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| <p>ORAU Team Dose Reconstruction Project for NIOSH</p> <p>Technical Information Bulletin – Validation of Thorium Annual Dose Conversion Factors</p> | <p>Document Number: ORAUT-OTIB-0028 Effective Date: 02/14/2005 Revision No.: 00 Controlled Copy No.: _____ Page 1 of 6</p> |
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1.0 **PURPOSE**

This document validates the annual dose conversion factors used for the assessment of ^{232}Th and ^{228}Th doses.

2.0 **BACKGROUND**

The IMBA Expert OCAS-Edition computer program is used for intake and dose assessments by the dose reconstructors on the Oak Ridge Associated Universities Dose Reconstruction Project for the National Institute for Occupational Safety and Health. The program was not designed to emulate independent kinetics for radionuclides with progeny chains, but the International Commission for Radiological Protection (ICRP) assumes independent kinetics for the progeny of several radionuclides. While this does not affect intake calculations, it results in inaccuracies for some of the doses. Dr. Keith Eckerman of the Oak Ridge National Laboratory generated annual dose conversion factor tables to be used in place of the IMBA values when a best estimate is needed. This document validates those values.

3.0 **VALIDATION**

Documentation of the dose conversion factors applied in IMBA is detailed in a dose quality assurance appendix to the User Manual (ACJ 2004). Each of the radionuclides in IMBA was benchmarked against the United Kingdom's National Radiological Protection Board's PLEIADES program. PLEIADES has been used extensively by the ICRP to calculate dose coefficients for its various publications. Only committed doses are benchmarked for all radionuclides; committed organ doses calculated using IMBA and PLEIADES are tabulated and compared.

As discussed in Section 2.0, replacement files for the thorium inhalation dose conversion factors were generated for use in cases where a best estimate is required. These files contain annual organ doses for the 65 years following an acute and 1-year chronic inhalation intake of 1 Bq of thorium. These values were validated in a manner similar to that used for the IMBA documentation. The annual organ doses in the replacement files were summed over the first 50 years and compared to the PLEIADES 50-year committed doses reported in the IMBA documentation.

Dose conversion factors from chronic intakes were not included in the IMBA benchmark tabulation. However, while there is some variation between a chronic and acute intake in the annual doses, particularly in the first few years, the 50-year dose from a 1-year chronic intake is almost identical to that from an acute intake of the same magnitude. The replacement file chronic doses were therefore compared to the PLEIADES acute doses for validation purposes.

3.1 **Th-232**

Results of the ^{232}Th comparisons are summarized in Tables 3-1 and 3-2. All of the replacement file values are within 5% of the PLEIADES values, with the majority falling within 3%.

Table 3-1: Dose conversion factors for inhalation of 1 Bq type S Th-232

| Organ | Pleiades* (Sv/Bq) | Acute (Sv/Bq) | % difference | 1-yr Chronic (Sv/Bq) | % difference |
|----------|----------------------|------------------|-----------------|----------------------------|-----------------|
| Adrenals | 4.10E-07 | 4.21E-07 | 2.65 | 4.16E-07 | 1.34 |
| UB_Wall | 4.00E-07 | 4.14E-07 | 3.42 | 4.08E-07 | 2.09 |
| Bone_Sur | 1.40E-04 | 1.45E-04 | 3.40 | 1.43E-04 | 2.37 |
| Brain | 4.00E-07 | 4.15E-07 | 3.63 | 4.09E-07 | 2.31 |
| Breasts | 4.10E-07 | 4.20E-07 | 2.37 | 4.14E-07 | 1.07 |
| St_Wall | 4.10E-07 | 4.17E-07 | 1.68 | 4.12E-07 | 0.38 |
| SI_Wall | 4.10E-07 | 4.15E-07 | 1.34 | 4.10E-07 | 0.04 |
| ULI_Wall | 4.30E-07 | 4.40E-07 | 2.23 | 4.34E-07 | 0.97 |
| LLI_Wall | 4.80E-07 | 4.89E-07 | 1.85 | 4.83E-07 | 0.66 |
| Kidneys | 2.40E-06 | 2.41E-06 | 0.55 | 2.39E-06 | -0.39 |
| Liver | 2.50E-06 | 2.55E-06 | 2.01 | 2.53E-06 | 1.02 |
| ET1-bas | 4.70E-07 | 4.84E-07 | 2.97 | 4.78E-07 | 1.73 |
| ET2-bas | 1.10E-04 | 1.05E-04 | -4.50 | 1.05E-04 | -4.12 |
| LN-ET | 7.10E-04 | 7.09E-04 | -0.21 | 7.02E-04 | -1.13 |
| BBi-bas | 3.30E-06 | 3.29E-06 | -0.32 | 3.31E-06 | 0.26 |
| BBi-sec | 2.80E-05 | 2.75E-05 | -1.63 | 2.78E-05 | -0.63 |
| AI | 1.70E-04 | 1.68E-04 | -1.04 | 1.68E-04 | -1.44 |
| LN-Th | 2.60E-03 | 2.61E-03 | 0.50 | 2.59E-03 | -0.42 |
| Muscle | 4.10E-07 | 4.16E-07 | 1.53 | 4.11E-07 | 0.24 |
| Ovaries | 1.30E-06 | 1.31E-06 | 0.69 | 1.30E-06 | -0.36 |
| Pancreas | 4.10E-07 | 4.18E-07 | 2.00 | 4.13E-07 | 0.69 |
| R_Marrow | 6.10E-06 | 6.28E-06 | 2.90 | 6.22E-06 | 1.98 |
| Skin | 4.00E-07 | 4.14E-07 | 3.62 | 4.09E-07 | 2.29 |
| Spleen | 4.10E-07 | 4.18E-07 | 2.06 | 4.13E-07 | 0.75 |
| Testes | 1.30E-06 | 1.33E-06 | 2.03 | 1.31E-06 | 0.97 |
| Thymus | 4.10E-07 | 4.21E-07 | 2.76 | 4.16E-07 | 1.45 |
| Thyroid | 4.10E-07 | 4.16E-07 | 1.53 | 4.11E-07 | 0.24 |
| Uterus | 4.00E-07 | 4.14E-07 | 3.41 | 4.08E-07 | 2.08 |
| Lung_66 | 7.70E-05 | 7.73E-05 | 0.36 | 7.71E-05 | 0.16 |

