SC&A's Evaluation of OTIB-0054 Workbook 1.5.11 with Air Concentration Data

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Introduction

SC&A evaluated the ORAUT-OTIB-0054 workbook in conjunction with the current version of ORAUT-OTIB-0054, Rev. 03, February 6, 2015 (*Fission and Activation Product Assignment for Internal Dose-Related Gross Beta and Gross Gamma Analyses*) (referred to as OTIB-0054). The sequence of the release of OTIB-0054 and its related Workbook is as follows:

5/11/2007, Rev. 00 of OTIB-0054 (ORAUT 2007a)

10/09/2007, Ver. 1.01 of OTIB-0054 Workbook (ORAUT 2007b)

11/19/2007, Rev. 00 PC-1 of OTIB-0054 (ORAUT 2007c)

6/13/2013, Rev. 01 of OTIB-0054 (ORAUT 2013a)

11/21/2013, Ver. 1.2.0 of OTIB-0054 Workbook (ORAUT 2013b)

3/06/2014, Rev. 02 of OTIB-0054. (ORAUT 2014)

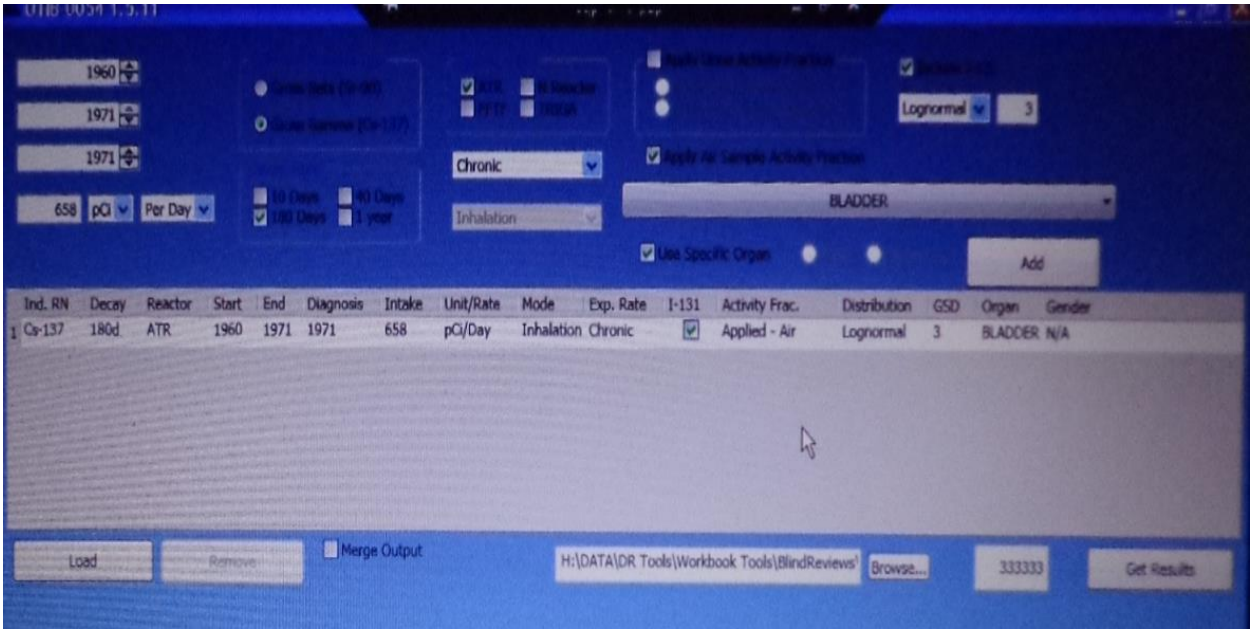
2/06/2015, Rev. 03 of OTIB-0054. (ORAUT 2015a)

March 2015, Ver. 1.5.11 of OTIB-0054 Workbook (ORAUT 2015b)

SC&A evaluated OTIB-0054 Workbook 1.2.0 in April 2014 (SC&A 2014) and found that the workbook performed correctly when using urine bioassay data, but it did not perform correctly when using air concentration data.

