DRAFT

AEROSOL RELEASES FROM THE IDAHO CHEMICAL PROCESSING PLANT 1957-1959

ADDENDUM TO

ATMOSPHERIC SOURCE TERMS
FOR THE IDAHO CHEMICAL
PROCESSING PLANT, 1957–1959

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Centers for Disease Control and Prevention
Atlanta, Georgia 30335

SC&A, Inc.
6858 Old Dominion Drive, Suite 301
McLean, Virginia 22101

SENES Oak Ridge, Inc.
102 Donner Drive
Oak Ridge, Tennessee 37830

Authors:

Robert P. Wichner, *SENES* Oak Ridge, Inc.
John-Paul Renier, *SENES* Oak Ridge, Inc.
A. Iulian Apostoaei, *SENES* Oak Ridge, Inc.

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TABLE OF CONTENTS

1.0 INTRODUCTION AND SCOPE 1

2.0 SUMMARY OF THE IDAHO CHEMICAL PROCESSING PLANT OFF-GAS AND STACK SAMPLER SYSTEMS 3

3.0 BETA-MINUS IODINE AND ALPHA RELEASE RECORD 5
- 3.1 Radiochemical Method for Beta-minus Iodine 5
- 3.2 Radiochemical Method for the Alpha Determinations 5
- 3.3 The Beta-minus Iodine and Alpha Release Record 5

4.0 INTERPRETATION OF THE BETA-MINUS IODINE AND ALPHA RELEASES 8
- 4.1 Daily Record of Beta-minus Iodine and Alpha Releases 8
- 4.2 Major Alpha-emitting Nuclides 12

5.0 NUCLIDES COMPRISING THE BETA-MINUS IODINE READINGS 13
- 5.1 Beta-minus Iodine Aerosol Formation Mechanism 13
- 5.2 Calculation of Beta-minus Iodine Releases from Measured Sampler Activities 13
- 5.3 Estimation of Alpha-emitting Aerosols 16
- 5.4 Calculation Procedure and Nuclides Comprising the Beta-minus Iodine Material in RaLa Aerosol Emissions 16

6.0 RESULTS AND DISCUSSION 19
- 6.1 Beta-minus Iodine Release Results 19
- 6.2 Alpha-emitting Aerosols 23
- 6.3 Comparison of Aerosol Releases with the 1991 INEL Historical Dose Evaluation 23
  - 6.3.1 The 1991 INEL Historical Dose Evaluation Method 23
  - 6.3.2 Methodology Differences between the 1991 INEL Historical Dose Evaluation and this Report. 24
  - 6.3.3 Comparison of Annual Releases with the 1991 INEL Historical Dose Evaluation 25

7.0 SUMMARY AND CONCLUSIONS 29

8.0 REFERENCES 30

APPENDICES

Appendix A Daily Beta-minus Iodine and Aerosol Releases from the Idaho Chemical Processing Plant as Reported in the Stack Monitor Data Sheets (with reported iodine-131 releases)

Appendix B Approach for Deriving Releases of Radionuclides Attached to Aerosols

Appendix C Beta-minus Iodine Activity of Solid Radionuclides in Material Testing Reactor Elements and Production During Criticality Accident

Appendix D Effect of Electron-emitting Nuclides and Low Energy Beta-emitters on the Beta-minus Iodine Reading

LIST OF TABLES

Table 3.1 Beta-minus Iodine Activity Measured in the Idaho Chemical Processing Plant Stack for the First Four RaLa Runs as Reported in the Health and Safety Division Annual Report, 1959 5

Table 4.1 Major Actinide Alpha-emitters in a Typical 2-day Cooled RaLa Fuel Element ...12

Table 5.1 Major Contributing Nuclides (>0.1%) to the Beta-minus Iodine Reading During the First Day of a Typical RaLa Run....18

Table 6.1 Estimated Beta-minus Iodine Activity Released Per Run for All Radionuclides..21

Table 6.2 Nuclide Composition of Beta-minus Iodine Releases in Curies: Annual Summary 22

Table 6.3 Monthly Summary of Alpha-emitting Aerosol Releases....23

Table 6.4 Annual Releases of Radionuclides Reported by the 1991 Idaho National Engineering Laboratory Historical Dose Evaluation....26

Table 6.5 Comparison of Alpha-emitting Actinide Contributors to the Aerosol Release 27

Table 6.6 Annual Beta-minus Iodine Aerosol Releases—Comparison to the 1991 Idaho National Engineering Laboratory Historical Dose Evaluation 27

Table 6.7 Dominant Beta-minus Iodine Nuclides in this Study Compared with the 1991 Idaho National Engineering Laboratory Historical Dose Evaluation in Approximate Order of Importance....28

LIST OF FIGURES

Figure 2.1 RaLa and Idaho Chemical processing Plant Off-gas Flow Schematic, 1957-1959 3

Figure 3.1a Portion of the First Page of the Stack Monitor Datasheet for February 1958 6
Figure 3.1b Portion of the Second Page of the Stack Monitor Datasheet for February 1958 7

Figure 4.1 Measured Activity in the Idaho Chemical Processing Plant Stack During May 1957 9
Figure 4.2 Measured Activity in the Idaho Chemical Processing Plant Stack During October 1958 10
Figure 4.3 Measured Activity in the Idaho Chemical Processing Plant Stack During October 1959 11

Figure 6.1 Predicted Releases of La-140 from the Idaho Chemical Processing Plant During October 1958 20

1.0 INTRODUCTION AND SCOPE

This addendum to the main report, *Atmospheric Source Terms for the Idaho Chemical Processing Plant, 1957–1959* (Wichner et al., 2003), addresses the contribution from aerosol releases. The objective is to estimate total activity emitted per day as aerosols and the nuclide composition of the aerosols during this 3-year period.

The main report, which dealt with radioiodine emissions, contains full descriptions of the RaLa Process within the Idaho Chemical Processing Plant (ICPP), the ICPP off-gas system, and an overview of the ICPP. A few key features of the off-gas and stack monitoring systems are briefly reviewed here. The main assumption of this evaluation is that the recorded capture of so-called beta-minus iodine (β-I) beta emitters and alpha (α)-emitting nuclides in the stack sampler, translated into a daily releases to the atmosphere by means of a correlation, were due to aerosol particles.

As noted in the main report, the evaluation of atmospheric releases from the ICPP in the 1957 through 1959 timeframe is hampered by the lack of primary descriptive and interpretive reports. For aerosol releases, only a fragmentary description of the (β-I) measurement method is available and only from unpublished project letters. Nothing at all is available on the procedure for determining the α-emitters, presumably also captured in the stack sampler in these early years. Nor has any report been found on the identification of the nuclide contributors to either the (β-I) or the α-releases. Thus, there is a difficulty in interpretation of the readings.

Identification of the aerosol nuclides would be aided if their source were known. The ICPP off-gas flow combined four reprocessing lines, one of which was RaLa. Radioiodines clearly came from RaLa, since it was the only one processing short-cooled fuel. But the other three reprocessing lines may have contributed to the aerosol releases. In addition, some assumption is required as to formation mechanism in order to determine the age of the particles, which directly bears on the nuclides in the aerosol.

Finally, the correlation connecting the curie amount of (β-I) and α-material captured in the stack sampler to the atmospheric release needs to be evaluated. For radioiodines, this correlation included an efficiency term (assumed to be 50%) and a decay factor to account for the 24-hour sampling period, both of which have a direct bearing on the calculated release.

Presented in this addendum are the following:

- The daily record of (β-I) and α emissions as provided by the Stack Monitor Datasheets (Appendix A)
- Interpretation of the (β-I) and α emissions in terms of contributing nuclides (Appendix B and Table 6.1)
- Review and possible revision of the procedure for determining the daily emissions from the sampler inventory

- Summary of (β-I) aerosol releases presented as annual totals and totals per RaLa run

- Comparison of results with the INEL Historical Dose Evaluation (HDE) reconstruction study (HDE 1991)

2.0 SUMMARY OF THE IDAHO CHEMICAL PROCESSING PLANT OFF-GAS AND STACK SAMPLER SYSTEMS

Figure 2.1 shows a schematic of the ICPP off-gas system in the 1957-1959 time frame. The significant point is that the stack sampler draws from a combined airflow from several sources:

- On a volume basis, the stack flow consisted primarily of ventilation air from the main process building.
- A second source was vessel off-gas (VOG), drawn by suction from all ICPP process vessels, excluding dissolvers and all RaLa vessels.
- The non-RaLa dissolver off-gas (non-RaLa DOG) drew from the three non-RaLa dissolvers in the ICPP.
- The RaLa off-gas (shown as RaLa DOG) drew from all the RaLa process vessels, including the RaLa dissolver, centrifuges, process vessels and storage vessels.

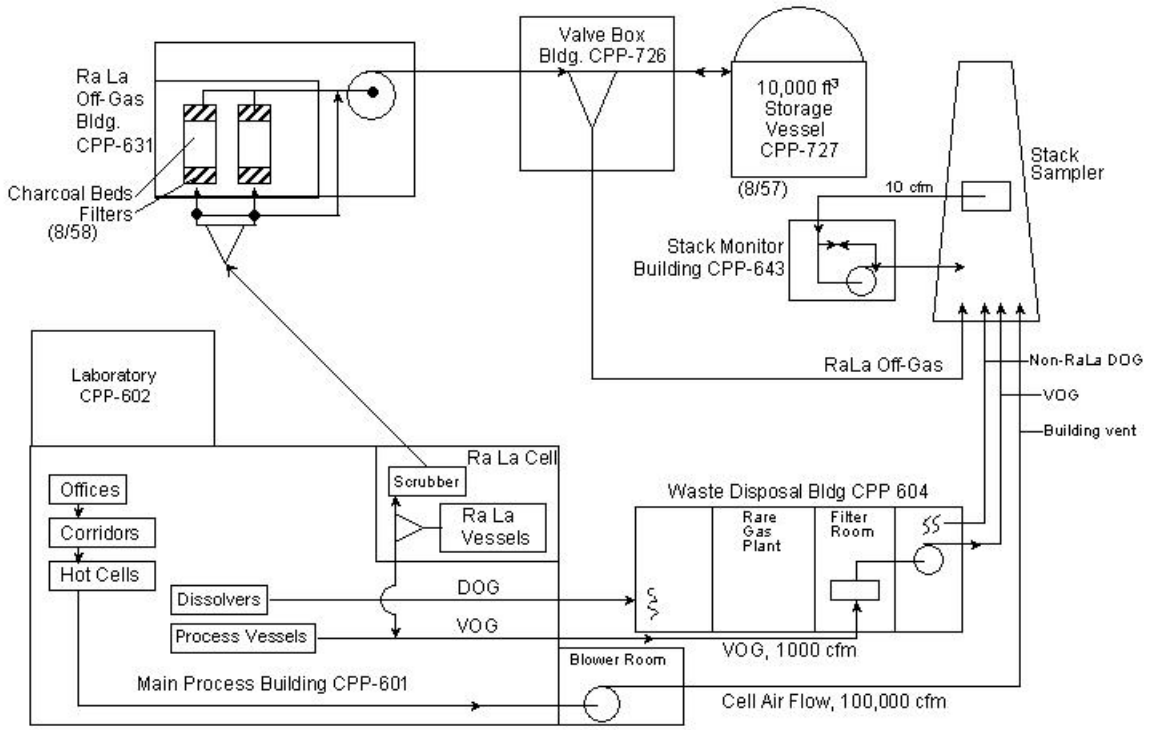


Figure 2.1 RaLa and Idaho Chemical Processing Plant Off-Gas Flow Schematic, 1957–1959

As noted in the main report, numerous piping interties and valve settings make other flow schemes possible, but the schematic shown is believed to be the predominant one.

During most of this period, the stack-sampling device consisted of about a 1-liter bottle fitted with a glass frit base through which the sampled air was bubbled. The flow rate through the sampling bottle was on the order of 0.2 ft^3/min (5.7 liter/min). The capture efficiency for gaseous iodine was administratively set at 50%, a value approximately borne out by numerous tests conducted in 1957.

From the brief discussion of the method for determining the curie level of (β-I) in the sampling bottle, it must be assumed that aerosols were captured in the sampling bottle liquid. No references to filters in the sampling system have been found for this time period. It is surmised that the α-emitting material was also determined from the residue of the sampling bottle contents after evaporation.

The capture efficiency of the sampling bottles for aerosols appears not to have been tested. It will be shown below from the listings in the stack monitor datasheets that a capture efficiency of 100% was assumed for aerosols. There appears to be no good way to evaluate aerosol capture efficiency from the information that is available, but 100% is probably too high.

Another difficulty in the interpretation of the (β-I) data is how to account for decay losses during the 24-hour sampling period when the contributing nuclides are not known. It will also be shown below that this was avoided by assuming no decay loss, i.e., only long-lived aerosol material was assumed to contribute to the (β-I) reading. This is certainly valid for the α-emitters, but not necessarily so for the (β-I) nuclides.

3.0 BETA-MINUS IODINE AND ALPHA RELEASE RECORD

3.1 Radiochemical Method for Beta-minus Iodine

Initial measurements of (β-I) activity were determined by heating the sampler liquid to near boiling, supposedly driving off the iodine, and measuring the resulting β activity. This was the method used in February and March 1957. It was soon recognized that this method did not drive off all the iodine (Rich 1957). The necessary correction, acidifying the sodium hydroxide-sodium thiosulfate sampler solution prior to heating, was made before run 3, April 5, 1957. Table 3.1 illustrates the effect of correcting the radiochemical procedure.

Table 3.1 Beta-minus Iodine Activity Measured in the Idaho Chemical Processing Plant Stack for the First Four RaLa Runs as Reported in the Health and Safety Division Annual Report, 1959

Run number	Date	(β-I) reported release Ci per run
1	Feb. 1-3, 1957	114.6 (incorrect)
2	Feb. 20-21, 1957	334.7 (incorrect)
3	April 5-6, 1957	1.3
4	May 19-20, 1957	6.6

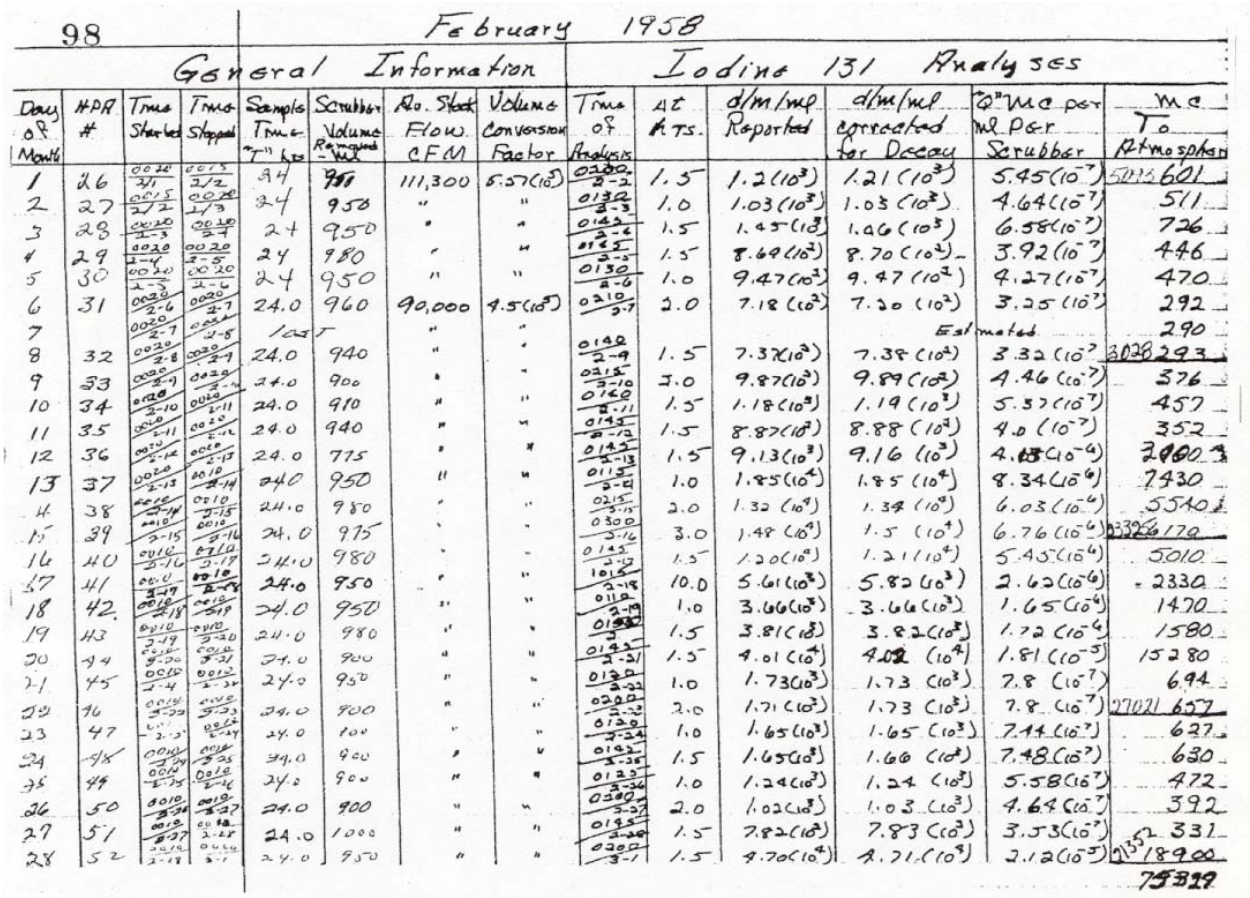
3.2 Radiochemical Method for the Alpha Determinations

No record has been found on the method for determining the α-emissions in the sampler solution. There is no mention of a particulate filter in the sampler line in this time frame. Therefore it must be assumed that the α-emitting particles were captured in the sampler solution. Counting would require evaporation to dryness and emplacement in geometry that counts all emissions, perhaps by a scintillation device that discriminates alphas from other radioactive emissions. (See Price 1958 for a contemporary α-counting method.)

3.3 The Beta-minus Iodine and Alpha Release Record

Figures 3.1a and 3.1b show a portion of the stack sampler data record (Stack Monitor Datasheets, 1957-1961) for February 1958. Figure 3.1a lists the date, sampler and stack flow-rates, sampler volume, I-131 sampler readings, and the calculated I-131 emissions. Figure 3.1b shows the (β–I) and α-readings in the sampler bottle and the calculated (β-I) and α emissions. The assumptions for calculating the emissions are discussed below.

