ORAU Team **Dose Reconstruction Project for NIOSH** Validation of Thorium Annual Dose Conversion Factors	Document Number: ORAUT-OTIB-0028 Effective Date: 03/07/2005 Revision No.: 01 Controlled Copy No.: _____ Page 1 of 7
Subject Expert: Elizabeth M. Brackett Document Owner Approval: Signature on File Date: 03/02/2005 Edward F. Maher, Task 5 Manager Concurrence: Signature on File Date: 03/05/2005 Richard E. Toohey, Project Director Approval: Signature on File Date: 03/07/2005 James W. Neton, Associate Director for Science	Supersedes: Revision No.: 00

RECORD OF ISSUE/REVISIONS

ISSUE AUTHORIZATION DATE	EFFECTIVE DATE	REV. NO.	DESCRIPTION
Draft	01/12/2005	00-A	New technical information bulletin for the validation of thorium dose conversion factors to be used for internal dose assessment. Initiated by Elizabeth M. Brackett.
02/14/2005	02/14/2005	00	First approved issue. Initiated by Elizabeth M. Brackett.
Draft	02/18/2005	01-A	Revised to add Th-228 values. Initiated by Elizabeth M. Brackett.
03/07/2005	03/07/2005	01	Approved issue of Revision 01. Initiated by Elizabeth M. Brackett.

1.0 PURPOSE

This document verifies 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 (ORNL) generated annual dose conversion factor tables to be used in place of the IMBA values when a best estimate is needed. Verification of these values was provided by Dr. Eckerman; details are incorporated into this document.

3.0 VERIFICATION

3.1 Discussion

Annual organ equivalent dose coefficients for inhalation of Th-228 and Th-232 in the workplace were derived for an acute intake of 1 becquerel (Bq) at time zero and for a chronic intake of 1 Bq over a year. The latter set of coefficients was derived by convolution of the organ dose rate following a unit acute intake. The calculations were performed using ORNL's DCAL code system. This code system was used in the calculations for ICRP Publication 68 (ICRP 1994) and provided in electronic form (CD) in the ICRP database of dose coefficients (ICRP 2001). Verification of the annual organ dose coefficients derived in this work can be achieved by comparing the values of the committed dose coefficients computed during the course of this work with the values tabulated by the ICRP since these numerical values (annual and committed) are derived from a common set of data; namely the organ dose rate at selected times following a unit intake. All input data into these calculations are those recommended by the ICRP.

The following data files were provided by Dr. Eckerman and are used:

Th228AM5.INT, Th228AS5.ANN

Th232AM5.INT, Th232AS5.ANN

The files with extension INT contain the annual dose coefficient (Sv Bq^{-1}) for each year (65 values) following an acute intake at time zero. The files with extension ANN contain the annual dose coefficient (Sv Bq^{-1}) for each year (65 values) following chronic uniform intake of 1 Bq during year 1. The first 5 characters in the root name of the file identify the radionuclide; that is, Th228AM5.INT contains information on Th-228. The "A" denotes that these data are for the adult. The seventh character (M or S) denoted assumed absorption type of the aerosol and the eighth character (5) indicates that the data are for an assumed aerosol characterized by a AMAD of 5 μm.

3.2 Results

Tables 3-1 and 3-2 compare the values of the committed equivalent dose coefficient (and effective dose) derived during the course of the calculations (under the column headed DCAL) with values tabulated by the ICRP. When a numerical difference occurs they appear to arise from round of the ICRP values to 2 digits while the DCAL values are listed to 3 places. As noted above all the data in the files provided in this work stem from a common data set. Thus the agreement evident in Tables 3-1 and 3-2 provides verification of the calculations.

Table 1. Comparison of the committed equivalent dose coefficients (Sv/Bq) for Th-228 computed using DCAL with the values tabulated by the ICRP: AMAD = 5.0µm

	--- Type M ---		--- Type S ---	
	f_1=5.0E-04		f_1=2.0E-04	
	DCAL	ICRP	DCAL	ICRP
Adrenals	7.74E-07	7.7E-07	3.79E-08	3.7E-08
Bladder Wall	7.78E-07	7.8E-07	3.47E-08	3.4E-08
Bone Surfaces	2.80E-04	2.8E-04	1.23E-05	1.2E-05
Brain	7.71E-07	7.7E-07	3.45E-08	3.4E-08
Breast	7.71E-07	7.7E-07	3.80E-08	3.7E-08
GI-Tract				
St Wall	7.72E-07	7.7E-07	3.70E-08	3.6E-08
SI Wall	7.75E-07	7.7E-07	3.70E-08	3.7E-08
ULI Wall	1.09E-06	1.1E-06	6.53E-08	6.5E-08
LLI Wall	1.73E-06	1.7E-06	1.42E-07	1.4E-07
Kidneys	7.33E-06	7.3E-06	3.24E-07	3.2E-07
Liver	1.17E-05	1.2E-06	5.15E-07	5.1E-07
Resp. Tract				
ET1-bas	7.57E-04	7.6E-04	7.56E-04	7.6E-04
ET2-bas	5.73E-05	5.7E-05	2.14E-04	2.1E-04
LN-ET	3.22E-06	3.2E-06	4.98E-05	5.0E-05
BBi-bas	1.17E-04	1.2E-04	1.60E-04	1.6E-04
BBi-sec	3.64E-04	3.6E-04	4.81E-04	4.8E-04
bbe-sec	9.83E-05	9.8E-05	1.46E-04	1.5E-04
AI	4.16E-05	4.2E-05	1.57E-04	1.6E-04
LN-Th	1.31E-05	1.3E-05	1.41E-04	1.4E-04
ET Region	5.79E-05	5.8E-05	2.14E-04	2.1E-04
Lung	1.27E-04	1.3E-04	2.08E-04	2.1E-04
Muscle	7.71E-07	7.7E-07	3.58E-08	3.5E-08
Ovaries	2.34E-06	2.3E-06	1.03E-07	1.0E-07
Pancreas	7.72E-07	7.7E-07	3.69E-08	3.6E-08
Red Marrow	2.16E-05	2.2E-05	9.53E-07	9.4E-07
Skin	7.70E-07	7.7E-07	3.50E-08	3.4E-08
Spleen	7.73E-07	7.7E-07	3.69E-08	3.6E-08
Testes	2.37E-06	2.4E-06	1.04E-07	1.0E-07
Thymus	7.71E-07	7.7E-07	3.87E-08	3.8E-08
Thyroid	7.71E-07	7.7E-07	3.58E-08	3.5E-08
G Bladder	7.73E-07	N/A	3.56E-08	N/A
Heart	7.73E-07	N/A	4.07E-08	N/A
Uterus	7.72E-07	7.7E-07	3.45E-08	3.4E-08
Remainder	8.66E-07	8.7E-07	1.46E-07	1.5E-07
Effective Dose	2.21E-05	2.2E-05	2.53E-05	2.5E-05