To evaluate OTIB-0054 Workbook 1.5.11 (referred to as the Workbook), SC&A analyzed the three examples provided on pages 68–71 of OTIB-0054 to verify the methodology and compatibility of the examples with the text and tables of OTIB-0054. SC&A then ran the intake calculations for these three examples using the OTIB-0054 Workbook 1.5.11. An example of the data input screen for the Workbook is shown in Exhibit A below.

Exhibit A. Example of OTIB-0054 Workbook 1.5.11 Data Input Screen



Operation of Workbook 1.5.11

Inputs

The input screen and operation of Workbook 1.5.11 is different than the older version of the Workbook (1.2.0) only in that it contains a button labeled "*Apply Air Sample Activity Fraction.*" The OTIB-0054 Workbook 1.5.11 is located in the DR Tools folder and can only be accessed through the use of the DR Tools unique password. To illustrate the use of the newer version, a summary of its inputs and operations will be provided:

- As the copy of the screen above indicates, you are required to enter the exposure start year, the end year, and the year the cancer was diagnosed
- Select if it is based on a Sr-90 beta or Cs-137 gamma as the indicator
- Enter the intake value of the gross beta or gamma indicator (in any of the units provided)
- Select the decay time
- Select the reactor group type(s)
- Select chronic or acute exposure
- Select the amount of urine sample processing, if applicable
- Select the air sample activity fraction, if applicable
- Select rather to include I-131 intakes
- Select the ICD cancer code
- Select the distribution function
- Enter the case number
- Select the location where the results will be saved

After these items are entered, click on *ADD*. If you want to change any of these inputs, you must highlight the entire line, click *REMOVE*, and then start over.

Once you are satisfied that the entries are correct, click on *Get Results*.

Computations

When the *Get Results* button is activated, the program goes through all the reactor types for the reactor group(s) selected (ATR1, ATR2, ATR3, FFTF1, FFTF2, N1, N2, TRIGA1, TRIGA2), up to nine total. It then provides the output in the form of three Excel spreadsheets.

Output

The results are provided in three Excel spreadsheets, labeled *IREP, Summary*, and *Detail 1*. A brief summary of these outputs is as follows:

***IREP* –** This spreadsheet lists the standard IREP table data and annual doses from the reactor that provides for the largest dose for the organ of concern. It also provides the type of reactor, (e.g., ATR2) that produced the largest dose.

***Summary* –** This spreadsheet provides a summary of the input parameters used, and the top reactor types that produced the largest doses for the organ of interest; along with the total dose derived for each of the these reactor types.

***Detail 1* –** This spreadsheet provides the details for each radionuclide intake used in deriving the dose, along with a summary of the input parameters, the reactor type that produced the largest dose, solubility type, and annual doses. Note that the output results for the intake values are always converted to Bq/year, regardless of the units used in the input; this cannot be changed.

SC&A's Evaluation

There are an enormous number of combinations of reactor types, decay times, sample processing, radionuclide indicators, and applicable radionuclides to test in this Workbook and compare them to values in OTIB-0054 (i.e., Tables 7-1a-b, 7-2, 7-3a-i, 7-4a-b). Therefore, SC&A found that an efficient way to evaluate the Workbook was to run Workbook for the three examples on pages 68-71 of OTIB-0054 and compare the details of the results from the Workbook to those hand calculated and/or listed in OTIB-0054. In April 2014 SC&A verified that Workbook 1.2.0 performed correctly for Examples #1 and #2 using urine bioassay data; however, it did not perform correctly for Example #3 using air data. NIOSH was informed of this problem and recently released Workbook 1.5.11 that was to correct the air data problem. SC&A evaluated all three example using the new version of the workbook to insure that nothing had been altered that would impact the results when using urine bioassay data, and to verify that the problem was correct when using air data. This evaluation is summarized in the following examples.