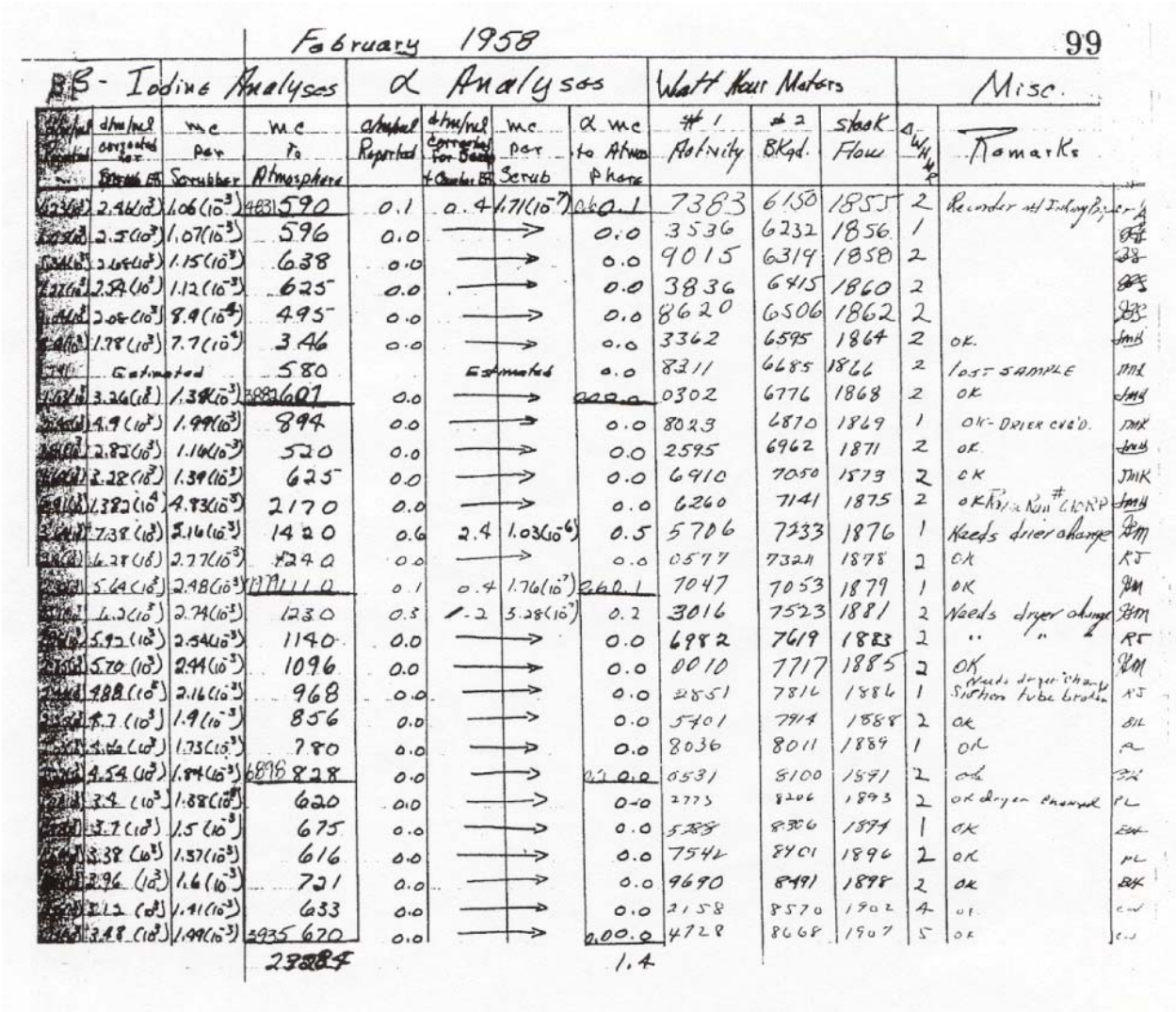
The entire daily (β–I) and α-release record, a portion of which is shown in Figure 3.1b, is reproduced as an Excel spreadsheet in Appendix A. For convenience, the I-131 release record is also recorded in this table taken from Appendix G of the main report. Further discussion of the Stack Monitor Data Sheets is given in Section 6.3 of the main report.



98 February 1958

General Information								Iodine 131 Analyses					
Day of Month	HPR #	Time Started	Time Stopped	Sample Time	Scrubber Volume Required	Ro. Stack Flow CFM	Volume Conversion Factor	Time of Analysis	At Hrs.	d/m/ml Reported	d/m/ml corrected for Decay	mc per ml per Scrubber	mc To Atmosphere
1	26	0020 3/1	0015 3/2	24	950	111,300	5.57(10^3)	0300 3-2	1.5	1.2(10^3)	1.21(10^3)	5.45(10^-7)	601
2	27	0015 3/2	0020 3/3	24	950	"	"	0130 3-3	1.0	1.03(10^3)	1.03(10^3)	4.64(10^-7)	511
3	28	0020 3-3	0020 3-4	24	950	"	"	0145 3-4	1.5	1.45(10^3)	1.46(10^3)	6.58(10^-7)	726
4	29	0020 3-4	0020 3-5	24	980	"	"	0145 3-5	1.5	8.69(10^2)	8.70(10^2)	3.92(10^-7)	446
5	30	0020 3-5	0020 3-6	24	950	"	"	0130 3-6	1.0	9.47(10^2)	9.47(10^2)	4.27(10^-7)	470
6	31	0020 3-6	0020 3-7	24.0	960	90,000	4.5(10^5)	0210 3-7	2.0	7.18(10^2)	7.20(10^2)	3.25(10^-7)	292
7		0020 3-7	0020 3-8	Lost		"	"				Estimated		290
8	32	0020 3-8	0020 3-9	24.0	940	"	"	0140 3-9	1.5	7.37(10^2)	7.38(10^2)	3.32(10^-7)	293
9	33	0020 3-9	0020 3-10	24.0	900	"	"	0215 3-10	3.0	9.87(10^2)	9.89(10^2)	4.46(10^-7)	376
10	34	0020 3-10	0020 3-11	24.0	910	"	"	0140 3-11	1.5	1.18(10^3)	1.19(10^3)	5.37(10^-7)	457
11	35	0020 3-11	0020 3-12	24.0	940	"	"	0145 3-12	1.5	8.87(10^2)	8.88(10^2)	4.0(10^-7)	352
12	36	0020 3-12	0020 3-13	24.0	775	"	"	0145 3-13	1.5	9.13(10^3)	9.16(10^3)	4.13(10^-6)	2900
13	37	0020 3-13	0010 3-14	24.0	950	"	"	0115 3-14	1.0	1.85(10^4)	1.85(10^4)	8.34(10^-6)	7430
14	38	0020 3-14	0010 3-15	24.0	980	"	"	0215 3-15	2.0	1.32(10^4)	1.34(10^4)	6.03(10^-6)	5540
15	39	0010 3-15	0010 3-16	24.0	975	"	"	0300 3-16	3.0	1.48(10^4)	1.5(10^4)	6.76(10^-6)	6179
16	40	0010 3-16	0010 3-17	24.0	980	"	"	0145 3-17	1.5	1.20(10^4)	1.21(10^4)	5.45(10^-6)	5010
17	41	0010 3-17	0010 3-18	24.0	950	"	"	1015 3-18	10.0	5.61(10^3)	5.82(10^3)	2.62(10^-6)	2330
18	42	0010 3-18	0010 3-19	24.0	950	"	"	0110 3-19	1.0	3.66(10^3)	3.66(10^3)	1.65(10^-6)	1470
19	43	0010 3-19	0010 3-20	24.0	980	"	"	0145 3-20	1.5	3.81(10^3)	3.82(10^3)	1.72(10^-6)	1580
20	44	0010 3-20	0010 3-21	24.0	900	"	"	0145 3-21	1.5	4.01(10^4)	4.02(10^4)	1.81(10^-5)	15280
21	45	0010 3-21	0010 3-22	24.0	950	"	"	0130 3-22	1.0	1.73(10^3)	1.73(10^3)	7.8(10^-7)	694
22	46	0010 3-22	0010 3-23	24.0	900	"	"	0200 3-23	2.0	1.71(10^3)	1.73(10^3)	7.8(10^-7)	27021 657
23	47	0010 3-23	0010 3-24	24.0	900	"	"	0130 3-24	1.0	1.65(10^3)	1.65(10^3)	7.44(10^-7)	627
24	48	0010 3-24	0010 3-25	24.0	900	"	"	0145 3-25	1.5	1.65(10^3)	1.66(10^3)	7.48(10^-7)	630
25	49	0010 3-25	0010 3-26	24.0	900	"	"	0130 3-26	1.0	1.24(10^3)	1.24(10^3)	5.58(10^-7)	472
26	50	0010 3-26	0010 3-27	24.0	900	"	"	0200 3-27	2.0	1.02(10^3)	1.03(10^3)	4.64(10^-7)	392
27	51	0010 3-27	0010 3-28	24.0	1000	"	"	0145 3-28	1.5	7.82(10^2)	7.83(10^2)	3.53(10^-7)	331
28	52	0010 3-28	0010 3-1	24.0	950	"	"	0300 3-1	1.5	4.70(10^4)	4.71(10^4)	2.12(10^-5)	27352 18900
													75322

Figure 3.1a Portion of the First Page of the Stack Monitor Datasheet for February 1958



February 1958 99

	β - Iodine Analyses			α Analyses				Watt Hour Meters			Misc.	
	dtm/ml corrected for Scrub Eff	mc per Scrubber	mc to Atmosphere	dtm/ml Reported	dtm/ml corrected for Scrub + Counter Eff	mc per Scrub	α mc to Atmosphere	#1 Activity	#2 BKgd.	Stack Flow	Δ WH	Remarks
	2.46(10^-3)	1.06(10^-3)	4831 590	0.1	0.4	1.71(10^-7)	0.1	7383	6150	1855	2	Recorder not Inking Properly
	2.5(10^-3)	1.07(10^-3)	596	0.0	→		0.0	3536	6232	1856	1	
	2.64(10^-3)	1.15(10^-3)	638	0.0	→		0.0	9015	6319	1858	2	
	2.54(10^-3)	1.12(10^-3)	625	0.0	→		0.0	3836	6415	1860	2	
	2.06(10^-3)	8.9(10^-4)	495	0.0	→		0.0	8620	6506	1862	2	
	1.78(10^-3)	7.7(10^-4)	346	0.0	→		0.0	3362	6595	1864	2	OK.
	Estimated		580		Estimated		0.0	8311	6685	1866	2	LOST SAMPLE
	3.26(10^-3)	1.38(10^-3)	3882 607	0.0	→		0.0	0302	6776	1868	2	OK
	4.9(10^-3)	1.99(10^-3)	894	0.0	→		0.0	8023	6870	1869	1	OK- DRIER CHG'D.
	2.82(10^-3)	1.16(10^-3)	520	0.0	→		0.0	2595	6962	1871	2	OK.
	2.28(10^-3)	1.39(10^-3)	625	0.0	→		0.0	6910	7050	1873	2	OK
	1.382(10^-4)	4.83(10^-3)	2170	0.0	→		0.0	6260	7141	1875	2	OK Pump Run # CHRP
	7.38(10^-3)	3.16(10^-3)	1420	0.6	2.4	1.03(10^-6)	0.5	5706	7333	1876	1	Needs drier change
	6.28(10^-3)	2.77(10^-3)	1240	0.0	→		0.0	0577	7321	1878	2	OK
	5.64(10^-3)	2.48(10^-3)	1111 0	0.1	0.4	1.76(10^-7)	0.1	7047	7053	1879	1	OK
	6.2(10^-3)	2.74(10^-3)	1230	0.5	2	3.28(10^-7)	0.2	3016	7523	1881	2	Needs dryer change
	5.92(10^-3)	2.54(10^-3)	1140	0.0	→		0.0	6982	7619	1883	2	" "
	5.70(10^-3)	2.44(10^-3)	1096	0.0	→		0.0	0010	7717	1885	2	OK
	4.88(10^-3)	2.16(10^-3)	968	0.0	→		0.0	2851	7816	1886	1	Needs dryer change Siphon tube broken
	4.7(10^-3)	1.9(10^-3)	856	0.0	→		0.0	5401	7914	1888	2	OK
	3.66(10^-3)	1.73(10^-3)	780	0.0	→		0.0	8036	8011	1889	1	OK
	4.54(10^-3)	1.84(10^-3)	6898 828	0.0	→		0.0	0531	8100	1891	2	ok
	3.4(10^-3)	1.88(10^-3)	620	0.0	→		0.0	2773	8206	1893	2	OK dryer changed
	3.7(10^-3)	1.5(10^-3)	675	0.0	→		0.0	5388	8306	1894	1	OK
	3.38(10^-3)	1.37(10^-3)	616	0.0	→		0.0	7542	8401	1896	2	OK
	3.96(10^-3)	1.6(10^-3)	721	0.0	→		0.0	9690	8491	1898	2	OK
	3.12(10^-3)	1.41(10^-3)	633	0.0	→		0.0	2158	8570	1902	4	OK
	3.48(10^-3)	1.49(10^-3)	3935 670	0.0	→		0.0	4728	8668	1907	5	OK
			23884				1.4					

Figure 3.1b Portion of the Second Page of the Stack Monitor Datasheet for February 1958

As noted in the main report, the Stack Monitor Datasheets were summarized in internal letters, the so-called Hayden Notegrams (1957-1961), which were then, without reference, summarized in the Health and Safety Division Annual reports (e.g., H & S Annual, 1959), and finally adopted in the INEL Historical Dose Evaluation (HDE 1991).

4.0 INTERPRETATION OF THE BETA-MINUS IODINE AND ALPHA RELEASES

4.1 Daily Record of Beta-minus Iodine and Alpha Releases

Figures 4.1, 4.2, and 4.3 plot the reported α and (β-I) daily measurements for the representative months of May 1957, October 1958, and October 1959, respectively.

We note first that the peaks in the α-readings seem generally to correlate with dates of RaLa runs. This is at least true for runs 4, 19, and 34 (but mysteriously not run 18). However, no other α-peaks are observed. Therefore, it seems reasonable to assume that the reported α-releases emanate from the RaLa fuel processing activity.

Similarly, the (β-I) release peaks seem to generally correlate with dates of RaLa runs, i.e., for runs 5, 18, 19, and 31.

It is important to note that not all (β-I) peaks correspond to I-131 peaks, and vice versa. The prominent I-131 peaks on May 22, 27, and October 15 have no corresponding (β-I) peaks. Also the prominent (β-I) peak of October 13 has no corresponding I-131 peak. These are important indications that the (β-I) readings were not simply residual iodine. (However, confirmation by at least one γ-spectrometer reading would have been extremely informative.)

Note the release behavior on October 16, 1959, the date of the criticality accident. (See Section 8 of the main report for a discussion of this accident.) There was a high (β-I) peak corresponding exactly to an I-131 peak, but there is no α-peak. Undoubtedly, the reason for the absence of an α–peak following the criticality accident is the absence of significant α activity produced in the brief criticality of an HEU solution. As shown below, the principal α activity in the RaLa peaks was the Pu-238 produced during Material Testing Reactor (MTR) irradiation. There were only minute amounts of Pu-238 produced in the criticality.

Conclusion regarding α and (β-I) release data. Though there are some unexplained details, the general view that the (β-I) and α readings represent aerosol emissions appears to be valid. Moreover, the daily record shown in Figures 4.1, 4.2 and 4.3 seem to indicate the source was the RaLa process solutions, except for the criticality accident.

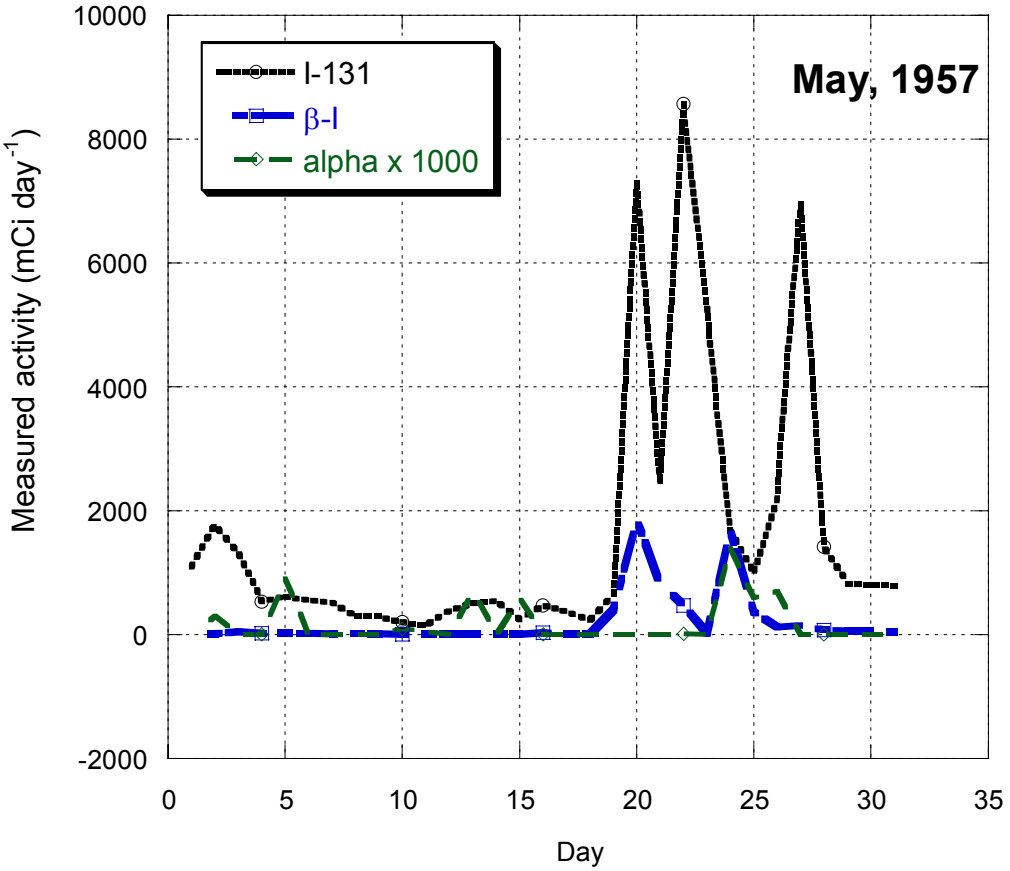


Figure 4.1 Measured Activity in the Idaho Chemical Processing Plant Stack During May 1957

RaLa Run #4 took place on May 19 –20

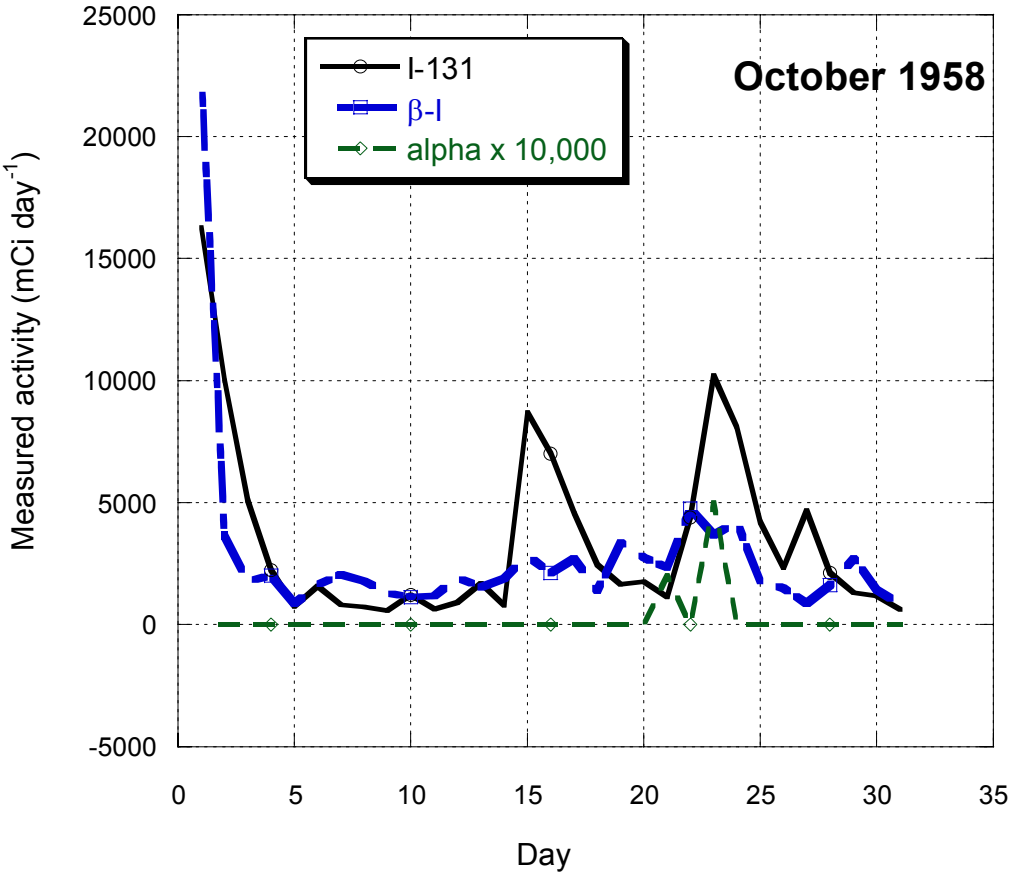


Figure 4.2 Measured Activity in the Idaho Chemical Processing Plant Stack During October 1958

