

TECHNICAL REPORT TITLE PAGE

Evaluation of the Dose Integration Parameter in RESRAD-BUILD  
Title

YA-REPT-00-010-03  
Technical Report Number

**COPY**

Approvals (Print & Sign Name)

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PAGE 1 OF 3

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PAGE 2 OF 3

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PAGE 3 OF 3

## Table of Contents

	<u>Page</u>
Executive Summary .....	3
Introduction .....	3
Discussion .....	3
Results .....	4
References .....	4

## Tables

	<u>Page No</u>
Table 1 - Evaluation of Maximum Number of Time Integration Points .....	4
Table 2 - Build Sensitivity Analysis vs. the Number of Dose Integrations .....	4
Case 1: Fe-55 at Time Integration Points = 1,3, 5, 17 .....	4
Case 2: Pu-241 at Time Integration Points = 3, 5, 9, 17 .....	4

## Appendices

	<u>No of Pages</u>
Appendix 1 - RESRAD-BUILD Input and Help Screens .....	4

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## Executive Summary

In order to improve run times for the RESRAD-BUILD v3.21 computer runs, an evaluation was performed on the Dose Integration parameter to support the use of a lower value than the default value of 17. Runs performed at different dose integration values show that a decrease to 5 integrations will not change the results of the sensitivity analysis or dose.

## Introduction

The dose computed by the RESRAD-BUILD code is obtained by integrating the dose rate over the exposure period. The maximum number of integrations can be specified by the user with the default value set by the code at 17. This report documents a study that demonstrates using a lower number of dose integrations produces the same sensitivity analysis results and dose as that obtained at the default setting.

## Discussion

Prior to the performance of the sensitivity analysis for the Building Occupancy Scenario using RESRAD-BUILD, the "evaluation time" parameter was tested for each nuclide of interest at the YR site [1] to determine the year in which the maximum dose occurs. Based on the guidance in the RESRAD Users Manual [2] and from the help feature of the RESRAD-BUILD code [3], up to nine evaluation times can be specified. The initial runs of this study used 5 Evaluation Times and 17 Dose Integrations. This combination of input specifications resulted in run times for the transuranic nuclides that approached or exceeded a day (and exceeded 9 days for Pu241). The code also displayed run problems that resulted in the termination of program execution. Discussions regarding the problems were held with RESRAD software support personnel at Argonne National Laboratory (ANL). The discussions led to several steps that allowed the code to run to completion and that reduced the run times for the sensitivity analysis and subsequent DCGL and Area Factor runs.

The first step involved the use of an updated version of a RESRAD-BUILD executable file, resbvb.exe, made available by ANL. The new file solved problems encountered as a result of the PC platform in use, Window XP, and allowed a smooth interface between the part of the code performing the computations and the windows interface modules. The need to use the updated executable file appears to be limited to the scenario that uses multiple evaluation times because the code runs successfully when one additional evaluation time is used. Consequently, only one additional evaluation time besides time = 0, which is always evaluated, was specified in these runs and the maximum number of time integrations was reduced from the default value.

According to Reference 1, the Time Integration parameter is the maximum number of integration points the code will use to compute the total dose over the exposure duration. In the integration of the dose rate, the difference in the dose based on 1 and 2 integration points is evaluated. If the change is greater than 1%, an additional integration based on 3 points is used. If the change in dose based on the 3-point integration is less than 1%, the integration process stops. If it exceeds 1%, then further integrations are performed until the user-specified maximum is reached.

The code does not provide an output of the actual number of integrations used in the calculation of a reported dose. Because the Pu-241 run times were the most excessive, a set of test runs were performed for Pu-241 at different values of the "Time Integration-Maximum Number of Points for Dose" parameter. The purpose of the runs was to evaluate and consequently improve the Pu-241 run time and to confirm that the dose and sensitivity analysis results remained the same. One other nuclide, Fe-55, was evaluated to compare the consistency of the changes. Fe-55 was

evaluated at Time Integrations values of 1, 3, 5, and 17. Pu-241 was evaluated at 3, 5, 9, and 17 Time Integrations. Note that the Pu-241 evaluations at 3 and 9 Time Integrations also included multiple evaluation times, as indicated in the footnotes of Table 1. This accounts for the longer run times experienced for these evaluations versus the 5 Time Integration run for Pu-241. The common evaluation times for Pu-241 were T= 0 and T=10 years.

Appendix 1 shows the RESRAD-BUILD code screens referred to in this report and the HELP Screen information that is also available in Reference 3. The information in Appendix 1 is provided to aid and direct the user to the portion of the code this report pertains to.