Example #1 –Urine Bioassay

This example involves an intake period of 1960-1971 using gross beta urinalysis for a waste management worker; therefore, according to Table 5-3, page 12, a 1-year decay would be used.

The bioassay urinalysis gross beta results listed in Table H-1, page 68, were used to derive a chronic intake of 161.36 pCi/d using the IMBA program (this corresponds to 76.0 pCi/d for ATR-1 as illustrated on page 68, but the Workbook requires a gross beta input, which is 161.36 pCi/d, not the Sr-90 intake value of 76.0 pCi/d). Major processing of the bioassay samples was indicated; therefore, this would be selected during the input phase (corresponding to using Table 7-2, page 19, of OTIB-0054).

Entering these parameters into the Workbook provided the results in three spreadsheets as previously described. The outputs of these spreadsheets were evaluated and compared to the results listed in OTIB-0054. SC&A compared the output from the *Detail 1* spreadsheet to the values in Table H-2, page 69 of OTIB-0054, and found them to match within rounding errors.

Example #2 – Urine Bioassay

This example involves an intake period of 1960-1971 using gross beta urinalysis for a spent fuel storage worker; therefore, according to Table 5-3, page 12, a 10-day decay would be used. The bioassay urinalysis gross beta results listed in Table H-3, page 70, were used to derive a chronic intake of 164.0 pCi/d using the IMBA program (this corresponds to 164.0 pCi/d x 2.14E-2 = 3.51 pCi/d for ATR-1 as illustrated on page 70, but the Workbook requires a gross beta input, not the Sr-90 intake value). Minor processing of the bioassay samples was indicated; therefore, this would be selected during the input phase (corresponding to using Table 7-1a, page 18, of OTIB-0054).

Entering these parameters into the Workbook provided the results in three spreadsheets as previously described. Since the Workbook provides the details of the intakes for the reactor (in this case ATR-2) that produces the largest dose to the organ of interest, these intakes were adjusted to those for ATR-1 for comparison to the values in Table H-4 (which is an illustration of the intake values for ATR-1). SC&A converted the ATR-2 intake value results from the Workbook to ATR-1 intake values by multiplying the intake values for ATR-2 by the ATR-1 activity fraction from Table 7-3a, then dividing by the ATR-2 activity fraction from Table 7-3b and then multiplying this result by the ATR-1 Sr-90 activity ratio from Table 7-1a, divided by the ATR-2 Sr-90 activity ratio from Table 7-1a. For example, for Co-60 the conversion from ATR-2 to ATR-1 intake value would be:

Co-60 (pCi/d) = 5.693E-3 Bq/y x 27 pCi/Bq x (1/365 d/y) x 2.05E-4/2.07E-4 x 0.0214/0.0124 = ***7.20 E-4 pCi/d***

After these adjustments, SC&A compared the intake values in the output of the Workbook to the values in Table H-4, p. 70, of OTIB-0054, and found the values to match within rounding errors.

Example #3 – Air Data

This example involves an intake period of 1960-1971 using gross gamma air sample data for a worker in a spent fuel dissolution area; therefore, according to Table 5-3, page 12 a 180-day decay would be used. The maximum gross air concentration measured during the period 1960-1971 was 1E-10 uCi/ml; this corresponds to 658 pCi/d gross gamma intake, and will be used to bound the intakes.

SC&A found that the Workbook has a box that lists "*Inhalation,*" but the user cannot change this selection; i.e., the user cannot select inhalation or ingestion. However, when using air data, the

program automatically calculates both *Inhalation* and *Ingestion* intakes and provides the results in the output. Comparison of SC&A's derived intake values using Workbook 1.5.11 to those listed in OTIB-0054 is provided for inhalation in Table 1, and for ingestion in Table 2.

SC&A verified the ingested intake values for Example #3 using TIB-009 (OCAS-TIB-009 2004), page 4, i.e.:

Ingested intake (pCi/d) = Inhaled intake (pCi/d) x 0.2 x 250 d x 1/2400m^3

Ingested intake (pCi/d) = Inhaled intake (pCi/d) x 0.0208

Because of the recent revision in Table H-5 of OTIB-54, SC&A compared all the derived ingested values using TIB-009 (OCAS-TIB-009 2004) to those listed in Table H-5, and found them to match correctly.