RaLa Run #18 took place on October 1 (1-day run)
RaLa Run #19 took place on October 22 (1-day run)

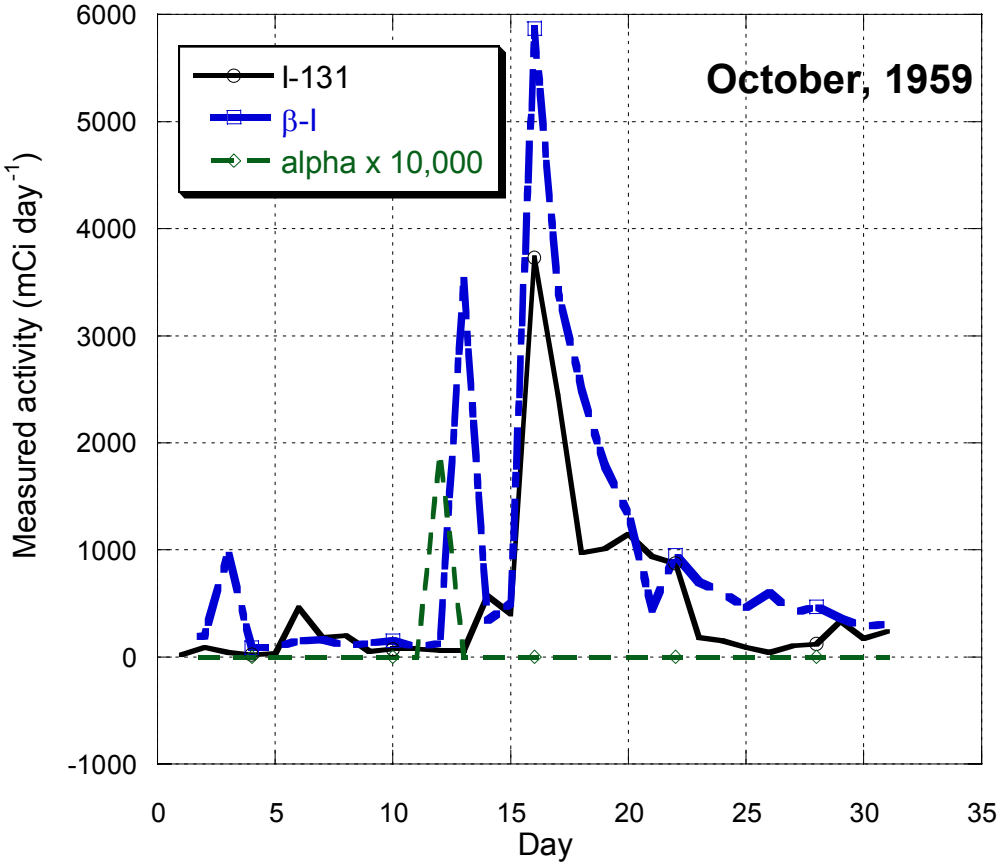


Figure 4.3 Measured Activity in the Idaho Chemical Processing Plant Stack During October 1959

RaLa Run # 34 took place on October 13-14

The criticality accident took place on October 16

4.2 Major Alpha-emitting Nuclides

As noted, Figures 4.1, 4.2, and 4.3 seem to indicate that the α-emitting aerosols were formed from RaLa process solutions, perhaps from dried droplets or from splatter and subsequent liftoff. In such case, the α-emitters would be representative of the RaLa process solution.

Table 4.1 lists the major actinide α-emitters in a typical 2-day cooled MTR element designated for use in RaLa as determined by an ORIGEN2 calculation.

The actinide levels were calculated assuming a "typical" highly enriched uranium (HEU) diffusion plant product of 93.5% U-235 and 6.5% U-238. The actual feed composition may vary somewhat case to case. Also note that the α-decay chain products of the three uranium isotopes were assumed to be zero in the as-charged fuel element. These would depend on the age of the diffusion plant product at the time of insertion of the fuel element into the MTR. These approximations should have a minor effect on the results in view of the extremely low level of α-emissions observed in the stack sampler solutions.

Table 4.1 Major Actinide Alpha-emitters* in a Typical 2-day Cooled RaLa Fuel Element

Nuclide	% Contribution to the activity (Ci)
U-234	0.253
U-235	0.121
U-236	0.331
Pu-238	95.947
Pu-239	1.358
Pu-240	0.846
Cm-242	0.990

*All actinide α-emitters contributing more than 0.1% to the total actinide curie level in the fuel element (including β-emitters U-237, Np-238, Np-239).

The table shows that the major α-emitting actinide aerosol was Pu-238 with minor contributions from Pu-239, Pu-240, and Cm-242, and even lesser contributions from U-234, U-235, and U-236.

It should also be noted that the α-decay chain products of the actinides listed in Table 4.1 would also be present in the aerosol, contributing to the total measured α Ci level. Thus the mix of nuclides in the aerosol is more complex than the composition shown in the table, which includes only the actinides. A more complete portrayal of the composition would include the various decay chain products of the actinides listed in the table. However, inclusion of the decay products would not affect the total alphas measured in the stack, only the composition (see Section 6 – Results and Discussion). Of course, the decay chain products are accounted for in the determination of the dose from exposure to the above actinides.

5.0 NUCLIDES COMPRISING THE BETA-MINUS IODINE READINGS

5.1 Beta-minus Iodine Aerosol Formation Mechanism

Above it was shown that the time trace of the (β-I) release readings correlated roughly with RaLa run dates and therefore was probably produced by some RaLa processing activity. Formation mechanisms could have been the following:

(1) Dryout of droplets formed from pumping or sampling the RaLa process solutions either directly from the dissolver and other process vessels, or delayed release from dried out splatter.

(2) Daughters of volatilized iodine, xenon, bromine or krypton from the RaLa process solutions.

(3) Adsorption of iodine or other volatilized material onto carbonate aerosols produced by reaction of the alkaline scrubber solution with carbon dioxide.

(4) Dusts associated with the operation of the charcoal beds.

(5) There remains the possibility that the (β-I) activity was actually residual I-131 and other radioiodines, incompletely driven off from the sampler solution by the acidification and heating process. However, as the above discussion showed, the (β-I) and I-131 peaks occasionally did not correspond, suggesting that the (β-I) readings were probably not residual radioiodines.

Mechanism 1 appears to be the most likely formation method although mechanisms 3 and 4 may also contribute.

Mechanism 2 could be eliminated by noting that few solid radioactive daughters of the volatile material would exist in 2-day cooled fuel.

Mechanism 5 remains a possibility. However, the non-correspondence of some (β-I) peaks with I-131 peaks seems to indicate that this was not the case. (It is unfortunate that γ-spectroscopy analysis of the (β-I) material was not performed; at least, none have been found.) The analysis of (β-I) activity outlined below is based on the assumption that mechanism 1 was the command aerosol production method.

5.2 Calculation of Beta-minus Iodine Releases from Measured Sampler Activities

Section 5.2 of the main report (Wichner, Renier and Anspaugh 2003) describes the relationship between the radioiodine sampler activity and release to the atmosphere, as used by ICPP personnel for I-131 and I-132. The situation is quite different for (β-I) aerosol releases in that the individual isotopic activities were not known. Hence, the decay correction for the 24-hour

sampling period could not be applied. In addition, no measurement was ever made (or none has been found) on the efficiency of aerosol capture in the sampler. As a result, ICPP personnel assumed 100% capture efficiency for aerosols in the sampler.

These two considerations led to the following simple relationship between (β-I) releases to the atmosphere and the measured sampler (β-I) activity employed by ICPP personnel:

$$R_{reported} = A_m Q_{stk}/Q_{sampler} \quad (5.1)$$

where,

$R_{reported}$	reported (β-I) atmospheric releases per sampling period, Ci
A_m	(β-I) activity measured in the sampler at the end of the 24-hour sampling period, Ci
Q_{stk}	stack air flowrate, m^3d^{-1}
$Q_{sampler}$	sampling flowrate, m^3d^{-1}

Values of $R_{reported}$ determined by Equation 5.1 were recorded in the Stack Monitor Datasheets (1957-1959) for each day of RaLa operation, from February 1957 through December 1959, and beyond. These values are reproduced in Appendix A.

Actual (β-I) releases differed from the reported releases for at least the following two reasons:

- The sampler capture efficiency for aerosols was undoubtedly less than 100%. No measurement has been found, but our judgment is that 50% efficiency is a more realistic estimate, which is the same as the assumed capture efficiency for radioiodine.

- Decay correction factors, if they could be applied, would tend to elevate the releases. These would be corrections both for decay in the sampler during the 24-hour sampling period and for the delay time before counting.

Adopting the mechanism 1 view of aerosol formation and further assuming that each nuclide contributes an equal fraction of its current inventory in the RaLa system to the aerosol material leads to the following:

$$R_i(t_n) = a\, A_{d,i}(t_n) \quad (5.2)$$

where,

$R_i(t_n)$ =	release of nuclide i to the atmosphere during sampling period on day t_n, Ci
a =	dimensionless factor
$A_{s,i}(t_n)$ =	activity of nuclide i in the RaLa system on day t_n after removal of the element from the MTR, Ci

Using Equation 5.2 as the principal assumption, Appendix B outlines a method for correcting the reported releases determined by Equation 5.1 that accounts for decay in the sampler during the sampling period and the delay time prior to counting. In addition, the individual nuclides contributing to the total (β-I) release may be identified.

As shown in Appendix B,

$$R_{corrected} = R_{reported} \cdot \frac{1}{f} \cdot \frac{\sum A_{d,i}}{S} \qquad (5.3)$$

where,

$R_{corrected}$ =	decay and sampler efficiency corrected (β-I) release to the atmosphere, Ci
F =	sampler efficiency
S =	$S = \sum_{\lambda} A_{d,i}\ Y_i \frac{1 - \exp(-\lambda_i t_s)}{\lambda_i t_s} \exp(-\lambda_i t_w)$ (See Appendix B)
Y_i =	the number of β-particles and ejected electrons emitted per disintegration that may be read by the 1957 detectors. (See discussion in Appendix D.)
λ_i =	decay constant of nuclide i, sec^{-1}
t_s =	sampling duration, usually 24 hours
t_w =	time delay from sample withdrawal to counting, sec

The major correction compared to the reported releases is due to assuming a sampler efficiency of 50% compared to 100% assumed in the Stack Monitor Datasheets. This effectively doubles the reported daily releases listed in Appendix A. As shown in sample calculations in Appendix B, the correction due to the factor $\Sigma A_{s,i}/S$ is on the order of 7% to 14%, depending on t_n.

Early records in the Stack Monitor Datasheets indicated that t_w ranged from 3 to 72 hours, with an average of 14 hours, at least for the month of April 1957. Since t_w had a minor impact on 8.3-day I-131, it ceased to be recorded early in 1957. The average t_w of 14 hours was assumed for the computation of the Appendix C tables.

The factor Y_i is required to account for the fact that some of the disintegrations emit betas too weak to be read by 1957 detectors. The discussion in Appendix D concludes that betas less than about 25 keV energy would not have penetrated the 1957 detector window. Nevertheless, such nuclides are included by ORIGEN2 as contributing curies, but in fact were not counted for at least a portion of the disintegrations. As seen in Appendix C, Tc-99m, Ru-106, and Ba-137m fall into this category.

The factor Y_i also corrects for cases where the total β plus e- emissions greater than 25 keV exceed unity per disintegration by virtue of knockout of interior orbital electrons by γ-rays. The Appendix C listing shows that U-237 and Np-239 fall into this category.

It is further shown in Appendix B that the assumption embodied in Equation 5.2 enables identification of the contributions of individual nuclides to the total release, in accordance with the following equation:

$$R_i(t_n) = R_{reported}(t_n)\frac{A_{d,i}(t_n)}{f\,S(t_n)} \qquad (5.4)$$

where

$R_i(t_n)$ = emission of radionuclide i on day t_n, Ci

That is, the factor $A_{d,i}/(f\,S)$, computed for each day for the solid fission products and β-emitting actinides using ORIGEN2, when multiplied by the reported release for that day from Appendix A, yields the contribution to the release by nuclide i. Such contributions are listed in the fourth column of Table C.1 for each of 3 to 33 days following withdrawal from the MTR, and in Table C.2 for the eight days following the October 16, 1957, criticality accident.

5.3 Estimation of Alpha-emitting Aerosols

Since the α-emitters are generally fairly long-lived actinides, the decay corrections used for the (β-I) readings are not necessary. Including only a sampler efficiency correction leads to the following:

$$R^{\alpha}_{corrected} = R^{\alpha}_{reported}/f \qquad (5.5)$$

where,

$R^{\alpha}_{reported}$ = α -emissions listed in the stack monitor data sheets for each day, reproduced in Appendix A, Ci

f = sampler efficiency

As for the (β-I) emissions, a sampler efficiency of 50% is assumed, because it is judged to be more reasonable than the 100% efficiency assumed by ICPP analysts. In addition, the mixture of α-emitters is not likely to significantly change during the time between RaLa runs. Therefore, the composition of the α-emitting aerosols may be identified by examining a typical mixture given by ORIGEN2. Thus the actinide mixture shown in Table 4.1 should be typical for the α-emitting aerosols for all days following the dissolving. As noted, Pu-238 dominates the α-activity, with about 96% of the total.

5.4 Calculation Procedure and Nuclides Comprising the Beta-minus Iodine Material in RaLa Aerosol Emissions

Equations 5.2 through 5.4 indicate the procedure for estimating a typical aerosol release and its composition. It should be emphasized that these results are only "typical" because of the

incomplete information on the inventory of nuclides in the RaLa feed elements[1] and the approximate nature of the assumption expressed in Equation 5.2. We have arbitrarily selected the feed element for RaLa run 2 as typical and assumed the nominal 2-day cooling prior to insertion into the dissolver. The calculation proceeds as follows:

- Nuclide inventories for the selected feed element are determined from ORIGEN2 for the selected typical element. Gases and halogens are removed from the list; the rest are assumed to contribute to the aerosols. Beta-emitting actinides, listed separately by ORIGEN2, are included with the fission products, which are all β-emitters. Inventories are calculated for a range of decay times, from an assumed 2-day decay prior to insertion to the maximum number of days between runs. Appendix C lists these inventories out to 33 days cooling time (i.e., 1-30 days after dissolving).

- The factor Y is determined for each nuclide from information contained in ORIGEN2. As noted above, Y is the average number of betas and knockout orbital electrons emitted per disintegration that would be counted by the 1957 vintage detectors. The effect of the parameter Y is seen in the Appendix C tables in the column labeled "Effective Activity."

- The parameter S for Equations 5.3 and 5.4 is determined by summation for each day after dissolving, enabling calculation of $R_{corrected}$, and the contributions from the individual nuclides. Appendix C lists these %-contributions to the total (β-I).

- Corrected total atmospheric releases are determined using the above parameters in conjunction with the reported daily releases reproduced in Appendix A. The composition for each day was used, starting with $t_n = 3$ for the first day of the dissolving, up to the day in which the next RaLa run was started.

This procedure was suggested by the method used in the Historical Dose Evaluation study (HDE 1991) and perhaps is a refinement thereof. The refinements include (1) a better estimate of the fuel element inventory (though still merely typical), (2) an accounting for the decay of individual nuclides in the sampler and prior to counting, (3) a more inclusive β-emitting nuclide list using ORIGEN2, and (4) an accounting of the effective activity based on countable emitted betas and electrons.

Table 5.1 reproduces a portion of the first day results, taken from Appendix C.1. Nuclides contributing less than 0.1% were rounded off to zero and omitted from Table 5.1, but included in Table C.1. Note that La-140 and Ba-140 are prominent contributors to the (β-I) release. Since the RaLa process efficiently separated this product from the balance of the flow stream, the contributions to aerosol release undoubtedly were different from that indicated in the tables. How different depends on precisely where in the system the aerosols are produced.

[1] Chapter 4 of the main report describes the difficulties encountered in attempting to identify the feed elements and their decay times.

Table 5.1 Major Contributing Nuclides (>0.1%) to the Beta-minus Iodine Reading During the First Day of a Typical RaLa Run (i.e., $t_n = 3$)
Determined from Equation 5.4

Isotope	Activity Ci	Effective Activity* Ci	Fraction† %
La-140	47,750	49,100	11.016
Pr-143	43,940	43,940	9.858
Ba-140	43,890	52,200	11.712
Ce-141	30,630	37,820	8.485
Mo-99	30,270	30,900	6.933
Tc-99m	29,160	3,218	0.722
Te-132	23,790	29,980	6.726
Zr-95	22,090	22,120	4.963
Y-91	21,670	21,670	4.862
Sr-89	18,920	18,920	4.245
Nd-147	15,520	25,170	5.647
Ce-143	14,410	17,390	3.902
Ru-103	14,180	14,360	3.222
Rh-103m	12,780	11,530	2.587
Nb-95	9,167	9,181	2.06
U-237	7,647	17,100	3.837
Pm-149	6,646	6,665	1.495
Pr-144	5,184	5,184	1.163
Ce-144	5,183	6,021	1.351
Nb-97	3,438	3,445	0.773
Zr-97	3,420	3,425	0.768
Rh-105	1,885	1,893	0.425
Sm-153	1,652	2,641	0.593
Pm-148	1,310	1,314	0.295
Te-127	965	966	0.217
Sb-127	962	1,017	0.228
Te-131m	849	1,009	0.226
Np-239	846	1,966	0.441
Pm-151	773	957	0.215
Y-93	506	507	0.114
Np-238	324	496	0.111
Total (listed nuclides)	**419,757**	**442,104**	**99.19**
Total (all nuclides)	**427,042**	**445,709**	**100.00**

* The effective activity is given by the number of electrons (detectable by the 1957-9 β-detector) per disintegration; expressed in Curies.

† The fractional contribution to the recorded (β-I) release, calculated using the effective activity.