## Results

For all runs, the dose and the Partial Rank Correlation Coefficient (PRCC) of the sensitivity analysis were evaluated. The results in Tables 1 and 2 shows that for Time Integrations equal to three and above, the dose and the sensitivity analysis results are unchanged. The difference from the result at 1 time integration is due to the different approach used, that is, the instantaneous dose at the user-specified- time is calculated. A value of 5 for the Maximum Number of Time Integrations for Dose was chosen to yield a shorter time to completion and not change the results from those obtained with a default value of 17.

Table 1 presents the results of the runs performed at different Maximum Number of Time Integrations. The run completion time is also evaluated for each Pu-241 case since this is the metric that must be improved.

Table 1 – Evaluation of Maximum Number of Time Integration Points

Nuclide	Run Completion Time (hrs)	Number of Integrations	Number of Observations	Number of Repetitions	Evaluation Times	Activity pCi/m <sup>2</sup>	Probabilistic Mean Dose
Fe-55	0.05	1	300	3	0	3.63E+08	2.86E+01
Fe-55	0.22	3	300	3	0	3.63E+08	2.50E+01
Fe-55	0.37	5	300	3	0	3.63E+08	2.50E+01
Fe-55	0.2	17	300	3	0	3.63E+08	2.50E+01
Pu-241 <sup>a</sup>	27	3	300	3	0	1	9.50E-06
					10	1	1.02E-05
Pu-241	16.5	5	300	3	0	1	9.50E-06
					10	1	1.02E-05
Pu-241 <sup>b</sup>	30.5	9	300	3	0	1	9.50E-06
					10		1.02E-05
Pu-241	216	17	300	3	0	1	9.50E-06
					10	1	1.02E-05
Pu-241 <sup>c</sup>	58	17	300	3	0	1	9.50E-06
					10	1	1.02E-05

<sup>a</sup> This run also evaluated the dose at T= 4, 6, 8, and 12 years.

<sup>b</sup> This run also evaluated the dose at T= 9, 11, 12, and 13 years.

<sup>c</sup> This run was made to confirm the results of the 216 hr run because of the excessive time it took for completion (9 days).

Sensitivity Analysis results were also compared for the runs performed at different Time Integration values. Table 2 shows the results of the sensitivity analysis for the same runs summarized in Table 1.

Table 2 - Build Sensitivity Analysis vs. the Number of Dose Integrations  
(All values correspond to the third repetition)

Case 1: Fe-55 at Time Integration Points = 1,3, 5, 17

1. Fe-55: Time Integration Points = 1

Coefficients for Total at Time: 1		PCC		SRC		PRCC		SRRC	
Coefficient =		3		3		3		3	
Repetition =									
Description of Probabilistic Variable		Sig	Coeff	Sig	Coeff	Sig	Coeff	Sig	Coeff
Deposition Velocity		6	-0.05	6	-0.06	6	-0.15	6	-0.05
Resuspension Rate		7	0.00	7	0.00	7	0.15	7	0.05
Release time of 1		4	-0.07	3	-0.14	1	-0.51	1	-0.24
Release time of 2		2	-0.08	2	-0.16	5	-0.43	5	-0.19
Release time of 3		5	-0.05	5	-0.11	3	-0.45	3	-0.21
Release time of 4		1	-0.08	1	-0.16	2	-0.47	2	-0.21
Release time of 5		3	-0.07	4	-0.14	4	-0.44	4	-0.20
R-SQUARE		0.45		0.45		0.98		0.98	

2. Fe-55: Time Integration Points = 3

Coefficients for Total at Time: 1		PCC		SRC		PRCC		SRRC	
Coefficient =		3		3		3		3	
Repetition =									
Description of Probabilistic Variable		Sig	Coeff	Sig	Coeff	Sig	Coeff	Sig	Coeff
Deposition Velocity		6	0.04	6	0.05	7	-0.09	7	-0.02
Resuspension Rate		7	0.01	7	0.01	6	0.13	6	0.02
Release time of 1		4	0.06	4	0.12	2	0.70	4	0.20
Release time of 2		1	0.08	2	0.17	5	0.68	5	0.20
Release time of 3		5	0.05	5	0.11	4	0.68	2	0.21
Release time of 4		2	0.08	1	0.17	1	0.74	1	0.23
Release time of 5		3	0.07	3	0.14	3	0.69	3	0.21
R-SQUARE		0.45		0.45		0.99		0.99	