* From IMBA documentation (ACJ 2004)

Table 3-2: Dose conversion factors for inhalation of 1 Bq type M Th-232

| Organ | Pleiades* (Sv/Bq) | Acute (Sv/Bq) | % difference | 1-yr Chronic (Sv/Bq) | % difference |
|----------|----------------------|------------------|-----------------|----------------------------|-----------------|
| Adrenals | 4.40E-06 | 4.37E-06 | -0.63 | 4.32E-06 | -1.81 |
| UB_Wall | 4.40E-06 | 4.36E-06 | -0.89 | 4.31E-06 | -2.06 |
| Bone_Sur | 1.50E-03 | 1.45E-03 | -3.20 | 1.44E-03 | -4.04 |
| Brain | 4.40E-06 | 4.37E-06 | -0.75 | 4.32E-06 | -1.93 |
| Breasts | 4.40E-06 | 4.36E-06 | -1.02 | 4.30E-06 | -2.20 |
| St_Wall | 4.40E-06 | 4.36E-06 | -0.96 | 4.31E-06 | -2.14 |
| SI_Wall | 4.40E-06 | 4.36E-06 | -0.83 | 4.31E-06 | -2.00 |
| ULI_Wall | 4.50E-06 | 4.45E-06 | -1.03 | 4.40E-06 | -2.20 |
| LLI_Wall | 4.60E-06 | 4.64E-06 | 0.82 | 4.58E-06 | -0.37 |
| Kidneys | 2.30E-05 | 2.26E-05 | -1.67 | 2.24E-05 | -2.42 |
| Liver | 2.30E-05 | 2.28E-05 | -1.02 | 2.26E-05 | -1.87 |
| ET1-bas | 4.40E-06 | 4.37E-06 | -0.73 | 4.32E-06 | -1.91 |
| ET2-bas | 1.50E-05 | 1.48E-05 | -1.49 | 1.48E-05 | -1.19 |
| LN-ET | 4.90E-06 | 4.89E-06 | -0.13 | 4.85E-06 | -1.11 |
| BBI-bas | 5.80E-06 | 5.84E-06 | 0.63 | 5.80E-06 | 0.01 |
| BBI-sec | 2.40E-05 | 2.43E-05 | 1.18 | 2.44E-05 | 1.87 |
| AI | 1.10E-05 | 1.11E-05 | 1.35 | 1.12E-05 | 1.47 |
| LN-Th | 6.70E-06 | 6.71E-06 | 0.21 | 6.68E-06 | -0.29 |
| Muscle | 4.40E-06 | 4.36E-06 | -0.87 | 4.31E-06 | -2.04 |
| Ovaries | 1.30E-05 | 1.32E-05 | 1.63 | 1.31E-05 | 0.67 |
| Pancreas | 4.40E-06 | 4.36E-06 | -0.85 | 4.31E-06 | -2.02 |
| R_Marrow | 5.70E-05 | 5.74E-05 | 0.68 | 5.70E-05 | -0.01 |
| Skin | 4.40E-06 | 4.36E-06 | -0.98 | 4.31E-06 | -2.15 |
| Spleen | 4.40E-06 | 4.36E-06 | -0.80 | 4.31E-06 | -1.98 |
| Testes | 1.30E-05 | 1.34E-05 | 3.00 | 1.33E-05 | 2.04 |
| Thymus | 4.40E-06 | 4.36E-06 | -0.94 | 4.31E-06 | -2.13 |
| Thyroid | 4.40E-06 | 4.36E-06 | -0.87 | 4.31E-06 | -2.05 |
| Uterus | 4.40E-06 | 4.36E-06 | -0.90 | 4.31E-06 | -2.08 |
| Lung_66 | 1.60E-05 | 1.58E-05 | -1.22 | 1.59E-05 | -0.77 |

* From IMBA documentation (ACJ 2004)

3.2 Th-228

Reserved.

REFERENCES

ACJ & Associates, 2004, *Appendix C: Dose Quality Assurance, User Manual for IMBA Expert OCAS-Edition, Phase II (Version 3.2)*, Richland, Washington, March.