6.0 RESULTS AND DISCUSSION

6.1 Beta-minus Iodine Release Results

The total daily (β-I) releases were determined using Equation 5.3 from the reported daily releases, reproduced in Appendix A corrected for an assumed sampler efficiency of 50% and decay prior to counting. The missing data for runs 1 and 2 were reconstructed from the observed releases for runs 3 through 8, which averaged about 12.5 Ci per run. Thus the "observed" releases for runs 1 and 2 were assumed to be 12.5 Ci each, distributed in time similar to RaLa run 4.

The corrected daily releases are available electronically, but as noted above, are twice the reported releases listed in Appendix A multiplied by a decay correction factor of approximately 1.10.

Total (β-I) releases per run are listed in Table 6.1. The average release was 45.3 Ci/run, with a total of 1675.3 for the 3-year period. (Annual releases are listed below in Table 6.6, compared with the evaluation in HDE 1991). Figure 6.1 shows the daily releases of La-140 from the ICPP during October 1958. The predicted releases generally follow the trends for total reported (β-I) releases for October 1958 (Figure 4.2).

Individual nuclide compositions of the releases were determined for each day from February 1, 1957, through December 30, 1959, by means of Equation 5.4. This voluminous file is also available electronically. The daily compositions consist of 114 fission product nuclides plus β and electron emitting actinides, which contribute a miniscule portion of the (β–I) release.[2] Annual summaries of the nuclide contributions to the (β–I) release are given in Table 6.2. The table includes all nuclides contributing more than 0.1% to the total release for the years 1957 through 1959.

[2] Alpha-emitting actinides also emit Auger and internal conversion electrons, some of which may be read by 1957-vintage (β–I) detectors. For example, about 8% of the Pu-238 disintegrations emit IC electrons in excess of 25keV. But β and electron emissions from actinides contribute a tiny portion of the (β–I) reading.

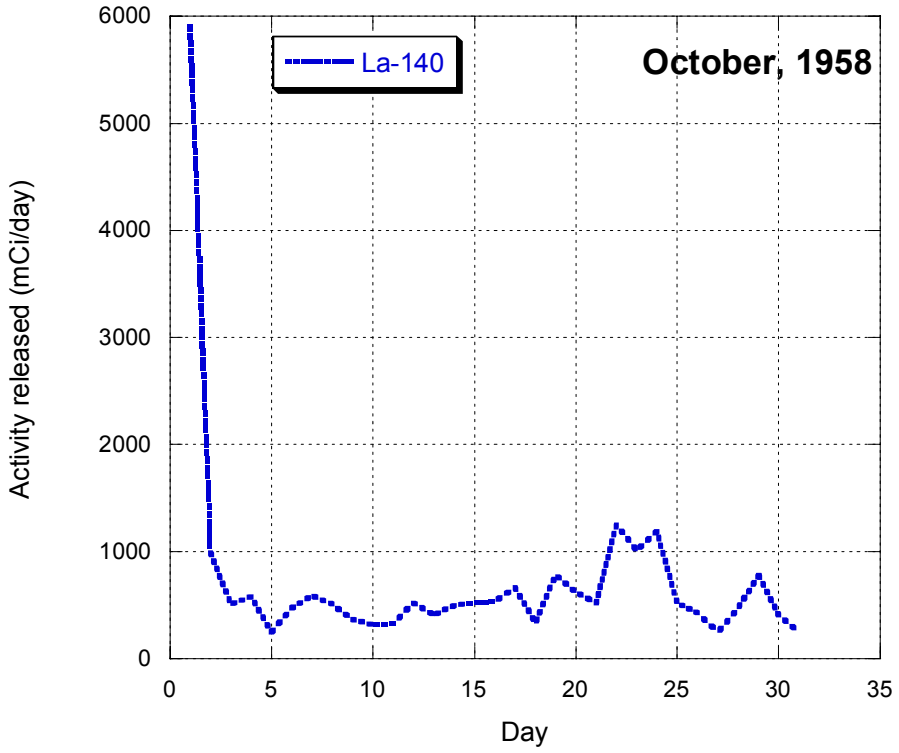


Figure 6.1 Predicted Releases of La-140 from the Idaho Chemical Processing Plant During October 1958

RaLa Run #18 took place on October 1 (1-day run)
RaLa Run #19 took place on October 22 (1-day run)

Table 6.1 Estimated Beta-minus Iodine Activity Released Per Run for All Radionuclides

Run no.	No. of days until next run	Date	Total Ci/run
1	19	February 1, 1957	27.9
2	44	February 20, 1957	27.8
3	44	April 5, 1957	3.0
4	36	May 19, 1957	15.3
5	79	June 24, 1957	14.3
6	26	September 11, 1957	11.4
7	14	October 7, 1957	23.6
8	77	October 21, 1957	87.6
9	37	January 6, 1958	59.9
10	29	February 12, 1958	58.4
11	34	March 13, 1958	27.7
12	14	April 16, 1958	20.4
13	28	April 30, 1958	52.7
14	5	May 28, 1958	66.2
15	65	June 2, 1958	116.6
16	7	August 6, 1958	33.3
17	49	August 13, 1958	170.1
18	21	October 1, 1958	138.6
19	21	October 22, 1958	68.0
21	84	November 12, 1958	157.6
22	21	February 4, 1959	36.4
23	21	February 25, 1959	14.1
24	21	March 18, 1959	17.7
25	21	April 8, 1959	23.7
26	20	April 29, 1959	60.0
27	22	May 19, 1959	48.8
28	26	June 10, 1959	59.7
29	15	July 6, 1959	18.4
30	21	July 21, 1959	18.8
31	21	August 11, 1959	21.1
32	21	September 1, 1959	8.9
33	21	September 22, 1959	10.6
34	3	October 13, 1959	11.9
Criticality accident	20	October 16, 1959	107.4
35	25	November 5, 1959	20.1
36	15	November 30, 1959	5.6
37	17	December 15, 1959	11.3
		Grand Total	**1,675.3**

Table 6.2 Nuclide Composition of Beta-minus Iodine Releases in Curies: Annual Summary

Isotope	1957	Year 1958	1959	Total	Half-life T1/2	units	Percent of the total
LA140	21	101	51	173	40.272	hours	10.30%
PR143	20	94	48	162	13.56	days	9.66%
CE141	21	96	42	159	32.501	days	9.52%
BA140	18	89	46	154	12.74	days	9.17%
ZR095	19	84	34	137	63.98	days	8.19%
Y091	18	81	33	132	58.51	days	7.88%
SR089	15	68	28	112	50.5	days	6.66%
NB095	14	57	20	92	35.15	days	5.47%
RU103	10	47	20	78	39.28	days	4.67%
RH103M	9.5	43	18	71	56.12	minutes	4.21%
ND147	6.0	29	16	50	10.98	days	3.01%
MO099	5.4	24	20	50	66	hours	2.97%
TC099M	5.2	23	19	48	6.02	hours	2.84%
TE132	4.6	21	16	41	78.2	hours	2.48%
PR144	5.6	23	9.1	38	17.28	minutes	2.27%
CE144	5.6	23	9.1	38	284.3	days	2.27%
CE143	1.7	8.1	13	23	33	hours	1.36%
U237	2.2	10	5.2	18	6.75	days	1.07%
NB097	0.28	1.5	9.2	11	72.1	minutes	0.66%
ZR097	0.28	1.5	8.8	11	16.9	hours	0.63%
NB097M	0.27	1.4	8.3	10	60	seconds	0.60%
PM149	1.0	4.7	3.8	9.6	53.08	hours	0.57%
Y093	0.032	0.19	6.4	6.6	10.1	hours	0.39%
SR091	0.021	0.13	5.4	5.6	9.5	hours	0.33%
RH105	0.23	1.1	2.3	3.6	35.3	hours	0.22%
Y091M	0.011	0.074	3.4	3.5	49.71	minutes	0.21%
PM147	0.54	2.16	0.78	3.5	2.6234	years	0.21%
PM148	0.33	1.55	0.77	2.7	5.37	days	0.16%
RH106	0.33	1.36	0.52	2.2	29.9	seconds	0.13%
RU106	0.33	1.36	0.52	2.2	368.2	days	0.13%
Y092	0.00	0.00	2.1	2.1	3.54	hours	0.13%
SM153	0.24	1.09	0.73	2.1	46.7	hours	0.12%
TE127	0.24	1.09	0.70	2.0	9.35	hours	0.12%
TE129M	0.26	1.17	0.51	1.9	33.6	days	0.12%
PR145	0.00	0.00	1.9	1.9	5.98	hours	0.11%
SB127	0.20	0.92	0.67	1.8	3.85	days	0.11%
Total *	**209.4**	**951.7**	**514.2**	**1,675.3**			100%
Listed *	**207.5**	**943.2**	**506.7**	**1,657.5**			98.94%

* There are 114 nuclides released. The listed ones have a release greater than 0.1% of the total release.

6.2 Alpha-emitting Aerosols

Daily releases of α-emitters as reported in the Stack Monitor Data Sheets are reproduced in Appendix A from start of operations in February 1957 through December 1959. Monthly summaries are given in Table 6.3.

Table 6.3 Monthly Summary of Alpha-emitting Aerosol Releases

	1957 mCi	1958 mCi	1959 mCi	Grand Total mCi
January	0	19.4	0.8	
February	161	1.8	0	
March	17.6	5.2	1.2	
April	4	6.8	0.6	
May	10.72	18.2	17.4	
June	2.16	24.4	4.8	
July	3.08	14.2	69.8	
August	3	11.4	4.8	
September	8.2	12	0.42	
October	10.8	1.4	0.38	
November	6.18	3.4	22.98	
December	9.6	0.8	2.92	
Total	**236.3**	**119.0**	**126.1**	**481.4**

Table 6.3 gives a set of estimated daily releases obtained, assuming that the stack monitor sampler has 50% efficiency (as opposed to 100% assumed by the contemporary operators). Thus, the daily estimates were obtained by multiplying the daily α releases reported in the datasheets by two. Note that units of Table 6.3 are mCi, and thus the α–releases are quite small compared with the (β-I) releases. The probable composition of the α-emitting aerosols is given in Table 4.1, where it is seen that about 96% of the α-aerosol emission is predicted to be Pu-238.

6.3 Comparison of Aerosol Releases with the 1991 INEL Historical Dose Evaluation

6.3.1 The 1991 INEL Historical Dose Evaluation Method

The HDE (1991) methodology is described in Appendix A starting on page A-37 of that report. There are several significant differences relative to this study.

As in this study, the HDE task group assumed that the (β-I) readings represented aerosol emissions from the RaLa process captured in the stack monitor sampler bottle. Evidently, the run summary reports in AEC (1959), summed to yield annual (β-I) emissions, were used in the evaluation.

Alpha releases reported in the Hayden Notegrams[3] appear not to have been used. Alpha-emitters were included together with the (β-I) listing.

The HDE (1991) determined the radionuclide inventory in a "typical" RaLa feed element as follows:

- The inventories of Sr-89, Sr-90, Sr-91 and Ba-140, hand calculated for an ideal irradiation and reported in Anderson (1959),[4] were used to determine the burn-up and specific power of the fuel element.

- RSAC-4 was then used to enumerate the principal fission products, assuming a nominal 2-day cooling period.[5]

The RSAC-4 total curies for each fission product were then adjusted proportionately to yield a sum equal to the (β-I) readings reported in AEC (1959)[6] for each year from 1953 through 1963. The releases reported in AEC (1959) are reported per RaLa run; these were summed and reported as annual releases.

Use of the (β-I) releases as reported in AEC (1959) presumed a capture efficiency of 100% in the stack sampler, compared with a 50% capture efficiency assumed in this study.

6.3.2 Methodology Differences between the 1991 INEL Historical Dose Evaluation and this Report

The major departure from the HDE (1991) method is use of the daily (β-I) and α-releases reported in the Stack Monitor Datasheets.[7] The HDE (1991) used only annual (β-I) releases, summing the releases per run reported in AEC (1959).

The AEC (1959) report, evidently the basis for the (β-I) releases used in the HDE (1991) study, contained the following two differences from that assumed in this study:

- The reported (β-I) release values for RaLa runs 1 and 2 in February 1957 are much too high in AEC (1959), due to an incorrect radiochemical method for this period. Thus, the reported annual (β-I) release for 1957, reported in HDE (1991), is too high; the release is probably closer to 80-100 Ci instead of 520.2 Ci for 1957.

- The AEC (1959) (β-I) releases were based on an assumed 100% aerosol capture efficiency of the stack monitor sampler bottle. The capture efficiency for aerosol particles was never determined, but 100% is certainly too high. A judgment of this

[3] See main report for complete reference.
[4] See main report for complete reference.
[5] RSAC-4 evidently obtained the number of fissions from the burnup, assumed a thermal yield from U-235, and applied decay chain relationships during and after irradiation. There are some significant differences between RSAC-4 and ORIGEN2. Use of ORIGEN2 is described in Chapter 5 of the main report.
[6] See the main report for complete reference.
[7] See the main report for complete reference.

study is that the capture efficiency was probably closer to 50%. Accordingly, the stack monitor readings reproduced in Appendix A are too low by approximately a factor of two.

- As in the HDE (1991) study, this report assumed a "typical" inventory of fission products in a 2-day cooled feed element to the dissolver. The inventory of this selected typical element was determined using ORIGEN2 using cross-sections appropriate for the MTR, and based on the element fed to RaLa run 2. The complex irradiation history of this element was deciphered from the MTR Monthly Reports. (See Chapter 4 of the main report.) The HDE (1991) obtained the "typical" inventory from an early estimate of key fission product levels and an idealized irradiation history. RSAC-4 was then used to flesh out the inventory. As noted below, there are some significant differences between RSAC-4 and ORIGEN2 results.

- The HDE (1991) analysts seem not to have used the α-release readings reported in the Hayden Notegrams; they were not reported in AEC (1959),[8] the reference they used for RaLa emissions. As a result, some α-emitters were included in the (β-I) listing.

- An attempt was made in this study to determine the effect of emitted β and electron energy levels on the (β-I) readings taken by 1957 vintage β-detectors. As seen in the Appendix C tables, a few nuclides have effective activities higher than determined by ORIGEN2 due to emission of orbital electrons sufficiently energetic to be read by the 1957 β–detectors. A few nuclides (e.g., Tc-99m, Ru-106, and Y-91m) have lower effective activities due to emission of weak betas.

- The method outlined in Appendix B of this report enables application of decay corrections for each nuclide during sampling and delay prior to counting.

6.3.3 Comparison of Annual Releases with the 1991 INEL Historical Dose Evaluation

Table 6.4 shows the releases determined by the HDE (1991) study for 1957-1959, extracted from the reference Tables A-14 and A-15. The table shows estimates for annual aerosol release of 605, 648, and 448 Ci for 1957, 1958, and 1959, respectively. No breakdown is given in the HDE for the month or day.

[8] See the main report for complete reference.

Table 6.4 Annual Releases of Radionuclides Reported by the 1991 Idaho National Engineering Laboratory Historical Dose Evaluation

Radionuclide*	1957 Ci/yr	1958 Ci/yr	1959 Ci/yr	1957-1959 Ci
Sr-89	19.2	14.8	7.6	41.6
Sr-90	35.0	49.8	40.9	125.7
Sr-91	0.92	1.0	0.4	2.4
Y-91	21.1	16.1	8.3	45.5
Nb-95	5.7	4.3	2.4	12.4
Zr-95	21.3	16.4	8.5	46.2
Ru-103	15.3	11.8	6.1	33.2
Ru-106	5.9	8.2	6.7	20.7
Te-132	34.1	30.6	15.1	79.8
Cs-134	0.5	0.8	0.6	1.9
Cs-136	3.2	2.2	0.5	5.9
Cs-137	35.7	50.7	41.7	128.1
Ba-140	58.5	46.7	23.7	128.9
La-140	63.1	49.6	25.3	138.0
Ce-141	33.2	25.7	13.1	72.0
Pr-143	57.9	45.6	23.2	126.7
Ce-144	54.0	73.9	59.7	187.6
Pm-147	140.0	200.0	164.0	504.0
Eu-154	0.071	0.100	0.082	0.253
Pu-238	0.078	0.112	0.091	0.281
Pu-239/240	0.012	0.016	0.013	0.041
Total (listed radionuclides)	604.8	648.4	447.8	1,701.0
Total (α-emitting nuclides)	0.089	0.13	0.10	0.32

*Includes only solid radionuclides.

Unexpectedly, Pm-147 (promethium) shows up as the dominant fission product according to the HDE (1991), with annual releases of 140, 200, and 164 Ci for these 3 years. This is at odds with results of his study, shown in Table 6.2 and Appendix C, where La-140, Pr-143, Ba-140, and Ce-141 are the major contributors.[9]

Another significant departure from the results based on ORIGEN2 is the prominence of Cs-137. Appendix C tables show the Cs-137 contribution to be less than 0.1% at day 1 following the dissolving to less than 0.2% at day 50.

Comparison of α-Releases

Table 6.4 shows the annual α-release estimates reported by HDE (1991). The total level is about 0.1 Ci for each year, composed primarily of Pu-238, Pu-239, and Pu-240. These releases

[9] The high Pm-147 level in the HDE (1991) summary table is so unlikely that one may suspect a typographical error.

compare fairly well with the efficiency-corrected releases of the Stack Monitor Data Sheets, as shown in Table 6.3, which indicate 0.2 Ci, 0.1 Ci and 0.1 Ci released during 1957, 1958 and 1959 respectively.

Table 6.5 Comparison of Alpha-emitting Actinide Contributors to the Aerosol Release

HDE (1991)	This Study
(% contribution to the α-emitting actinide release during a normal RaLa run)	
Pu-238 (87.2%)	Pu-238 (96. %)
Pu-239/Pu-240 (12.8%)	Pu-239 (1.4%)
	Pu-240 (0.8%)
	Cm-242 (1.0%)

As shown in Table 6.5, this study concurs with HDE (1991) that the dominant α-emitting actinide was Pu-238, with small contributions from Pu-239, and Pu-240. This study shows a contribution from Cm-242 roughly on the par with Pu-239 and Pu-240.

Comparison of Annual Beta-minus Iodine Releases

Table 6.6 compares the annual (β-I) aerosol releases developed in this study with that reported by HDE (1991).

Table 6.6 Annual Beta-minus Iodine Aerosol Releases—Comparison to the 1991 Idaho National Engineering Laboratory Historical Dose Evaluation

	1957 Ci	1958 Ci	1959 Ci	1957-1959 Ci
This study	209.4	951.7	514.2	1675.3
HDE (1991)	604.8	648.4	447.8	1701.0

The high reported releases for 1957 in the HDE study are due to the inclusion of the erroneously high releases reported for February and March, which were caused by an error in the radiochemical method. In general, the β-I measurements indicate lower releases in 1957 than in 1958 or 1959, possibly due to improved operations.

Composition of the (β-I) Emitting Aerosols

The dominant (β-I) nuclides in each study are compared in Table 6.7. As seen, there are significant differences in the predicted composition of the (β-I) emitting aerosols using ORIGEN2 in this study and the RSAC-4 results used in HDE (1991). The reasons are not at all apparent. Pm-147 seems to be an unlikely dominant nuclide in the HDE study, which is difficult to rationalize.