Table 1. Comparison of Workbook Inhalation Results to OTIB-0054 for Example #3

ATR-1	Cs-137 indictor Workbook Bq/year	180 day decay Workbook pCi/d	Table H-5 pCi/d	Intake from gross gamma air data Input = 658 pCi/d Workbook/ Table H-5
Ce-141	3.744E+02	2.77E+01	2.77E+01	1.00
Ce-144	3.109E+03	2.30E+02	2.30E+02	1.00
Co-60	3.142E-02	2.33E-03	2.32E-03	1.00
Cs-134	1.042E+02	7.71E+00	7.70E+00	1.00
Cs-137	1.628E+02	1.21E+01	1.20E+01	1.00
Eu-154	3.695E+00	2.74E-01	2.73E-01	1.00
I-131	8.513E-02	6.30E-03	6.29E-03	1.00
Nb-95	4.281E+03	3.17E+02	3.16E+02	1.00
Pm-147	4.411E+02	3.27E+01	3.26E+01	1.00
Pr-143	2.100E+00	1.55E-01	1.55E-01	1.00
Ru-103	3.646E+02	2.70E+01	2.70E+01	1.00
Ru-106	2.067E+02	1.53E+01	1.53E+01	1.00
Sr-89	1.065E+03	7.88E+01	7.87E+01	1.00
Sr-90	1.610E+02	1.19E+01	1.19E+01	1.00
Y-90	1.612E+02	1.19E+01	1.19E+01	1.00
Y-91	1.742E+03	1.29E+02	1.29E+02	1.00
Zr-95	2.246E+03	1.66E+02	1.66E+02	1.00
	Total:	**1068.2**	**1066.2**	

Table 2. Comparison of Workbook Ingestion Results to OTIB-0054 for Example #3

ATR-1	Cs-137 indictor Workbook Bq/year	180 day decay Workbook pCi/d	Table H-5 pCi/d	Intake from gross gamma air data Input = 658 pCi/d Workbook/ Table H-5
Ce-141	7.787E+00	5.77E-01	5.77E-01	1.00
Ce-144	6.467E+01	4.79E+00	4.79E+00	1.00
Co-60	6.535E-04	4.84E-05	4.84E-05	1.00
Cs-134	2.167E+00	1.60E-01	1.60E-01	1.00
Cs-137	3.386E+00	2.51E-01	2.51E-01	1.00
Eu-154	7.686E-02	5.69E-03	5.69E-03	1.00
I-131	1.771E-03	1.31E-04	1.31E-04	1.00
Nb-95	8.905E+01	6.59E+00	6.59E+00	1.00
Pm-147	9.176E+00	6.79E-01	6.79E-01	1.00
Pr-143	4.368E-02	3.23E-03	3.23E-03	1.00
Ru-103	7.584E+00	5.62E-01	5.62E-01	1.00
Ru-106	4.300E+00	3.18E-01	3.18E-01	1.00
Sr-89	2.214E+01	1.64E+00	1.64E+00	1.00
Sr-90	3.349E+00	2.48E-01	2.48E-01	1.00
Y-90	3.352E+00	2.48E-01	2.48E-01	1.00
Y-91	3.623E+01	2.68E+00	2.68E+00	1.00
Zr-95	4.672E+01	3.46E+00	3.46E+00	1.00
	Total:	**22.22**	**22.22**	

Conclusions

From the tests that SC&A performed, OTIB-0054 Workbook 1.5.11 correctly derives the intake values when using Sr-90 or Cs-137 as the indicating radionuclide when used in conjunction with the *Apply Urine Activity Fraction* or the *Apply Air Sample Activity Fraction*. Additionally, SC&A verified the revised ingestion values in Table H-5 were correct. SC&A had no findings in this workbook.

References

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