3. Fe-55: Time Integration Points = 5

Coefficients for Total at Time: 1		PCC		SRC		PRCC		SRRC	
Coefficient =		3		3		3		3	
Repetition =									
Description of Probabilistic Variable		Sig	Coeff	Sig	Coeff	Sig	Coeff	Sig	Coeff
Deposition Velocity		6	0.04	6	0.05	7	-0.09	7	-0.02
Resuspension Rate		7	0.01	7	0.01	6	0.13	6	0.02
Release time of 1		4	0.06	4	0.12	2	0.70	4	0.20
Release time of 2		1	0.08	2	0.17	5	0.68	5	0.20
Release time of 3		5	0.05	5	0.11	4	0.68	2	0.21
Release time of 4		2	0.08	1	0.17	1	0.74	1	0.23

Release time of 5	3	0.07	3	0.14	3	0.69	3	0.21
R-SQUARE		0.45		0.45		0.99		0.99

-Rank is set to zero if the dose is zero or the correlation matrix is singular.  
-R-SQUARE varies between 0 and 1 and is called the coefficient of determination; it provides a measure of the variation in the dependent variable (Dose) explained by regression on the independent variables.

#### 4. Fe-55: Time Integration Points = 17

Coefficients for Total at Time: 1

Coefficient =	PCC	SRC	PRCC	SRRC
Repetition =	3	3	3	3
Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 0.04	6 0.05	7 -0.09	7 -0.02
Resuspension Rate	7 0.01	7 0.01	6 0.13	6 0.02
Release time of 1	4 0.06	4 0.12	2 0.70	4 0.20
Release time of 2	1 0.08	2 0.17	5 0.68	5 0.20
Release time of 3	5 0.05	5 0.11	4 0.68	2 0.21
Release time of 4	2 0.08	1 0.17	1 0.74	1 0.23
Release time of 5	3 0.07	3 0.14	3 0.69	3 0.21
R-SQUARE	0.45	0.45	0.99	0.99

#### Case 2: Pu-241 Time Integration Points = 3, 5, 9, 17 and Evaluation Time = 0 yr and 10 yr

##### 1. Pu-241: 3 dose integrations T=0

Coefficients for Total at Time: 1

Coefficient =	PCC	SRC	PRCC	SRRC
Repetition =	3	3	3	3
Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 -0.04	6 -0.05	6 -0.14	6 -0.02
Resuspension Rate	7 -0.01	7 -0.01	7 0.12	7 0.01
Release time of 1	3 -0.07	3 -0.15	1 -0.88	1 -0.26
Release time of 2	1 -0.08	1 -0.16	3 -0.81	4 -0.19
Release time of 3	5 -0.05	5 -0.10	5 -0.79	5 -0.19
Release time of 4	2 -0.08	2 -0.15	2 -0.82	2 -0.20
Release time of 5	4 -0.07	4 -0.14	4 -0.81	3 -0.20
R-SQUARE	0.45	0.45	1.00	1.00

##### 2. Pu-241: 5 dose integrations T=0

Coefficients for Total at Time: 1

Coefficient =	PCC	SRC	PRCC	SRRC
Repetition =	3	3	3	3
Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 -0.04	6 -0.05	6 -0.14	6 -0.02
Resuspension Rate	7 -0.01	7 -0.01	7 0.12	7 0.01
Release time of 1	3 -0.07	3 -0.15	1 -0.88	1 -0.26
Release time of 2	1 -0.08	1 -0.16	3 -0.81	4 -0.19
Release time of 3	5 -0.05	5 -0.10	5 -0.79	5 -0.19
Release time of 4	2 -0.08	2 -0.15	2 -0.82	2 -0.20
Release time of 5	4 -0.07	4 -0.14	4 -0.81	3 -0.20



R-SQUARE	0.45	0.45	1.00	1.00
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3. Pu-241: 9 dose integrations T=0

Coefficients for Total at Time: 1

Coefficient =	PCC	SRC	PRCC	SRRC
Repetition =	3	3	3	3

  

Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 -0.04	6 -0.05	6 -0.14	6 -0.02
Resuspension Rate	7 -0.01	7 -0.01	7 0.12	7 0.01
Release time of 1	3 -0.07	3 -0.15	1 -0.88	1 -0.26
Release time of 2	1 -0.08	1 -0.16	3 -0.81	4 -0.19
Release time of 3	5 -0.05	5 -0.10	5 -0.79	5 -0.19
Release time of 4	2 -0.08	2 -0.15	2 -0.82	2 -0.20
Release time of 5	4 -0.07	4 -0.14	4 -0.81	3 -0.20

  

R-SQUARE	0.45	0.45	1.00	1.00
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4. Pu-241: 17 dose integrations T=0