Table 6.7 Dominant Beta-minus Iodine Nuclides in this Study Compared with the 1991 Idaho National Engineering Laboratory Historical Dose Evaluation in Approximate Order of Importance

This study	HDE (1991)
La-140	Pm-147
Pr-143	Ce-144
Ce-141	La-140
Ba-140	Ba-140
Zr-95	Cs-137
Y-91	Pr-143
Sr-89	Sr-90

7.0 SUMMARY AND CONCLUSIONS

(1) Examination of the (β-I) and α-releases record in the Stack Monitor Data Sheets indicates they were probably due to aerosol emissions generated by RaLa process operations.

(2) Daily (β-I) and α-releases reported by the Stack Monitor Data Sheets are listed in Appendix A. These values are based on an assumed 100% capture efficiency of the stack sampler. It is judged that a 50% efficiency is more likely, approximately doubling the values of the Appendix A releases. This also applies to the listed α-releases.

(3) The Appendix C tables list the nuclide compositions of the (β-I) aerosols for each day following the dissolving. These results are based on an ORIGEN2 determination of the nuclide inventory in a typical MTR-irradiated fuel element used for RaLa feed and modeling assumptions outlined in Appendix B.

(4) Total annual (β-I) aerosol releases in this study are slightly higher, but roughly comparable with releases reported by HDE (1991) for 1958 and 1959. The HDE (1991) releases are significantly higher for 1957. The reason is the erroneously high values reported for February and March 1957 caused by an error in the radiochemical procedure used during these initial 2 months of operation.

(5) The compositions of the (β-I) emitting aerosols are significantly different between this study and HDE (1991). This study, using ORIGEN2 for a recreated MTR irradiation, predicts La-140 as the dominant nuclide compared with the unlikely Pm-147 for the HDE study. The present study also includes a much larger list of radionuclides than HDE (1991).

(6) The total α-emitting releases predicted by this study are quite low: 0.24, 0.12, and 0.13 Ci/yr for 1957, 1958, and 1959, respectively. These results are similar to those reported in HDE (1991). In both studies, Pu-238 was the dominant α-emitting nuclide, contributing 96% to the total α-releases in this study and 87% in HDE (1991).

8.0 REFERENCES

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APPENDIX A

DAILY BETA-MINUS IODINE AND AEROSOL RELEASES FROM THE IDAHO CHEMICAL PROCESSING PLANT AS REPORTED IN THE STACK MONITOR DATA SHEETS (WITH REPORTED IODINE-131 RELEASES)

FEBRUARY 1957 – DECEMBER 1959

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for February 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in February	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	run 1	NA†	0	71,400
2	run 1	NA	0	56,100
3	run 1	NA	0	32,800
4		NA	0	9,590
5	(β-I) procedure	NA	0	24,800
6	incorrect in	NA	0	27,100
7	Feb., March	NA	0	18,400
8		NA	0	20,000
9		NA	0	44,500
10		NA	0	28,900
11		NA	0	26,400
12		NA	0	6,600
13		NA	0	1,900
14		NA	0	2,100
15		NA	0	2,100
16		NA	0	2,300
17		NA	7.1	2,410
18		NA	0	2,000
19		NA	1.4	2,200
20	run 2	NA	38.2	7,000
21	run 2	NA	16	51,600
22		NA	0	10,700
23		NA	0	10,700
24		NA	0	10,700
25		NA	2.8	96,600
26		NA	0	46,800
27		NA	15	27,300
28		NA	0	18,300

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

† Reported (β-I) releases for February and March 1957 are omitted due to error in the radiochemical procedure.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for March 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in March	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in March	NA†	0	4,840
2		NA	0	15,540
3	(β-I) procedure incorrect	NA	0	13,200
4	in Feb., March	NA	0	10,820
5		NA	0	2,050
6		NA	0	1,360
7		NA	0	1,910
8		NA	0	1,850
9		NA	0	1,235
10		NA	0	824
11		NA	0	1,360
12		NA	0	777
13		NA	0	10,900
14		NA	8.8	6,950
15		NA	0	5,175
16		NA	0	5,175
17		NA	0	3,400
18		NA	0	1,270
19		NA	0	1,200
20		NA	0	523
21		NA	0	705
22		NA	0	412
23		NA	0	470
24		NA	0	1,330
25		NA	0	2,190
26		NA	0	399
27		NA	0	227
28		NA	0	227
29		NA	0	227
30		NA	0	227
31		NA	0	227

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.
† Reported (β-I) releases for February and March 1957 are omitted due to error in the radiochemical procedure.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for April 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in April	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		19.1	0	54
2		11.6	0	28
3		0	0	31
4		133	0	909
5	run 3	35	0	1,787
6	run 3	73.9	0	920
7		57.2	0	671
8		110	0	378
9		47.4	0	4,170
10		41.4	0	529
11		30.9	0	465
12		31.5	0	1,080
13		24	0	4,770
14		90.6	0	3,180
15		21.1	0	4,910
16		70	0	4,460
17		185	0	13,130
18		41.3	0	4,470
19		40	0	3,440
20		17.1	0	6,980
21		33.3	0	7,270
22		27.7	0.9	3,210
23		20	0.7	1,215
24		7	0	291
25		0	0	455
26		5.3	0	843
27		30.9	0	808
28		0.8	0	773
29		18.5	0.4	2,828
30		20	0	1,670

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for May 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in May	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		20	0	1,100
2		18.5	0.3	1,770
3		46.1	0	1,325
4		22.1	0	537
5		29.6	0.9	619
6		26.4	0	565
7		17.5	0	514
8		26.3	0	304
9		10.3	0	294
10		3.5	0.1	200
11		13.86	0.05	146
12		10.97	0	384
13		11.6	0.7	512
14		6	0	541
15		7	0.6	250
16		34	0	475
17		0	0	377
18		4.8	0	236
19	run 4	396	0	654
20	run 4	1,850	0	7,334
21		825	0	2,436
22		471	0.01	8,561
23		25.6	0	5,300
24		1,670	1.4	1,675
25		36	0.6	995
26		124	0.7	2,210
27		144.1	0	1,217
28		72.3	0	1,410
29		61.3	0	825
30		57.3	0	800
31		37.1	0	783

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for February 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in June	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		38.5	0	685
2		45	0	650
3		39.2	0	603
4		36	0	527
5		155	0	447
6		85.2	0	1,130
7		49.6	0	650
8		39.5	0	225
9		25.6	0	168
10		37.1	0	95
11		14.2	0.2	182
12		31.2	0	104
13		40.3	0	73
14		19.4	0	620
15		18.8	0	285
16		36.4	0	285
17		25	0	289
18		14.9	0	249
19		7.2	0	309
20		10.2	0	109
21		4.5	0	113
22		0	0.44	33
23		340	0	28
24	run 5	897	0	2,070
25	run 5	438	0	3,350
26		440	0	264
27		384	0.44	813
28		492	0	86,000
29		497	0	33,200
30		284	0	9,460

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for July 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in July	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in July	32.2	0	4,470
2		231	0	3,195
3		233	0	2,130
4		130	0	4,040
5		146	0	1,250
6		139	0	632
7		101	0.23	812
8		62	0	576
9		60	0.26	372
10		73	0	304
11		56	0.19	254
12		57	0	186
13		45	0	155
14		32	0	132
15		143	0	205
16		196	0.18	3,745
17		37	0	108
18		54	0	52
19		45	0.18	60
20		43	0	61
21		41	0	113
22		13	0	75
23		5	0	68
24		66	0	74
25		78	0	76
26		83	0	51
27		18	0	23
28		44	0	16
29		14	0	16
30		3	0	9
31		26	0.5	16

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for August 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in August	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in August	3	0.1	1
2		0	0	1
3		4	0.2	9
4		0	0.4	7
5		6	0	3
6		9	0	8
7		8	0	6
8		0	0	6
9		0	0	14
10		0	0	3
11		4	0	4
12		1	0	6
13		5	0	5
14		104	0	3
15		12	0.4	2
16		20	0	0
17		15	0	8
18		14	0.2	8
19		2	0.1	8
20		0	0	9
21		2	0	3
22		0	0.1	0
23		0	0	0
24		0	0	0
25		0	0	5
26		0	0	7
27		0	0	3
28		5	0	1
29		2	0	0
30		14	0	6
31		23	0	8

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for September 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in September	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		5	0	24
2		11	0.3	14
3		17	0.05	17
4		2	0	17
5		22	0	2
6		5	1	21
7		24	0	17
8		3	0	22
9		51	0	4
10		323	0	29
11	run 6 - a one day run	3,230	0	63
12		271	0	3,900
13		51	0	4,200
14		126	0	2,560
15		55	0.7	3,690
16		71	1.4	1,810
17		50	0.3	1,730
18		67	0	966
19		42	0	628
20		45	0	953
21		52	0.1	685
22		0	0	1,123
23		25	0	1,550
24		6	0	1,020
25		46	0.05	1,450
26		3	0	1,530
27		32	0.2	327
28		19	0	1,150
29		82	0	1,023
30		42	0	913

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for October 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in October	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		21	0	942
2		1	0	898
3		68	0	19,100
4		112	0	19,840
5		186	0.3	9,900
6		259	0	19,200
7	run 7 - one day run	2,740	0	40,600
8		915	0.8	12,400
9		630	0	9,720
10		645	0.7	4,070
11		673	0	3,740
12		402	0	5,110
13		808	0.5	6,200
14		771	0	9,580
15		573	0	7,550
16		523	0.8	13,680
17		562	0	7,500
18		612	0	2,660
19		388	0	1,900
20		354	1.3	1,450
21	run 8 - one day run	441	0.5	1,535
22		516	0	13,800
23		778	0	25,800
24		664	0	12,800
25		313	0	7,050
26		513	0	2,850
27		433	0	2,050
28		44	0	2,610
29		107	0	3,390
30		376	0.5	3,600
31		920	0	6,220

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for November 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in November	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in November	921	0	15,600
2		587	0	4,320
3		657	0.7	3,520
4		482	0	8,830
5		334	0	7,350
6		495	0	10,100
7		469	0	16,200
8		582	0	31,400
9		457	0	19,600
10		491	0	17,600
11		572	0	23,200
12		315	0	11,150
13		572	0	14,370
14		784	0	7,300
15		612	0	6,560
16		826	0.85	8,360
17		780	0.74	4,530
18		897	0	4,080
19		748	0	2,430
20		843	0	3,240
21		955	0	1,420
22		625	0.6	1,055
23		552	0	1,150
24		624	0	937
25		423	0.2	396
26		526	0	288
27		787	0	254
28		620	0	300
29		885	0	176
30		844	0	125

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for December 1957
(Stack Monitor Datasheets, 1957-1959)*

Day in December	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in December	618	0	155
2		1,080	0	87
3		890	0	269
4		795	2.2	151
5		871	0	171
6		800	0	109
7		532	0	97
8		563	0.9	98
9		525	0	131
10		525	0	339
11		534	0	199
12		360	0.5	121
13		398	0	94
14		281	0	52
15		354	0	68
16		388	0	59
17		310	0	41
18		401	0	42
19		291	0.2	29
20		625	0	9
21		228	0	31
22		286	0	22
23		178	0.2	12
24		191	0	30
25		149	0	13
26		243	0	15
27		318	0	9
28		1,460	0.5	13
29		107	0.3	5
30		256	0	41
31		120	0	0

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for January 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in January	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		170	3.6	30
2		78	0.2	18
3		180	0	12
4		110	0	8
5		192	0.6	65
6	run 9 - one day run	3,000	0.9	3,500
7		2,500	0	4,000
8		2,000	0.5	2,600
9		888	0	1,780
10		846	0	2,460
11		558	0.5	2,520
12		342	0	2,260
13		803	0	1,880
14		498	0	1,045
15		518	0	550
16		753	0.5	930
17		630	0	677
18		376	1.9	413
19		365	0.5	398
20		593	0	138
21		458	0	76
22		272	0	19
23		224	0	15
24		417	0	108
25		326	0	512
26		1,100	0	456
27		783	0	773
28		567	0.5	700
29		430	0	913
30		643	0	805
31		718	0	845

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for February 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in February	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		590	0.1	601
2		596	0	511
3		638	0	726
4		625	0	446
5		495	0	470
6		346	0	292
7		580	0	290
8		602	0	293
9		894	0	376
10		520	0	457
11		625	0	352
12	run 10 - one day run	2,170	0	3,000
13		1,420	0.5	7,430
14		1,240	0	5,540
15		1,110	0.1	6,170
16		1,230	0.2	5,010
17		1,140	0	2,330
18		1,096	0	1,470
19		968	0	1,580
20		856	0	15,280
21		780	0	694
22		828	0	657
23		620	0	627
24		675	0	630
25		616	0	472
26		721	0	392
27		633	0	331
28		670	0	18,900

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for March 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in March	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		828	0	48,200
2		508	0	14,700
3		625	0	11,030
4		855	0	3,030
5		978	0	2,000
6		458	0	927
7		667	0	1,340
8		800	0	1,000
9		1,050	0	740
10		1,500	0.4	557
11		1,070	0	258
12		513	0	258
13	run 11	1,000	0.1	1,290
14	run 11	557	0.1	7,400
15		302	0.1	2,960
16		323	0.1	2,480
17		822	0.3	1,540
18		797	0.2	1,510
19		576	0.8	2,350
20		1,040	0	4,220
21		310	0	3,200
22		877	0	1,700
23		810	0	2,520
24		364	0	2,060
25		372	0	1,750
26		344	0	1,880
27		270	0.5	2,260
28		314	0	2,420
29		279	0	1,310
30		368	0	1,230
31		186	0	1,590

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for April 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in April	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		193	0	1,725
2		308	0	2,020
3		112	0	755
4		315	0	595
5		63	0	486
6		145	0	1,120
7		323	0	683
8		332	0	823
9		265	0	312
10		223	0	363
11		110	0	280
12		65	0.7	260
13		52	0.8	170
14		146	0	195
15		65	0	150
16	run 12 - one day run	1,650	1.3	3,375
17		1,300	0	6,560
18		1,110	0	7,120
19		774	0	3,420
20		610	0	2,490
21		525	0	2,380
22		450	0	995
23		445	0	1,410
24		352	0	1,700
25		496	0.3	1,260
26		397	0	993
27		340	0.1	956
28		425	0	2,000
29		276	0	276
30	run 13	2,280	0.2	4,220

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for May 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in May	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	run 13	2,220	0	5,850
2		1,540	0.3	3,180
3		1,240	0.7	1,830
4		1,120	2.3	1,980
5		910	0	2,250
6		910	0	3,620
7		750	0	1,960
8		685	0.2	1,720
9		825	0.4	1,750
10		73	0.3	678
11		330	0	567
12		1,130	0.4	18,600
13		863	0.2	39,300
14		394	0.2	20,500
15		475	0.6	12,900
16		800	0	10,800
17		388	0	8,780
18		580	0	7,840
19		657	0	6,000
20		885	0	5,480
21		990	1.1	2,900
22		1,200	0	3,140
23		925	0.3	1,780
24		658	0.6	1,500
25		330	0	1,300
26		390	0	3,320
27		355	0	2,870
28	run 14 - one day run	17,500	0	49,500
29		6,330	0.3	33,400
30		2,860	1.2	14,000
31		1,160	0	6,350

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for June 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in June	Comment	β-I mCi/day	a mCi/day	I-131 mCi/day
1		750	0	7,900
2	run 15 - one day run	1,040	0	7,100
3		650	0.5	6,300
4		650	0	6,200
5		1,340	1.4	11,700
6		970	1.7	9,000
7		790	0.2	6,500
8		690	0.2	2,400
9		1,900	1.9	18,400
10		1,060	0.2	34,200
11		590	4.8	32,500
12		770	0	25,500
13		690	0	13,400
14		680	0	12,700
15		330	0	6,600
16		300	0	5,300
17		350	0	1,400
18		570	1.1	1,500
19		1,150	0	1,000
20		730	0	630
21		550	0	110
22		1,060	0	216
23		830	0	190
24		1,110	0	300
25		755	0	440
26		720	0	225
27		800	0	260
28		990	0.2	76
29		940	0	76
30		710	0	50

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for July 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in July	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in July	680	0	54
2		880	1	67
3		959	0	567
4		732	0.5	17
5		740	0.8	42
6		920	0.4	67
7		770	0.2	49
8		770	0.5	58
9		570	0.2	96
10		680	0	38
11		1,390	0	52
12		730	0	37
13		820	0	24
14		1,190	0	16
15		970	0.6	54
16		910	1.4	32
17		1,910	0	38
18		1,340	0	47
19		860	0	19
20		510	0.3	4
21		86	0.1	26
22		122	0	31
23		830	0	12
24		1,100	0.1	3
25		620	0	8
26		610	0	9
27		630	0.3	6
28		710	0.5	0
29		820	0	3
30		700	0	7
31		570	0.2	12

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for August 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in August	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	First month with	410	0.3	12
2	charcoal absorber	400	0	8
3		770	0	9
4		1,090	0.2	9
5		1,450	0	6
6	run 16 - one day run	1,580	0	270
7		3,000	1.3	310
8		2,450	0	290
9		1,290	0	240
10		1,000	0	150
11		4,020	0	12,800
12		1,570	3.1	13,600
13	run 17 - one day run	2,370	0	8,300
14		3,000	0	6,100
15		2,100	0	4,670
16		2,300	0	3,190
17		2,060	0	2,770
18		1,810	0	1,090
19		1,950	0	1,450
20		2,710	0	820
21		900	0	990
22		1,330	0.5	1,000
23		1,070	0	730
24		1,470	0	260
25		1,720	0	480
26		1,380	0	170
27		1,820	0	300
28		1,120	0	3,740
29		1,860	0	12,600
30		1,120	0.3	1,170
31		1,140	0	990

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for September 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in September	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in September	470	0	1,170
2		2,668	0	1,000
3		1,730	0.2	470
4		1,420	0	2,000
5		1,150	0	3,730
6		1,410	0	3,150
7		1,240	0.4	1,850
8		3,090	0	2,010
9		850	0	460
10		1,750	0	1,950
11		2,740	0	840
12		1,980	0	890
13		1,580	0	320
14		1,500	0	100
15		2,110	0	550
16		2,290	0	570
17		3,250	0	630
18		1,300	0	1,060
19		1,880	0	970
20		940	0	250
21		1,030	0	150
22		840	0	100
23		720	0	30
24		770	0	10
25		690	0.3	40
26		1,030	3.9	54
27		910	0	16
28		1,260	1.2	63
29		1,200	0	46
30		520	0	13

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for October 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in October	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	run 18 - one day run	22,430	0	16,300
2		3,600	0	10,000
3		1,790	0	5,100
4		2,010	0	2,240
5		860	0	750
6		1,630	0	1,590
7		2,050	0	820
8		1,780	0	720
9		1,290	0	560
10		1,130	0	1,210
11		1,180	0	630
12		1,910	0	900
13		1,540	0	1,700
14		1,900	0	800
15		2,050	0	8,690
16		2,130	0	7,000
17		2,710	0	4,570
18		1,400	0	2,460
19		3,360	0	1,650
20		2,750	0	1,760
21		2,350	0	1,120
22	run 19 - one day run	4,770	0	4,390
23		3,680	0	10,200
24		4,200	0	8,100
25		1,790	0.2	4,230
26		1,480	0	2,330
27		850	0.5	4,660
28		1,630	0	2,110
29		2,700	0	1,300
30		1,430	0	1,170
31		860	0	620