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Output files: Th228AM5.hef, Th228AS5.hef
<<  HTAB32  Ver 6.0  (July 30, 2004) --- Run Jan 18, 2005, at 14:48 >>
HTAB32 exe file was:      HTAB32.EXE             49kb 07-30-04 15:02
Dose rate file was:     TH228AM5.HRT             63kb 01-18-05 14:48
Dose rate file was:     TH228AS5.HRT             63kb 01-18-05 14:49
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Table 2. Comparison of the committed equivalent dose coefficients (Sv/Bq) for Th-232 computed using DCAL with the values tabulated by the ICRP: AMAD = 5.0µm

	--- Type M ---		--- Type S ---	
	f_1=5.0E-04		f_1=2.0E-04	
	DCAL	ICRP	DCAL	ICRP
Adrenals	4.37E-06	4.4E-06	4.12E-07	4.1E-07
Bladder Wall	4.36E-06	4.4E-06	4.05E-07	4.0E-07
Bone Surfaces	1.45E-03	1.5E-03	1.42E-04	1.4E-04
Brain	4.37E-06	4.4E-06	4.06E-07	4.0E-07
Breast	4.35E-06	4.4E-06	4.11E-07	4.1E-07
GI-Tract				
St Wall	4.36E-06	4.4E-06	4.08E-07	4.1E-07
SI Wall	4.36E-06	4.4E-06	4.07E-07	4.1E-07
ULI Wall	4.45E-06	4.5E-06	4.31E-07	4.3E-07
LLI Wall	4.64E-06	4.6E-06	4.80E-07	4.8E-07
Kidneys	2.26E-05	2.3E-05	2.36E-06	2.4E-06
Liver	2.28E-05	2.3E-05	2.51E-06	2.5E-06
Resp. Tract				
ET1-bas	4.37E-06	4.4E-06	4.75E-07	4.7E-04
ET2-bas	1.48E-05	1.5E-05	1.05E-04	1.1E-04
LN-ET	4.89E-06	4.9E-06	7.09E-04	7.1E-04
BBi-bas	5.84E-06	5.8E-06	3.28E-06	3.3E-06
BBi-sec	2.43E-05	2.4E-05	2.75E-05	2.8E-05
bbe-sec	2.12E-05	2.1E-05	4.06E-05	4.1E-05
AI	1.12E-05	1.1E-05	1.68E-04	1.7E-04
LN-Th	6.71E-06	6.7E-06	2.61E-03	2.6E-03
ET Region	1.48E-05	1.5E-05	1.06E-04	1.1E-04
Lung	1.58E-05	1.6E-05	7.73E-05	7.7E-05
Muscle	4.36E-06	4.4E-06	4.08E-07	4.1E-07
Ovaries	1.32E-05	1.3E-05	1.28E-06	1.3E-06
Pancreas	4.36E-06	4.4E-06	4.09E-07	4.1E-07
Red Marrow	5.74E-05	5.7E-05	6.16E-06	6.1E-06
Skin	4.36E-06	4.4E-06	4.06E-07	4.0E-07
Spleen	4.36E-06	4.4E-06	4.10E-07	4.1E-07
Testes	1.34E-05	1.3E-05	1.30E-06	1.3E-06
Thymus	4.36E-06	4.4E-06	4.13E-07	4.1E-07
Thyroid	4.36E-06	4.4E-06	4.08E-07	4.1E-07
G Bladder	4.36E-06	N/A	4.07E-07	N/A
Heart	4.36E-06	N/A	4.16E-07	N/A
Uterus	4.36E-06	4.4E-06	4.05E-07	4.0E-07
Remainder	4.55E-06	4.6E-06	4.80E-07	4.8E-07
Effective Dose	2.93E-05	2.9E-05	1.20E-05	1.2E-05

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Output files: Th232AM5.hef, Th232AS5.hef
<<  HTAB32  Ver 6.0  (July 30, 2004) --- Run Jan 18, 2005, at 14:50 >>
HTAB32 exe file was:      HTAB32.EXE             49kb 07-30-04 15:02
Dose rate file was:     TH232AM5.HRT             67kb 01-18-05 14:50
Dose rate file was:     TH232AS5.HRT             67kb 01-18-05 14:51
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REFERENCES

ICRP (International Commission on Radiological Protection), 1994, *Dose Coefficients for Intakes of Radionuclides by Workers*, Publication 68, Pergamon Press, Oxford, England.

ICRP (International Commission on Radiological Protection), 2001, *ICRP Database of Dose Coefficients: Workers and Members of the Public, Ver. 2*, Pergamon Press, Oxford, England.