Coefficients for Total at Time: 1

Coefficient =	PCC	SRC	PRCC	SRRC
Repetition =	3	3	3	3

  

Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 -0.04	6 -0.05	6 -0.14	6 -0.02
Resuspension Rate	7 -0.01	7 -0.01	7 0.12	7 0.01
Release time of 1	3 -0.07	3 -0.15	1 -0.88	1 -0.26
Release time of 2	1 -0.08	1 -0.16	3 -0.81	4 -0.19
Release time of 3	5 -0.05	5 -0.10	5 -0.79	5 -0.19
Release time of 4	2 -0.08	2 -0.15	2 -0.82	2 -0.20
Release time of 5	4 -0.07	4 -0.14	4 -0.81	3 -0.20

  

R-SQUARE	0.45	0.45	1.00	1.00
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5. Pu-241: 3 dose integrations T=10 years

Coefficients for Total at Time: 5

Coefficient =	PCC	SRC	PRCC	SRRC
Repetition =	3	3	3	3

  

Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 0.05	6 0.06	7 -0.03	7 0.00
Resuspension Rate	7 0.00	7 0.01	6 0.08	6 0.01
Release time of 1	4 0.06	4 0.12	5 0.81	5 0.19
Release time of 2	1 0.09	1 0.17	2 0.84	2 0.21
Release time of 3	5 0.05	5 0.11	4 0.82	4 0.21
Release time of 4	2 0.09	2 0.17	1 0.85	1 0.22
Release time of 5	3 0.08	3 0.15	3 0.83	3 0.21

  

R-SQUARE	0.47	0.47	1.00	1.00
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6. Pu-241: 5 dose integrations T=10 years

Coefficients for Total at Time: 2

Coefficient =	PCC	SRC	PRCC	SRRC
Repetition =	3	3	3	3

  

Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 0.05	6 0.06	7 -0.03	7 0.00
Resuspension Rate	7 0.00	7 0.01	6 0.08	6 0.01
Release time of 1	4 0.06	4 0.12	5 0.81	5 0.19
Release time of 2	1 0.09	1 0.17	2 0.84	2 0.21
Release time of 3	5 0.05	5 0.11	4 0.82	4 0.21
Release time of 4	2 0.09	2 0.17	1 0.85	1 0.22
Release time of 5	3 0.08	3 0.15	3 0.83	3 0.21

R-SQUARE	0.47	0.47	1.00	1.00
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7. Pu-241: 9 dose integrations T=10 years

Coefficients for Total at Time: 3  
Coefficient =  
Repetition =

	PCC 3	SRC 3	PRCC 3	SRRC 3
Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 0.05	6 0.06	7 -0.03	7 0.00
Resuspension Rate	7 0.01	7 0.01	6 0.08	6 0.01
Release time of 1	4 0.06	4 0.12	5 0.81	5 0.19
Release time of 2	1 0.09	1 0.17	2 0.84	2 0.21
Release time of 3	5 0.05	5 0.11	4 0.82	4 0.21
Release time of 4	2 0.09	2 0.17	1 0.85	1 0.22
Release time of 5	3 0.08	3 0.15	3 0.83	3 0.21
R-SQUARE	0.47	0.47	1.00	1.00

8. Pu-241: 17 dose integrations T=10 years

Coefficients for Total at Time: 2  
Coefficient =  
Repetition =

	PCC 3	SRC 3	PRCC 3	SRRC 3
Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 0.05	6 0.06	7 -0.03	7 0.00
Resuspension Rate	7 0.00	7 0.01	6 0.08	6 0.01
Release time of 1	4 0.06	4 0.12	5 0.81	5 0.19
Release time of 2	1 0.09	1 0.17	2 0.84	2 0.21
Release time of 3	5 0.05	5 0.11	4 0.82	4 0.21
Release time of 4	2 0.09	2 0.17	1 0.85	1 0.22
Release time of 5	3 0.08	3 0.15	3 0.83	3 0.21
R-SQUARE	0.47	0.47	1.00	1.00

9. Pu-241<sup>a</sup>: 17 dose integrations T=10 years

\*\* RESRAD-BUILD Regression and Correlation output 3.21B 12/06/03 20:00:49 Page: 30 \*\*

Title : Yankee Rowe Pu-241 17 obs  
Input File : C:\Program Files\RESRAD\_Family\BUILD\Pu-241YR\_Build\_17.BLD