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for November 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in November	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		1,050	0.4	450
2		960	0	560
3		500	0	450
4		700	0	540
5		690	0	160
6	No run 20	450	0	310
7	numbering error	470	0	830
8		450	0	1,010
9		500	0	900
10		890	0	860
11		540	0	460
12	run 21 - one day run	2,490	0	3,510
13		2,220	0	4,080
14		990	0	9,540
15		690	0	3,800
16		2,680	0	990
17		3,000	0	1,160
18		1,250	0	420
19		11,480	0	1,530
20		3,810	0.1	1,030
21		1,660	0.9	730
22		830	0	250
23		540	0	180
24		2,000	0.3	220
25		720	0	190
26		440	0	40
27		1,170	0	80
28		750	0	110
29		1,550	0	480
30		950	0	160

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for December 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in December	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in December	820	0	190
2		360	0	140
3		310	0	180
4		320	0	130
5		1,000	0	130
6		980	0	100
7		580	0	90
8		900	0	90
9		580	0	70
10		3,620	0	770
11		800	0	170
12		1,150	0	60
13		540	0	30
14		660	0	30
15		210	0	30
16		790	0	150
17		1,160	0	20
18		440	0	10
19		710	0.4	160
20		860	0	160
21		250	0	110
22		370	0	80
23		690	0	250
24		170	0	110
25		370	0	130
26		170	0	60
27		2,330	0	190
28		660	0	30
29		1,590	0	140
30		260	0	0
31		200	0	5

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for January 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in January	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	No runs in January	110	0	6
2		100	0	1
3		510	0	1
4		1,980	0	4
5		1,420	0	10
6		320	0	10
7		260	0	13
8		160	0	2
9		110	0.4	8
10		100	0	11
11		110	0	16
12		90	0	18
13		60	0	53
14		20	0	0
15		150	0	0
16		100	0	9
17		70	0	2
18		250	0	8
19		10	0	0
20		290	0	12
21		280	0	1
22		200	0	9
23		320	0	5
24		230	0	7
25		130	0	8
26		140	0	5
27		90	0	0
28		70	0	13
29		150	0	3
30		140	0	10
31		110	0	3

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for February 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in February	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		300	0	6
2		120	0	4
3		190	0	10
4	run 22 - one day run	3,180	0	6,440
5		2,950	0	9,570
6		2,920	0	31,500
7		2,030	0	20,300
8		210	0	7,830
9		280	0	2,250
10		160	0	2,220
11		50	0	1,420
12		500	0	1,860
13		440	0	1,750
14		350	0	370
15		740	0	1,930
16		410	0	160
17		220	0	1,350
18		400	0	7,540
19		950	0	5,940
20		150	0	1,360
21		70	0	70
22		60	0	460
23		50	0	280
24		130	0	180
25	run 23 - one day run	150	0	450
26		2,410	0	2,490
27		510	0	2,230
28		280	0	1,680

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for March 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in March	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		80	0	420
2		90	0	250
3		70	0.1	160
4		210	0	430
5		140	0	320
6		140	0	190
7		60	0	130
8		150	0	100
9		140	0.4	250
10		300	0	420
11		250	0	1,120
12		270	0	1,090
13		200	0	1,200
14		200	0	560
15		290	0	330
16		290	0	400
17		140	0	150
18	run 24 - one day run	480	0	460
19		2,420	0	13,000
20		1,380	0	12,600
21		450	0	4,700
22		350	0	1,650
23		310	0	1,390
24		270	0	1,550
25		360	0	3,090
26		430	0	360
27		200	0	210
28		210	0	250
29		160	0	100
30		110	0.1	190
31		220	0	140

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for April 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in April	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		150	0	210
2		150	0	170
3		80	0	80
4		30	0	90
5		100	0	70
6		80	0	90
7		10	0	90
8	run 25 - one day run	220	0	150
9		80	0	140
10		40	0	140
11		30	0	190
12		40	0	80
13		110	0	100
14		60	0	50
15		150	0	320
16		70	0	1,520
17		90	0	760
18		30	0	250
19		270	0	310
20		900	0	100
21		720	0	180
22		530	0	50
23		710	0	60
24		1,170	0.1	90
25		1,520	0	90
26		1,150	0	60
27		1,310	0.1	40
28		1,770	0.1	60
29	run 26 - one day run	3,420	0	1,030
30		1,500	0	1,200

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for May 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in May	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		1,780	0.1	320
2		880	2.6	120
3		1,340	0.6	120
4		1,320	0	60
5		1,000	0	100
6		1,490	0	40
7		1,150	0	50
8		1,310	0	60
9		1,020	0	30
10		1,020	0	30
11		650	0	20
12		950	1.6	20
13		1,750	0	30
14		1,250	0.1	10
15		1,150	0.4	40
16		1,700	0.6	60
17		1,640	0	30
18		970	1.1	20
19	run 27 - one day run	1,390	0	40
20		2,560	1.3	910
21		1,480	0	310
22		1,620	0	110
23		1,140	0.1	90
24		810	0.2	100
25		1,120	0	60
26		650	0	50
27		770	0	70
28		540	0	80
29		570	0	50
30		450	0	20
31		530	0	40

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for June 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in June	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		660	0	30
2		815	0	0
3		900	0	20
4		670	0	250
5		1,020	0	50
6		1,050	0	20
7		850	1.3	0
8		1,280	0	20
9		1,340	0	0
10	run 28 - one day run	1,800	0	650
11		1,700	0.5	240
12		1,490	0	140
13		1,200	0.2	40
14		270	0	50
15		1,550	0	20
16		2,310	0	10
17		1,280	0.4	250
18		2,030	0	200
19		1,950	0	50
20		1,530	0	30
21		1,220	0	20
22		890	0	20
23		850	0	40
24		600	0	60
25		1,220	0	50
26		990	0	30
27		290	0	60
28		380	0	20
29		560	0	20
30		310	0	20

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for July 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in July	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		1,040	0	0
2		640	0	40
3		280	0	10
4		290	0	30
5		590	0	10
6	run 29	420	0	250
7	run 29	1,140	0	2,560
8		710	0	1,180
9		930	5.5	280
10		600	4	160
11		670	2.6	60
12		500	0.2	30
13		460	0	10
14		290	1.3	90
15		730	20.4	220
16		350	0	190
17		600	0.2	80
18		280	0	70
19		290	0	40
20		380	0	90
21	run 30	550	0	1,100
22	run 30	1,000	0.7	750
23		300	0	750
24		460	0	480
25		1,380	0	1,270
26		230	0	120
27		230	0	60
28		210	0	30
29		120	0	30
30		280	0	40
31		160	0	40

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for August 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in August	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		250	0	60
2		300	0	30
3		1,280	0	430
4		420	0	340
5		470	0	340
6		200	0	180
7		230	0	60
8		240	0	100
9		250	0	80
10		10	0	70
11	run 31	670	0	500
12	run 31	760	0	190
13		1,130	0.8	180
14		660	0	180
15		360	0.8	40
16		470	0.4	80
17		380	0	80
18		170	0	110
19		130	0	90
20		3,420	0	20
21		90	0	30
22		100	0.4	10
23		100	0	30
24		60	0	290
25		80	0	80
26		120	0	90
27		110	0	20
28		190	0	50
29		270	0	10
30		210	0	40
31		130	0	10

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for September 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in September	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	run 32	550	0	420
2	run 32	260	0	280
3		270	0	200
4		240	0	100
5		200	0	20
6		170	0	40
7		150	0.21	30
8		220	0	340
9		200	0	690
10		200	0	960
11		200	0	320
12		160	0	130
13		190	0	90
14		120	0	70
15		90	0	30
16		110	0	80
17		290	0	280
18		100	0	140
19		100	0	160
20		110	0	80
21		120	0	30
22	run 33	290	0	270
23	run 33	140	0	190
24		390	0	130
25		250	0	100
26		260	0	90
27		230	0	690
28		290	0	960
29		220	0	850
30		280	0	300

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for October 1958
(Stack Monitor Datasheets, 1957-1959)*

Day in October	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		160	0	200
2		210	0	90
3		970	0	40
4		90	0	20
5		90	0	30
6		170	0	460
7		190	0	180
8		100	0	200
9		130	0	50
10		150	0	70
11		90	0	70
12		130	0.19	60
13	run 34	3,860	0	60
14	run 34	630	0	570
15		600	0	400
16	ICPP Criticality Accident	8,170	0	3,730
17		4,930	0	2,440
18		2,860	0	970
19		1,850	0	1,010
20		1,400	0	1,150
21		520	0	940
22		960	0	870
23		710	0	180
24		630	0	150
25		460	0	90
26		600	0	40
27		410	0	100
28		470	0	120
29		360	0	330
30		280	0	170
31		310	0	240

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for November 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in November	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1		200	0	100
2		130	0	140
3		190	0	140
4		50	0	70
5	run 35	890	0	800
6	run 35	670	0	1,830
7		270	0	4,470
8		140	0	160
9		260	0	270
10		180	0	300
11		210	0	490
12		780	0	60
13		1,440	2.72	930
14		1,590	5.95	150
15		620	1.32	550
16		270	0.1	330
17		120	0.22	320
18		190	0	390
19		110	0	270
20		170	0	120
21		170	0	300
22		340	0	310
23		100	0	540
24		350	0	160
25		70	0	70
26		70	0	20
27		60	0	30
28		60	1.15	10
29		50	0	10
30	run 36	50	0	20

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

Table A.1 Reported Daily Beta-minus Iodine, Alpha, and Iodine-131 Releases From the Idaho Chemical Processing Plan for December 1959
(Stack Monitor Datasheets, 1957-1959)*

Day in December	Comment	β-I mCi/day	α mCi/day	I-131 mCi/day
1	run 36	70	0	60
2		70	0	110
3		50	0	50
4		50	0	50
5		110	0	20
6		260	0	20
7		60	0	10
8		140	0	20
9		330	0	10
10		200	0	10
11		140	0	10
12		440	0	10
13		280	0	20
14		330	0.22	20
15	run 37	960	0	200
16	run 37	410	0.56	240
17		210	0	160
18		470	0	210
19		200	0	140
20		280	0	100
21		220	0	60
22		360	0	70
23		400	0	60
24		350	0	40
25		560	0	40
26		160	0	30
27		240	0.68	10
28		80	0	10
29		50	0	10
30		80	0	20
31		90	0	0

* All reported (β-I) and α releases were based on an assumed 100% capture efficiency of aerosols in the stack sampler.

APPENDIX B

APPROACH FOR DERIVING RELEASES OF RADIONUCLIDES ATTACHED TO AEROSOLS

APPENDIX B: APPROACH FOR DERIVING RELEASES OF RADIONUCLIDES ATTACHED TO AEROSOLS

This approach is designed to account for the sampler efficiency and for the decay of short-lived radionuclides, both during sampling and during the waiting time between the end of the sampling period and the beginning of the sample counting.

The following information is available:

- Reported β-I daily releases (R_m; Appendix A), obtained from the Stack Monitor Datasheets. These releases are obtained from the measured β-I activity in the sample of air collected from stack, corrected for the differences in the stack flow rate (Q_{stk}) and sampling line flow rate ($Q_{sampler}$). As discussed in Chapter 4, the reported daily releases are based on an assumed 100% sampler efficiency, and they are not corrected for the decay of short-lived radionuclides, both during sampling and during the waiting time between the end of the sampling period and the beginning of the sample counting.

- The activity of each radionuclide, following the dissolution in the RaLa processing tanks ($A_{d,i}$; i = index for the radionuclides; in Ci), for each of the 100 days after removal from the reactor of a "typical" MTR fuel element. The list of radionuclides does not include gaseous nuclides (i.e., iodine, bromine, xenon, and krypton), which should not have contributed significantly to the β-I measurements.

- The number of beta particles and electrons with an average energy greater than 25 keV, emitted on average from each nuclear disintegration of a given radionuclide (Y_i).

In a given day after a RaLa run, a radionuclide i with an activity $A_{d,i}$ in the RaLa processing tanks will produce a concentration in the stack airflow $C_{a,i}$ (Ci m^{-3}) which is proportional to the activity $A_{d,\,i}$.

$$C_{a,i}(t_n) = a \cdot A_{d,i}(t_n) \qquad \text{(B-1)}$$

The principal assumption is that the proportionality parameter "*a*" is the same for all radionuclides that attach to particles. That is, all radionuclides are assumed to have more or less the same affinity to attach to aerosols. The time (t_n) represents the number of days from the beginning of the RaLa run.

Our purpose is to determine the activity released into the atmosphere for each radionuclide i ($R_{cor,\,i}$, in Ci), corrected for the reduced sampler efficiency and for the decay of short-lived radionuclides, both during sampling and during the waiting time between the end of the sampling period and the beginning of the sample counting.

The corrected releases ($R_{cor,\,i}$, in Ci) are calculated for every day (t_n) during the RaLa release, given that, during that day, the air in the stack was sampled for 24 hours (i.e., the sampling period = t_s = 24 hours = 1 day).

$$R_{cor,i} = C_{a,i} \cdot Q_{stk} \cdot t_s = a \cdot A_{d,i} \cdot Q_{stk} \cdot t_s \qquad \text{(B-2)}$$

where

$C_{a,i}$	=	concentration of radionuclide i in the stack airflow (Ci m^{-3})
Q_{stk}	=	stack flow rate (m^3 d^{-1})
t_s	=	sampling period (d)
a	=	proportionality constant (m^{-3}) between the activity $A_{d,i}$ in the RaLa processing tanks (Ci) and the concentration in the stack airflow $C_{a,i}$ (Ci m^{-3})

The reported releases were made by sampling the air going out of the stack, drawing air at flow rate $Q_{sampler}$. The releases reported in the datasheet have been corrected for the differences between the Q_{stk} and $Q_{sampler}$, so that they represent an amount released and not the amount sampled.

To relate the reported releases (R_m) to the concentration in the air flow, the following mass-balance equation can be written for the number of atoms (N_i) of radionuclide i accumulating in the sampler:

$$\frac{dN_i}{dt} = \left(\frac{C_{a,i}}{\lambda_i}\right) \cdot Q_{sampler} \cdot f - \lambda_i N_i \qquad \text{(B-3)}$$

where

N_i	=	number of atoms of radionuclide i accumulating in the sampler (unitless)
$C_{a,i}$	=	concentration of radionuclide i in the stack airflow (Ci m^{-3})
$Q_{sampler}$	=	flow rate in the sampling line (m^3 d^{-1})
f	=	efficiency of the sampler in collecting particles (unitless)
$\lambda_{,i}$	=	radioactive decay constant for radionuclide i (d^{-1})

Assuming the release rate is constant during the sampling period (t_s), the activity present in the sample at the end of the sampling period ($A_{s,i}$) is:

$$A_{s,i}(t_s) = \lambda_i N_i = C_{a,i} \cdot Q_{sampler} \cdot f \cdot \frac{1 - \exp(-\lambda_i t_s)}{\lambda_i} \qquad \text{(B-4)}$$

where all quantities are defined above and

$A_{s,i}$	=	activity in the sample at the end of the sampling period (Ci)

The contribution of radionuclide i to the number of β-I counts registered on the detector is determined given the following:

- Only a fraction Y_i of the decays produce beta particles or electrons with an average energy greater than 25 keV (Appendix D)
- The activity decreases during the waiting time between the end of the sampling and the beginning of measurement (t_w).

$$A_{m,i} = a \cdot A_{d,i} \cdot Y_i \cdot Q_{sampler} \cdot f \cdot \frac{1-\exp(-\lambda_i t_s)}{\lambda_i} \cdot \exp(-\lambda_i t_w) \qquad \text{(B-5)}$$

where all quantities are defined above and

$A_{m,i}$	=	the activity of radionuclide i (Ci) that contributes to the total activity of measured by the detector.
t_w	=	waiting time between the end of the sampling and the beginning of measurement (d)

In the above equation the concentration in the airflow was replaced by its relationship with the activity in the dissolver (see Equation B-1).

The total activity measured (A_m) is the sum of the contributions from each radionuclide ($A_{m,i}$).

$$A_m = \sum_{i=1}^{N} A_{m,i}$$

$$= a \cdot Q_{sampler} \cdot f \cdot t_s \cdot \sum_{i=1}^{N} A_{d,i} \cdot Y_i \cdot \frac{1-\exp(-\lambda_i t_s)}{\lambda_i t_s} \cdot \exp(-\lambda_i t_w) \qquad \text{(B-6)}$$

$$= a \cdot Q_{sampler} \cdot f \cdot t_s \cdot S$$

where all quantities are defined above and

S	=	decay-corrected and sample-efficiency-corrected activity in the dissolver, summed over all radionuclides (in Ci)
A_m	=	the total activity of measured by the detector (Ci)

The activities $A_{d,i}$, the fractions Y_i, and the radioactive decay constant λ_i are known. The sampling time is also known (t_s was generally 24 hours). Based on the few available records for April 1957, the average waiting time was determined to be about t_w = 14 hours (with a range 3 – 48 hours). Thus, the activity S can be calculated with available information for any given day (t_n).

The reported β-I releases (R_m) were obtained by multiplying the total activity measured (A_m) by the ratio of the stack to sampler flow rates (F_{flow}), so that the product of ($Q_{sampler} \times F_{flow}$) is equal to the stack flow rate (Q_{stk}).

$$R_m = A_m \cdot F_{flow} = a \cdot Q_{stk} \cdot f \cdot t_s \cdot S \qquad \text{(B-7)}$$

where all quantities are defined above and

F_{flow}	=	the ratio of the stack and sampler flow rates ($Q_{stk}/Q_{sampler}$; unitless).
Q_{stk}	=	stack flow rate ($m^3\ d^{-1}$)
$Q_{sampler}$	=	flow rate in the sampling line ($m^3\ d^{-1}$)

The proportionality constant a between the activity $A_{d,i}$ in the dissolver (Ci) and the concentration in the stack airflow $C_{a,i}$ (Ci m^{-3}) is given by:

$$a = \frac{R_m}{Q_{stk} \cdot f \cdot t_s \cdot S} \qquad \text{(B-8)}$$

Using Equations B-2 and B-8, the amount of radionuclide i released during the sampling period (corrected for the decay of short-lived radionuclides during sampling, and during the waiting time between the end of the sampling period and the beginning of the sample counting and corrected for the reduced sampler efficiency) can be determined as a function of the reported β-I releases (R_m).

$$R_{cor,i} = a \cdot A_{d,i} \cdot Q_{stk} \cdot t_s = A_{d,i} \cdot \left(\frac{R_m}{f} \cdot \frac{1}{S} \right) \qquad \text{(B-9)}$$

The above equation estimates releases for all radionuclides, including those that have no contribution to the measured β-I daily releases. For instance, ^{106}Ru is present in the dissolver and is released into the atmosphere, but due to the weak beta particles produces no contribution to the measured β-I daily releases (i.e., $Y_{Ru\text{-}106} = 0$). The amount released ($R_{Ru=106}$) does not depend directly on Y_i. It depends on the activity in the dissolver $A_{d,I}$, the sampler efficiency f, and the activity S (which is a function of the Y_i for all radionuclides).

In principle, Equation B-9 can be used to determine releases of any radionuclides, including gases (e.g., iodine, xenons, kryptons, bromines), as long as the activity in the dissolver ($A_{d,i}$) can be determined for that radionuclide in the day when the measurement (R_m) was taken. For the radionuclides that can attach to particles, the activity in the dissolver can be determined using ORIGEN computer code, because the loss of radioactivity (*via* emission as aerosols) is small compared to the inventory in the dissolver. For gases, however, the majority of the radioactivity is lost shortly after dissolution, so the activity in the dissolver at a given time after dissolution is hard to predict.

