 | 368.2d | S | 5 | 0.05 | 1.61E-08 |
| Sb-124 | 60.20d | F | 5 | 0.1 | 2.96E-07 |
| Sb-124 | 60.20d | M | 5 | 0.01 | 1.20E-07 |
| Sb-125 | 2.77y | F | 5 | 0.1 | 2.08E-07 |

## ATTACHMENT C

## Inhalation DACs

| Nuclide | Half Life | Type | AMAD | f1 | Limiting DAC (µCi/cc) |
|---|---|---|---|---|---|
| Sb-125 | 2.77y | M | 5 | 0.01 | 1.70E-07 |
| Sm-151 | 90y | M | 5 | 0.0005 | 7.92E-08 |
| Sn-121 | 27.06h | F | 5 | 0.02 | 4.69E-06 |
| Sn-121 | 27.06h | M | 5 | 0.02 | 2.01E-06 |
| Sn-121m | 55y | F | 5 | 0.02 | 5.80E-07 |
| Sn-121m | 55y | M | 5 | 0.02 | 1.70E-07 |
| Sr-89 | 50.5d | F | 5 | 0.3 | 4.02E-07 |
| Sr-89 | 50.5d | S | 5 | 0.01 | 1.00E-07 |
| Sr-90 | 29.12y | F | 5 | 0.3 | 1.22E-08 |
| Sr-90 | 29.12y | S | 5 | 0.01 | 7.31E-09 |
| Tc-99 | 2.13E5y | F | 5 | 0.8 | 1.41E-06 |
| Tc-99 | 2.13E5y | M | 5 | 0.8 | 1.76E-07 |
| Te-125m | 58d | V | 5 | 0.3 | 1.04E-07 |
| Te-125m | 58d | F | 5 | 0.3 | 2.56E-07 |
| Te-125m | 58d | M | 5 | 0.3 | 1.94E-07 |
| Th-232 | 1.405E10y | M | 5 | 0.0005 | 3.75E-12 |
| Th-232 | 1.405E10y | S | 5 | 0.0002 | 4.02E-11 |
| Th-234 | 24.10d | M | 5 | 0.0005 | 1.06E-07 |
| Th-234 | 24.10d | S | 5 | 0.0002 | 9.70E-08 |
| U-233 | 1.585E5y | F | 5 | 0.02 | 4.69E-10 |
| U-233 | 1.585E5y | M | 5 | 0.02 | 2.56E-10 |
| U-233 | 1.585E5y | S | 5 | 0.002 | 7.40E-11 |
| U-234 | 2.445E5y | F | 5 | 0.02 | 5.11E-10 |
| U-234 | 2.445E5y | M | 5 | 0.02 | 2.68E-10 |
| U-234 | 2.445E5y | S | 5 | 0.002 | 7.50E-11 |
| U-235 | 703.8E6y | F | 5 | 0.02 | 5.11E-10 |
| U-235 | 703.8E6y | M | 5 | 0.02 | 3.13E-10 |
| U-235 | 703.8E6y | S | 5 | 0.002 | 8.15E-11 |
| U-236 | 2.3415E7y | F | 5 | 0.02 | 5.11E-10 |
| U-236 | 2.3415E7y | M | 5 | 0.02 | 2.96E-10 |
| U-236 | 2.3415E7y | S | 5 | 0.002 | 7.92E-11 |
| U-238 | 4.468E9y | F | 5 | 0.02 | 5.63E-10 |
| U-238 | 4.468E9y | M | 5 | 0.02 | 3.52E-10 |
| U-238 | 4.468E9y | S | 5 | 0.002 | 8.65E-11 |
| Y-90 | 64.0h | M | 5 | 0.0001 | 3.52E-07 |
| Y-90 | 64.0h | S | 5 | 0.0001 | 3.31E-07 |
| Zr-93 | 1.53E6y | F | 5 | 0.002 | 3.75E-09 |
| Zr-93 | 1.53E6y | M | 5 | 0.002 | 1.70E-08 |
| Zr-93 | 1.53E6y | S | 5 | 0.002 | 1.52E-07 |
| Zr-95 | 63.98d | F | 5 | 0.002 | 9.07E-08 |
| Zr-95 | 63.98d | M | 5 | 0.002 | 1.56E-07 |
| Zr-95 | 63.98d | S | 5 | 0.002 | 1.34E-07 |