Coefficients for Total at Time: 2  
Coefficient =  
Repetition =

	PCC 3	SRC 3	PRCC 3	SRRC 3
Description of Probabilistic Variable	Sig Coeff	Sig Coeff	Sig Coeff	Sig Coeff
Deposition Velocity	6 0.05	6 0.06	7 -0.03	7 0.00
Resuspension Rate	7 0.00	7 0.01	6 0.08	6 0.01
Release time of 1	4 0.06	4 0.12	5 0.81	5 0.19
Release time of 2	1 0.09	1 0.17	2 0.84	2 0.21
Release time of 3	5 0.05	5 0.11	4 0.82	4 0.21
Release time of 4	2 0.09	2 0.17	1 0.85	1 0.22
Release time of 5	3 0.08	3 0.15	3 0.83	3 0.21
R-SQUARE	0.47	0.47	1.00	1.00

<sup>a</sup> This run was made to confirm the results of the 216 hr run because of the excessive time it took for completion (9 days).

## References

1. YA-REPT-00-001-03, " Radionuclide Selection for DCGL Determination, October 2003
  2. ANL/EAD/03-1, "User's Manual for RESRAD-BUILD Version 3, Yu, C., et al, June 2003
  3. RESRAD-BUILD V3.21 Dose Model Code
-

## Appendix 1

### RESRAD-BUILD Input and Help Screens

RESRAD-BUILD Evaluation Times Screen showing the default Time Integration value and corresponding Help Screen

The screenshot shows the 'Evaluation Times' dialog box. It has a title bar with 'OK' and 'Cancel' buttons. The main area is titled 'Times for Calculation (years):' and contains a horizontal slider with values 1, 10, 100, 1000, 10000, and 100000. The slider is currently set to 1. Below the slider are 'Remove' and 'Add' buttons. To the right of the slider is a small input field containing the number 1. Below the slider is a section titled 'Time Integration' with the label 'Maximum number of points for:' and a dropdown menu showing 'Dose' and the value '17'. At the bottom of the dialog, there are several input fields: 'Number of Rooms' (1), 'Deposition Velocity' (0.01 m/s), 'Resuspension Rate' (0.000005 1/s), and 'Air Flow'. To the right of these fields is a section titled 'Source Parameters' with fields for 'Source #', 'Room', 'Type/Dx', 'Volume', and 'Location [m]'.

The screenshot shows the 'Build.hlx' help screen. It has a title bar with 'Build.hlx' and standard window controls. Below the title bar is a menu bar with 'File', 'Edit', 'Bookmark', 'Options', and 'Help'. Below the menu bar is a toolbar with buttons for 'Contents', 'Index', 'Back', 'Print', and navigation arrows. The main content area is titled 'Maximum number of time integration points' and contains the following text: 'The dose reported at any time is obtained by numerically integrating the dose rate over the exposure duration at each receptor location. The user can specify the maximum number of point to be used for the time integration. The code will use as many time integration points as is necessary to achieve the preset convergence criteria, subject to the limit specified here.' Below the text is a section titled 'Related topic' with the link 'Evaluation times'.

RESRAD-BUILD Time Integration pull-down menu showing Maximum Number of Points for Dose options  
(not shown are the values 129 and 257)

**Evaluation Times**

OK  
Cancel

Times for Calculation (years):

1 10 100 1000 10000 100000

Remove Add

**Time Integration**

Maximum number of points for:

Dose 17

1  
2  
3  
5  
9  
17  
33  
65

Number of Rooms 9  
Deposition Velocity 17 m/s  
Resuspension Ratio 65 1/s

Air Flow

**Source Parameters**

Source # 1  
Room 1  
Type/Dir Volume  
Location [m]

ANL/EAD/03-1, User's Manual for RESRAD-BUILD Version 3

J-14

### J.1.5 Maximum Time Integration Points

**Definition:** This parameter refers to the maximum number of points used in integrating the dose rate over the exposure duration.

**Parameter Name:** POINT **Units:** Unitless **Range:** 1, 2, 3, 5, 9, 17, 33, 65, 129, 257

**Default Value:** 17

**Window:** Time Parameters ☐ Maximum Time Integration Points

**Discussion:** The dose reported at any evaluation time is obtained by numerically integrating the dose rate over the exposure duration at each receptor location. The user can specify the maximum number of points to be used for the time integration. The code will use as many time integration points as is necessary to achieve the present convergence criteria, subject to the maximum points (limits) specified.

The user can select 1, 2, 3, 5, 9, 17, 33, 65, 129, or 257 as the number of points to calculate the time-integrated dose. If the user selects 1, then the instantaneous dose at the user specified time is calculated. The use of integration points is discussed in Appendix H.