Table B.1 presents an example calculation for the first day of RaLa Run #6 (September 1, 1957), while Table B.2 gives the estimated releases during day 15 (Feb 18, 1959) of RaLa Run #22.

One should note that the decay correction has a larger effect for short times after the beginning of a RaLa run. However, for some radionuclides (e.g., ^{99m}Tc), the decay correction is important for any time after exposure.

Table B.1 Estimated Releases During the First Day of RaLa Run #6 on September 11, 1957, When the Beta-minus Iodine Release Reported in the Stack Monitor Datasheets was R_m = 3230 mCi

Radionuclide	Activity Released: No decay Correction* mCi/day	Activity Released: With decay correction† mCi/day	Half-life $T_{1/2}$	units
LA140	712	849	40.272	hours
PR143	637	781	13.56	days
BA140	757	781	12.74	days
CE141	548	545	32.501	days
MO099	448	538	66	hours
TC099M	47	519	6.02	hours
TE132	435	423	78.2	hours
ZR095	321	393	63.98	days
Y091	314	385	58.51	days
SR089	274	336	50.5	days
ND147	365	276	10.98	days
CE143	252	256	33	hours
RU103	208	252	39.28	days
RH103M	167	227	56.12	minutes
NB095	133	163	35.15	days
U237	248	136	6.75	days
PM149	97	118	53.08	hours
PR144	75	92	17.28	minutes
CE144	87	92	284.3	days
NB097	50	61	72.1	minutes
ZR097	50	61	16.9	hours
NB097M	1.0	58	60	seconds
RH105	27	34	35.3	hours
SM153	38	29	46.7	hours
PM148	19	23	5.37	days
TE127	14	17	9.35	hours
SB127	15	17	3.85	days
TE131M	15	15	30	hours
NP239	28	15	2.335	days
PM151	14	14	28.4	hours
Y093	7.3	9.0	10.1	hours

* Estimated by ignoring the decay corrections as follows: $R_i = \frac{1}{f} \cdot \frac{A_{d,i} \cdot Y_i}{\sum_{i=1}^{N} A_{d,i} \cdot Y} \cdot R_m$.

† Estimated Equation B-9 in the text.

Table B.1 Estimated Releases During the First Day of RaLa Run #6 on September 11, 1957, When the Beta-minus Iodine Release Reported in the Stack Monitor Datasheets was R_m = 3230 mCi - Continued

Radionuclide	Activity Released: No decay Correction* mCi/day	Activity Released: With decay correction† mCi/day	Half-life $T_{1/2}$	units
TE129M	5.4	6.6	33.6	days
PM147	5.1	6.3	2.6234	years
SR091	4.9	6.0	9.5	hours
NP238	7.2	5.8	2.117	days
EU156	6.1	5.4	15.19	days
RH106	4.3	5.3	29.9	seconds
RU106	0.0	5.3	368.2	days
TE129	4.1	4.3	69.6	minutes
Y091M	0.2	3.8	49.71	minutes
TE131	3.3	3.4	25	minutes
CS137	2.3	2.9	30	years
SR090	2.3	2.8	29.12	years
Y090	2.3	2.8	64	hours
BA137M	0.2	2.7	2.552	minutes
NB095M	1.6	2.6	86.6	hours
AG111	1.8	2.2	7.45	days
CS136	1.8	1.7	13.1	days
SN125	1.2	1.5	9.64	days
PM148M	1.2	1.3	41.3	days
CS134	0.78	1.3	2.062	years
PR144M	0.62	1.1	7.2	minutes
IN115M	0.42	0.94	4.486	hours
CD115	0.71	0.86	53.46	hours
TE127M	0.68	0.81	109	days
PU241	3.1E-07	6.0E-03	14.4	years
PU238	5.4E-04	3.8E-03	87.74	years
AM242	4.8E-05	5.7E-05	16.02	hours
PU239	3.4E-06	5.3E-05	24065	years
NP236M	2.4E-05	5.0E-05	22.5	hours
CM242	5.0E-06	3.9E-05	162.8	days
PU240	4.5E-06	3.3E-05	6537	years

* Estimated by ignoring the decay corrections as follows: $R_i = \frac{1}{f} \cdot \frac{A_{d,i} \cdot Y_i}{\sum_{i=1}^{N} A_{d,i} \cdot Y} \cdot R_m$.

† Estimated Equation B-9 in the text.

Table B.1 Estimated Releases During the First Day of RaLa Run #6 on September 11, 1957, When the Beta-minus Iodine Release Reported in the Stack Monitor Datasheets was R_m = 3230 mCi – Continued

Radionuclide	Activity Released: No decay Correction* mCi/day	Activity Released: With decay correction† mCi/day	Half-life $T_{1/2}$	units
U240	2.5E-05	2.3E-05	14.1	hours
U236	2.8E-06	1.3E-05	23415000	years
U234	2.2E-06	9.9E-06	244500	years
TH231	9.0E-06	5.2E-06	25.52	hours
U235	1.9E-06	4.8E-06	7.04E+08	years
NP237	2.6E-06	2.8E-06	2140000	years
PU236	4.1E-07	1.6E-06	2.851	years
PU243	1.0E-06	1.1E-06	4.956	hours
CM244	5.9E-08	1.1E-06	18.11	years
PU237	7.0E-08	9.8E-07	45.3	days
PA233	1.3E-06	8.5E-07	27	days
PA232	1.5E-06	7.9E-07	1.31	days
AM244	1.4E-06	6.2E-07	10.1	hours
AM241	1.8E-07	3.1E-07	432.2	years
U238	1.4E-08	7.7E-08	4.47E+09	years
TH234	4.6E-08	6.1E-08	24.19	days
PA234M	5.0E-08	6.1E-08	1.17	minutes
AM243	1.1E-08	4.4E-08	7380	years
NP235	6.7E-10	2.6E-08	396.1	days
PU242	2.0E-09	1.8E-08	376300	years
TOTAL	**6460.0‡**	**7594.5**		

* Estimated by ignoring the decay corrections as follows: $R_i = \frac{1}{f} \cdot \frac{A_{d,i} \cdot Y_i}{\sum_{i=1}^{N} A_{d,i} \cdot Y} \cdot R_m$.

† Estimated Equation B-9 in the text.

‡ The total release (6460 mCi) is twice the release reported in the Stack Monitor Datasheets (3230 mCi) because the sampler efficiency was assumed to be 50%.

Table B.2 Estimated Releases During the Day 15 (February 18, 1959) of RaLa Run #22 (February 4, 1959) When the Beta-minus Iodine Release Reported in the Stack Monitor Datasheets was R_m = 400 mCi

Radionuclide	Activity Released: No decay Correction* mCi/day	Activity Released: With decay correction† mCi/day	Half-life $T_{1/2}$	units
LA140	90	102	40.272	hours
CE141	104	98	32.501	days
PR143	83	96	13.56	days
BA140	91	89	12.74	days
ZR095	71	82	63.98	days
Y091	68	79	58.51	days
SR089	58	67	50.5	days
NB095	44	51	35.15	days
RU103	42	48	39.28	days
RH103M	34	43	56.12	minutes
ND147	39	28	10.98	days
PR144	19	22	17.28	minutes
CE144	22	22	284.3	days
U237	15	7.8	6.75	days
TE132	5.7	5.2	78.2	hours
MO099	3.4	3.8	66	hours
TC099M	0.4	3.7	6.02	hours
PM147	1.7	2.0	2.6234	years
RH106	1.1	1.3	29.9	seconds
RU106	0.0	1.3	368.2	days
TE129M	1.0	1.2	33.6	days
PM148	0.81	0.94	5.37	days
TE129	0.78	0.78	69.6	minutes
EU156	0.82	0.70	15.19	days
CS137	0.60	0.70	30	years
Y090	0.58	0.67	64	hours
SR090	0.58	0.67	29.12	years
BA137M	0.063	0.66	2.552	minutes
NB095M	0.39	0.60	86.6	hours
TE127	0.44	0.51	9.35	hours
PM149	0.31	0.36	53.08	hours

* Estimated by ignoring the decay corrections as follows: $R_i = \frac{1}{f} \cdot \frac{A_{d,i} \cdot Y_i}{\sum_{i=1}^{N} A_{d,i} \cdot Y} \cdot R_m$.

† Estimated Equation B-9 in the text.

Table B.2 Estimated Releases During the Day 15 (February 18, 1959) of RaLa Run #22 (February 4, 1959) When the Beta-minus Iodine Release Reported in the Stack Monitor Datasheets was R_m = 400 mCi – Continued

Radionuclide	Activity Released: No decay Correction* mCi/day	Activity Released: With decay correction† mCi/day	Half-life $T_{1/2}$	units
SB127	0.30	0.33	3.85	days
CS134	0.20	0.31	2.06E+00	years
PR144M	0.15	0.26	7.2	minutes
PM148M	0.25	0.25	41.3	days
TE127M	0.17	0.20	109	days
CS136	0.22	0.19	13.1	days
AG111	0.13	0.15	7.45	days
SN125	0.11	0.13	9.64	days
NP239	0.12	0.059	2.335	days
NP238	1.9E-02	1.4E-02	2.117	days
PU241	8.1E-08	1.4E-03	14.4	years
PU238	1.5E-04	1.0E-03	87.74	years
PU239	9.4E-07	1.4E-05	24065	years
CM242	1.2E-06	8.9E-06	162.8	days
PU240	1.2E-06	8.1E-06	6537	years
U236	7.1E-07	3.2E-06	2.34E+07	years
U234	5.8E-07	2.4E-06	2.45E+05	years
TH231	2.1E-06	1.2E-06	25.52	hours
U235	5.0E-07	1.2E-06	7.04E+08	years
NP237	8.8E-07	9.0E-07	2.14E+06	years
PA233	6.1E-07	3.9E-07	27	days
PU236	1.1E-07	3.8E-07	2.851	years
CM244	1.5E-08	2.6E-07	18.11	years
PU237	1.5E-08	1.9E-07	45.3	days
AM241	1.0E-07	1.6E-07	432.2	years
U238	3.7E-09	1.9E-08	4.47E+09	years
TH234	1.3E-08	1.6E-08	24.19	days
PA234M	1.4E-08	1.6E-08	1.17	minutes
AM243	2.9E-09	1.1E-08	7380	years
NP235	1.7E-10	6.1E-09	396.1	days
PU242	5.1E-10	4.3E-09	376300	years

* Estimated by ignoring the decay corrections as follows: $R_i = \frac{1}{f} \cdot \frac{A_{d,i} \cdot Y_i}{\sum_{i=1}^{N} A_{d,i} \cdot Y} \cdot R_m$.

† Estimated Equation B-9 in the text.

Table B.2 Estimated releases during the day 15 (February 18, 1959) of RaLa Run #22 (February 4, 1959) when the beta-minus iodine release reported in the Stack Monitor Datasheets was R_m = 400 mCi - Continued

Radionuclide	Activity Released: No decay Correction* mCi/day	Activity Released: With decay correction† mCi/day	Half-life $T_{1/2}$	units
AM242M	2.0E-09	2.3E-09	152	years
AM242	2.0E-09	2.3E-09	16.02	hours
U232	4.2E-10	1.5E-09	72	years
CM243	1.1E-09	9.7E-10	28.5	years
TOTAL	**800‡**	**861.5**		

* Estimated by ignoring the decay corrections as follows: $R_i = \frac{1}{f} \cdot \frac{A_{d,i} \cdot Y_i}{\sum_{i=1}^{N} A_{d,i} \cdot Y} \cdot R_m$.

† Estimated Equation B-9 in the text.

‡ The total releases (800 mCi) is twice the release reported in the Stack Monitor Datasheets (400 mCi) because the sampler efficiency was assumed to be 50%.

APPENDIX C

BETA-MINUS IODINE ACTIVITY OF SOLID RADIONUCLIDES IN MATERIAL TESTING REACTOR ELEMENTS AND PRODUCTION DURING CRITICALITY ACCIDENT

APPENDIX C: BETA-MINUS IODINE ACTIVITY OF SOLID RADIONUCLIDES IN MATERIAL TESTING REACTOR ELEMENTS AND PRODUCTION DURING CRITICALITY ACCIDENT

The tables in this Appendix give the composition of the solid fission products and actinides contributing to the (β-I) reading each day after the irradiation (for the normal RaLa runs) and each day after the criticality accident (October 16, 1959). The table headers are described below.

For the normal RaLa runs, the tables are given starting with day 3 after irradiation, because dissolution started after a minimum fuel-element cooling time of 2 days.

Day N after irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution to Release %

For the October 1959 criticality accident, the tables are given starting with day 1 after the criticality event.

Day N after the criticality event

Nuclide	Activity Ci	Effective Activity Ci	Contribution to Release %

The tables contain the following columns:

NUCLIDE—The ORIGEN2 nuclide list of a 2-day cooled "typical" MTR element, less the iodine, bromine, xenon, and krypton nuclides, for each of 3-33 days after removal from the reactor. For the 1959 accident, the ORIGEN2 nuclide list for each of the 1-8 days after the criticality event.

ACTIVITY—The inventory (Ci) of solid radionuclides contributing to (β-I) activity in a typical MTR fuel element, 3-33 days cooling, estimated by ORIGEN2 for the RaLa run 2 element.

EFFECTIVE ACTIVITY—The ACTIVITY multiplied by the factor, Y, described in Appendix D, i.e., the number of betas plus ejected electrons (detectable by the 1957-1959 β-detector system) per disintegration.

CONTRIBUTION—The percent of the effective (β-I) activity of a given nuclide in the fuel contributing to the (β-I) reported release.

The EFFECTIVE ACTIVITY may occasionally exceed the ACTIVITY value given by ORIGEN2. The reason is that more than one electron (exceeding the estimated detector cut-off energy of 25 keV) can be emitted by the nuclide. The tables also shows that electrons ejected from the valence shell of metastable nuclides generally exceed 25 keV and thus are counted along with the betas.

Generally, the Effective Activity very nearly equals the actual Activity for a given nuclide. One notable exception is Ru-106, which has no detectable betas. Also, Tc-99m emits significantly fewer detectable betas than indicated by its curies level. Two cases where the Effective Activity significantly exceeds the actual nuclide Activity are Eu-156 and Nd-147.

Table C.1 Activity (Ci) of Solid Radionuclides in a Typical Material Testing Reactor Feed Element, from 3–33 Days Cooling; and Fractional Contributions of Each Solid Radionuclide to Beta-minus Iodine Aerosol Releases, from 3–33 Days Cooling

Table C.1 is presented on the following pages.

Table C.1 Day 3 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	4.78E+04	4.91E+04	11.016	**Ag111**	1.26E+02	1.26E+02	0.028
Pr143	4.39E+04	4.39E+04	9.858	**Cs136**	9.47E+01	1.24E+02	0.028
Ba140	4.39E+04	5.22E+04	11.712	**Sn125**	8.46E+01	8.43E+01	0.019
Ce141	3.06E+04	3.78E+04	8.485	**Pm148m**	7.32E+01	8.43E+01	0.019
Mo099	3.03E+04	3.09E+04	6.933	**Cs134**	7.30E+01	5.39E+01	0.012
Tc099m	2.92E+04	3.22E+03	0.722	**Pr144m**	6.22E+01	4.29E+01	0.01
Te132	2.38E+04	3.00E+04	6.726	**In115m**	5.26E+01	2.89E+01	0.006
Zr095	2.21E+04	2.21E+04	4.963	**Cd115**	4.84E+01	4.89E+01	0.011
Y091	2.17E+04	2.17E+04	4.862	**Te127m**	4.54E+01	4.66E+01	0.01
Sr089	1.89E+04	1.89E+04	4.245	**Th231**	2.90E-04	6.18E-04	0
Nd147	1.55E+04	2.52E+04	5.647	**Th234**	3.42E-06	3.15E-06	0
Ce143	1.44E+04	1.74E+04	3.902	**Pa232**	4.45E-05	1.03E-04	0
Ru103	1.42E+04	1.44E+04	3.222	**Pa233**	4.81E-05	8.66E-05	0
Rh103m	1.28E+04	1.15E+04	2.587	**Pa234m**	3.42E-06	3.46E-06	0
Nb095	9.17E+03	9.18E+03	2.06	**U234**	5.58E-04	1.55E-04	0
Pm149	6.65E+03	6.67E+03	1.495	**U235**	2.68E-04	1.33E-04	0
Pr144	5.18E+03	5.18E+03	1.163	**U236**	7.33E-04	1.91E-04	0
Ce144	5.18E+03	6.02E+03	1.351	**U237**	7.65E+03	1.71E+04	3.837
Nb097	3.44E+03	3.45E+03	0.773	**U238**	4.35E-06	9.97E-07	0
Zr097	3.42E+03	3.43E+03	0.768	**U240**	1.32E-03	1.75E-03	0
Nb097m	3.24E+03	6.71E+01	0.015	**Np235**	1.44E-06	4.63E-08	0
Rh105	1.89E+03	1.89E+03	0.425	**Np236m**	2.84E-03	1.66E-03	0
Sm153	1.65E+03	2.64E+03	0.593	**Np237**	1.57E-04	1.79E-04	0
Pm148	1.31E+03	1.31E+03	0.295	**Np238**	3.24E+02	4.96E+02	0.111
Te127	9.65E+02	9.66E+02	0.217	**Np239**	8.46E+02	1.97E+03	0.441
Sb127	9.62E+02	1.02E+03	0.228	**Np240m**	1.33E-03	2.06E-03	0
Te131m	8.49E+02	1.01E+03	0.226	**Pu236**	8.73E-05	2.85E-05	0
Pm151	7.73E+02	9.57E+02	0.215	**Pu237**	5.50E-05	4.84E-06	0
Y093	5.06E+02	5.07E+02	0.114	**Pu238**	2.12E-01	3.69E-02	0
Te129m	3.69E+02	3.74E+02	0.084	**Pu239**	3.00E-03	2.35E-04	0
Pm147	3.53E+02	3.53E+02	0.079	**Pu240**	1.87E-03	3.09E-04	0
Sr091	3.39E+02	3.39E+02	0.076	**Pu241**	3.35E-01	2.17E-05	0
Eu156	3.06E+02	4.18E+02	0.094	**Pu242**	9.97E-07	1.37E-07	0
Rh106	2.98E+02	2.99E+02	0.067	**Pu243**	6.35E-05	7.11E-05	0
Ru106	2.98E+02	0.00E+00	0	**Am241**	1.73E-05	1.27E-05	0
Te129	2.40E+02	2.80E+02	0.063	**Am242**	3.22E-03	3.29E-03	0
Y091m	2.15E+02	1.08E+01	0.002	**Am243**	2.46E-06	7.67E-07	0
Te131	1.91E+02	2.25E+02	0.051	**Am244**	3.50E-05	9.83E-05	0
Cs137	1.62E+02	1.62E+02	0.036	**Cm242**	2.19E-03	3.44E-04	0
Sr090	1.56E+02	1.56E+02	0.035	**Cm244**	6.01E-05	4.04E-06	0
Y090	1.55E+02	1.55E+02	0.035				
Ba137m	1.53E+02	1.69E+01	0.004				
Nb095m	1.48E+02	1.10E+02	0.025	**Total**	4.27E+05	4.46E+05	100

Table C.1 Day 4 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	4.60E+04	4.73E+04	11.718	Cs136	8.98E+01	1.18E+02	0.029
Pr143	4.23E+04	4.23E+04	10.478	Sn125	7.87E+01	7.84E+01	0.019
Ba140	4.16E+04	4.94E+04	12.243	Cs134	7.29E+01	5.38E+01	0.013
Ce141	3.00E+04	3.70E+04	9.17	Pm148m	7.19E+01	8.29E+01	0.021
Mo099	2.35E+04	2.40E+04	5.946	Pr144m	6.21E+01	4.28E+01	0.011
Tc099m	2.27E+04	2.50E+03	0.619	Sr091	5.88E+01	5.89E+01	0.015
Zr095	2.19E+04	2.19E+04	5.418	Te127m	4.59E+01	4.71E+01	0.012
Y091	2.14E+04	2.14E+04	5.302	In115m	3.85E+01	2.11E+01	0.005
Te132	1.92E+04	2.42E+04	6	Th231	2.80E-04	5.96E-04	0
Sr089	1.87E+04	1.87E+04	4.623	Th234	3.45E-06	3.17E-06	0
Nd147	1.46E+04	2.36E+04	5.854	Pa232	2.62E-05	6.04E-05	0
Ru103	1.39E+04	1.41E+04	3.492	Pa233	5.09E-05	9.17E-05	0
Rh103m	1.26E+04	1.13E+04	2.806	Pa234m	3.45E-06	3.48E-06	0
Nb095	9.42E+03	9.43E+03	2.335	U234	5.58E-04	1.55E-04	0
Ce143	8.70E+03	1.05E+04	2.603	U235	2.68E-04	1.33E-04	0
Pr144	5.17E+03	5.17E+03	1.281	U236	7.33E-04	1.91E-04	0
Ce144	5.17E+03	6.01E+03	1.487	U237	6.90E+03	1.54E+04	3.821
Pm149	4.86E+03	4.87E+03	1.206	U238	4.35E-06	9.97E-07	0
Nb097	1.29E+03	1.29E+03	0.319	U240	4.04E-04	5.37E-04	0
Zr097	1.28E+03	1.28E+03	0.317	Np235	1.44E-06	4.62E-08	0
Nb097m	1.21E+03	2.51E+01	0.006	Np236m	1.36E-03	7.95E-04	0
Rh105	1.18E+03	1.18E+03	0.293	Np237	1.64E-04	1.87E-04	0
Sm153	1.16E+03	1.85E+03	0.458	Np238	2.33E+02	3.57E+02	0.089
Pm148	1.15E+03	1.16E+03	0.286	Np239	6.31E+02	1.47E+03	0.363
Te127	8.14E+02	8.15E+02	0.202	Np240m	4.08E-04	6.34E-04	0
Sb127	8.04E+02	8.49E+02	0.21	Pu236	8.79E-05	2.87E-05	0
Te131m	4.88E+02	5.80E+02	0.144	Pu237	5.42E-05	4.77E-06	0
Pm151	4.31E+02	5.32E+02	0.132	Pu238	2.18E-01	3.80E-02	0
Pm147	3.64E+02	3.64E+02	0.09	Pu239	3.06E-03	2.39E-04	0
Te129m	3.61E+02	3.66E+02	0.091	Pu240	1.87E-03	3.09E-04	0
Rh106	2.98E+02	2.98E+02	0.074	Pu241	3.35E-01	2.17E-05	0
Ru106	2.98E+02	0.00E+00	0	Pu242	9.97E-07	1.37E-07	0
Eu156	2.93E+02	3.99E+02	0.099	Pu243	2.21E-06	2.48E-06	0
Te129	2.35E+02	2.74E+02	0.068	Am241	1.88E-05	1.38E-05	0
Cs137	1.62E+02	1.62E+02	0.04	Am242	1.14E-03	1.16E-03	0
Sr090	1.56E+02	1.56E+02	0.039	Am243	2.46E-06	7.67E-07	0
Y090	1.56E+02	1.56E+02	0.039	Am244	6.74E-06	1.89E-05	0
Ba137m	1.53E+02	1.69E+01	0.004	Cm242	2.19E-03	3.43E-04	0
Nb095m	1.49E+02	1.11E+02	0.027	Cm244	6.01E-05	4.04E-06	0
Ag111	1.15E+02	1.15E+02	0.028				
Te131	1.10E+02	1.30E+02	0.032				
Y093	9.74E+01	9.76E+01	0.024	Total	3.83E+05	4.04E+05	100

Table C.1 Day 5 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	4.41E+04	4.54E+04	12.177	**Cs136**	8.52E+01	1.12E+02	0.03
Pr143	4.05E+04	4.05E+04	10.883	**Sn125**	7.32E+01	7.30E+01	0.02
Ba140	3.94E+04	4.68E+04	12.574	**Cs134**	7.29E+01	5.38E+01	0.014
Ce141	2.94E+04	3.62E+04	9.728	**Pm148m**	7.07E+01	8.16E+01	0.022
Zr095	2.16E+04	2.17E+04	5.812	**Te131**	6.31E+01	7.44E+01	0.02
Y091	2.12E+04	2.12E+04	5.68	**Pr144m**	6.19E+01	4.27E+01	0.011
Sr089	1.84E+04	1.84E+04	4.942	**Te127m**	4.63E+01	4.75E+01	0.013
Mo099	1.83E+04	1.87E+04	5.009	**Th231**	2.74E-04	5.84E-04	0
Tc099m	1.76E+04	1.94E+03	0.522	**Th234**	3.47E-06	3.20E-06	0
Te132	1.55E+04	1.96E+04	5.259	**Pa232**	1.54E-05	3.56E-05	0
Ru103	1.37E+04	1.39E+04	3.721	**Pa233**	5.39E-05	9.70E-05	0
Nd147	1.37E+04	2.22E+04	5.962	**Pa234m**	3.47E-06	3.51E-06	0
Rh103m	1.23E+04	1.11E+04	2.988	**U234**	5.58E-04	1.55E-04	0
Nb095	9.66E+03	9.67E+03	2.596	**U235**	2.68E-04	1.33E-04	0
Ce143	5.26E+03	6.35E+03	1.704	**U236**	7.33E-04	1.91E-04	0
Pr144	5.16E+03	5.16E+03	1.385	**U237**	6.23E+03	1.39E+04	3.739
Ce144	5.16E+03	5.99E+03	1.608	**U238**	4.35E-06	9.97E-07	0
Pm149	3.55E+03	3.56E+03	0.956	**U240**	1.24E-04	1.65E-04	0
Pm148	1.01E+03	1.02E+03	0.273	**Np235**	1.43E-06	4.61E-08	0
Sm153	8.10E+02	1.30E+03	0.348	**Np236m**	6.47E-04	3.79E-04	0
Rh105	7.36E+02	7.39E+02	0.198	**Np237**	1.70E-04	1.93E-04	0
Te127	6.88E+02	6.89E+02	0.185	**Np238**	1.68E+02	2.58E+02	0.069
Sb127	6.71E+02	7.09E+02	0.19	**Np239**	4.70E+02	1.09E+03	0.293
Nb097	4.80E+02	4.81E+02	0.129	**Np240m**	1.25E-04	1.95E-04	0
Zr097	4.78E+02	4.78E+02	0.128	**Pu236**	8.82E-05	2.87E-05	0
Nb097m	4.52E+02	9.37E+00	0.003	**Pu237**	5.33E-05	4.70E-06	0
Pm147	3.74E+02	3.74E+02	0.1	**Pu238**	2.22E-01	3.87E-02	0
Te129m	3.54E+02	3.58E+02	0.096	**Pu239**	3.10E-03	2.43E-04	0
Rh106	2.97E+02	2.98E+02	0.08	**Pu240**	1.87E-03	3.09E-04	0
Ru106	2.97E+02	0.00E+00	0	**Pu241**	3.35E-01	2.17E-05	0
Te131m	2.80E+02	3.33E+02	0.089	**Pu242**	9.97E-07	1.37E-07	0
Eu156	2.80E+02	3.81E+02	0.102	**Am241**	2.02E-05	1.48E-05	0
Pm151	2.40E+02	2.96E+02	0.08	**Am242**	4.03E-04	4.12E-04	0
Te129	2.30E+02	2.68E+02	0.072	**Am243**	2.46E-06	7.67E-07	0
Cs137	1.62E+02	1.62E+02	0.043	**Am244**	1.30E-06	3.65E-06	0
Sr090	1.56E+02	1.56E+02	0.042	**Cm242**	2.18E-03	3.42E-04	0
Y090	1.56E+02	1.56E+02	0.042	**Cm244**	6.01E-05	4.04E-06	0
Ba137m	1.53E+02	1.69E+01	0.005				
Nb095m	1.50E+02	1.11E+02	0.03				
Ag111	1.04E+02	1.05E+02	0.028	**Total**	3.50E+05	3.73E+05	100

Table C.1 Day 6 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	4.21E+04	4.33E+04	12.462	**Ag111**	9.50E+01	9.53E+01	0.027
Pr143	3.87E+04	3.87E+04	11.142	**Cs136**	8.08E+01	1.06E+02	0.031
Ba140	3.73E+04	4.44E+04	12.764	**Cs134**	7.28E+01	5.37E+01	0.015
Ce141	2.87E+04	3.55E+04	10.207	**Pm148m**	6.96E+01	8.02E+01	0.023
Zr095	2.14E+04	2.14E+04	6.159	**Sn125**	6.82E+01	6.79E+01	0.02
Y091	2.09E+04	2.09E+04	6.015	**Pr144m**	6.18E+01	4.26E+01	0.012
Sr089	1.82E+04	1.82E+04	5.224	**Te127m**	4.65E+01	4.77E+01	0.014
Mo099	1.42E+04	1.45E+04	4.171	**Te131**	3.62E+01	4.27E+01	0.012
Tc099m	1.37E+04	1.51E+03	0.435	**Th231**	2.72E-04	5.78E-04	0
Ru103	1.35E+04	1.36E+04	3.918	**Th234**	3.50E-06	3.22E-06	0
Nd147	1.29E+04	2.09E+04	6.001	**Pa232**	9.10E-06	2.10E-05	0
Te132	1.26E+04	1.58E+04	4.554	**Pa233**	5.69E-05	1.02E-04	0
Rh103m	1.21E+04	1.09E+04	3.144	**Pa234m**	3.50E-06	3.53E-06	0
Nb095	9.89E+03	9.90E+03	2.849	**U234**	5.58E-04	1.55E-04	0
Pr144	5.15E+03	5.15E+03	1.48	**U235**	2.68E-04	1.33E-04	0
Ce144	5.15E+03	5.98E+03	1.719	**U236**	7.33E-04	1.91E-04	0
Ce143	3.18E+03	3.83E+03	1.103	**U237**	5.62E+03	1.26E+04	3.616
Pm149	2.60E+03	2.60E+03	0.749	**U238**	4.35E-06	9.97E-07	0
Pm148	8.91E+02	8.93E+02	0.257	**U240**	3.82E-05	5.07E-05	0
Te127	5.82E+02	5.83E+02	0.168	**Np235**	1.43E-06	4.60E-08	0
Sm153	5.67E+02	9.07E+02	0.261	**Np236m**	3.09E-04	1.81E-04	0
Sb127	5.61E+02	5.92E+02	0.17	**Np237**	1.75E-04	1.99E-04	0
Rh105	4.60E+02	4.62E+02	0.133	**Np238**	1.21E+02	1.86E+02	0.053
Pm147	3.83E+02	3.83E+02	0.11	**Np239**	3.50E+02	8.13E+02	0.234
Te129m	3.47E+02	3.51E+02	0.101	**Np240m**	3.85E-05	5.98E-05	0
Rh106	2.97E+02	2.97E+02	0.085	**Pu236**	8.83E-05	2.88E-05	0
Ru106	2.97E+02	0.00E+00	0	**Pu237**	5.25E-05	4.63E-06	0
Eu156	2.67E+02	3.64E+02	0.105	**Pu238**	2.25E-01	3.93E-02	0
Te129	2.26E+02	2.63E+02	0.076	**Pu239**	3.13E-03	2.45E-04	0
Nb097	1.79E+02	1.80E+02	0.052	**Pu240**	1.87E-03	3.09E-04	0
Zr097	1.79E+02	1.79E+02	0.051	**Pu241**	3.35E-01	2.17E-05	0
Nb097m	1.69E+02	3.50E+00	0.001	**Pu242**	9.97E-07	1.37E-07	0
Cs137	1.62E+02	1.62E+02	0.046	**Am241**	2.17E-05	1.59E-05	0
Te131m	1.61E+02	1.91E+02	0.055	**Am242**	1.43E-04	1.46E-04	0
Sr090	1.56E+02	1.56E+02	0.045	**Am243**	2.46E-06	7.67E-07	0
Y090	1.56E+02	1.56E+02	0.045	**Cm242**	2.17E-03	3.41E-04	0
Ba137m	1.53E+02	1.69E+01	0.005	**Cm244**	6.01E-05	4.04E-06	0
Nb095m	1.50E+02	1.11E+02	0.032				
Pm151	1.33E+02	1.65E+02	0.047	**Total**	3.25E+05	3.48E+05	100

Table C.1 Day 7 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	4.01E+04	4.13E+04	12.624	**Cs134**	7.27E+01	5.37E+01	0.016
Pr143	3.69E+04	3.69E+04	11.293	**Pm148m**	6.84E+01	7.89E+01	0.024
Ba140	3.53E+04	4.20E+04	12.853	**Nb097**	6.70E+01	6.72E+01	0.021
Ce141	2.81E+04	3.47E+04	10.623	**Zr097**	6.67E+01	6.68E+01	0.02
Zr095	2.12E+04	2.12E+04	6.479	**Sn125**	6.34E+01	6.32E+01	0.019
Y091	2.07E+04	2.07E+04	6.323	**Nb097m**	6.32E+01	1.31E+00	0
Sr089	1.79E+04	1.79E+04	5.478	**Pr144m**	6.16E+01	4.25E+01	0.013
Ru103	1.32E+04	1.34E+04	4.093	**Te127m**	4.67E+01	4.79E+01	0.015
Nd147	1.21E+04	1.96E+04	5.992	**Th231**	2.70E-04	5.75E-04	0
Rh103m	1.19E+04	1.07E+04	3.285	**Th234**	3.52E-06	3.24E-06	0
Mo099	1.11E+04	1.13E+04	3.447	**Pa232**	5.36E-06	1.24E-05	0
Tc099m	1.06E+04	1.17E+03	0.359	**Pa233**	5.99E-05	1.08E-04	0
Te132	1.02E+04	1.28E+04	3.915	**Pa234m**	3.52E-06	3.56E-06	0
Nb095	1.01E+04	1.01E+04	3.099	**U234**	5.58E-04	1.55E-04	0
Pr144	5.13E+03	5.13E+03	1.57	**U235**	2.68E-04	1.33E-04	0
Ce144	5.13E+03	5.96E+03	1.824	**U236**	7.33E-04	1.91E-04	0
Ce143	1.92E+03	2.32E+03	0.708	**U237**	5.07E+03	1.13E+04	3.469
Pm149	1.90E+03	1.90E+03	0.582	**U238**	4.35E-06	9.97E-07	0
Pm148	7.83E+02	7.86E+02	0.24	**U240**	1.17E-05	1.56E-05	0
Te127	4.94E+02	4.95E+02	0.151	**Np235**	1.43E-06	4.59E-08	0
Sb127	4.68E+02	4.95E+02	0.151	**Np236m**	1.48E-04	8.65E-05	0
Sm153	3.97E+02	6.35E+02	0.194	**Np237**	1.80E-04	2.05E-04	0
Pm147	3.92E+02	3.92E+02	0.12	**Np238**	8.73E+01	1.34E+02	0.041
Te129m	3.40E+02	3.44E+02	0.105	**Np239**	2.61E+02	6.06E+02	0.185
Rh106	2.96E+02	2.96E+02	0.091	**Np240m**	1.18E-05	1.84E-05	0
Ru106	2.96E+02	0.00E+00	0	**Pu236**	8.83E-05	2.88E-05	0
Rh105	2.87E+02	2.88E+02	0.088	**Pu237**	5.17E-05	4.56E-06	0
Eu156	2.55E+02	3.48E+02	0.106	**Pu238**	2.28E-01	3.96E-02	0
Te129	2.21E+02	2.57E+02	0.079	**Pu239**	3.16E-03	2.47E-04	0
Cs137	1.62E+02	1.62E+02	0.049	**Pu240**	1.87E-03	3.09E-04	0
Sr090	1.56E+02	1.56E+02	0.048	**Pu241**	3.35E-01	2.17E-05	0
Y090	1.56E+02	1.56E+02	0.048	**Pu242**	9.97E-07	1.37E-07	0
Ba137m	1.53E+02	1.69E+01	0.005	**Am241**	2.32E-05	1.70E-05	0
Nb095m	1.50E+02	1.11E+02	0.034	**Am242**	5.10E-05	5.21E-05	0
Te131m	9.24E+01	1.10E+02	0.034	**Am243**	2.46E-06	7.67E-07	0
Ag111	8.66E+01	8.68E+01	0.027	**Cm242**	2.16E-03	3.40E-04	0
Cs136	7.66E+01	1.01E+02	0.031	**Cm244**	6.01E-05	4.04E-06	0
Pm151	7.42E+01	9.18E+01	0.028	**Total**	3.05E+05	3.27E+05	100

Table C.1 Day 8 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	3.82E+04	3.93E+04	12.69	**Pr144m**	6.15E+01	4.24E+01	0.014
Pr143	3.52E+04	3.52E+04	11.368	**Sn125**	5.90E+01	5.88E+01	0.019
Ba140	3.35E+04	3.98E+04	12.871	**Te131m**	5.31E+01	6.31E+01	0.02
Ce141	2.75E+04	3.40E+04	10.993	**Te127m**	4.68E+01	4.80E+01	0.016
Zr095	2.09E+04	2.10E+04	6.774	**Pm151**	4.13E+01	5.11E+01	0.017
Y091	2.04E+04	2.04E+04	6.602	**Th231**	2.69E-04	5.73E-04	0
Sr089	1.77E+04	1.77E+04	5.713	**Th234**	3.55E-06	3.26E-06	0
Ru103	1.30E+04	1.31E+04	4.248	**Pa232**	3.16E-06	7.28E-06	0
Rh103m	1.17E+04	1.06E+04	3.411	**Pa233**	6.30E-05	1.13E-04	0
Nd147	1.13E+04	1.84E+04	5.949	**Pa234m**	3.55E-06	3.58E-06	0
Nb095	1.03E+04	1.03E+04	3.343	**U234**	5.58E-04	1.55E-04	0
Mo099	8.59E+03	8.76E+03	2.833	**U235**	2.68E-04	1.33E-04	0
Tc099m	8.27E+03	9.13E+02	0.295	**U236**	7.33E-04	1.91E-04	0
Te132	8.21E+03	1.04E+04	3.346	**U237**	4.58E+03	1.02E+04	3.308
Pr144	5.12E+03	5.12E+03	1.656	**U238**	4.35E-06	9.97E-07	0
Ce144	5.12E+03	5.95E+03	1.923	**U240**	3.61E-06	4.79E-06	0
Pm149	1.39E+03	1.39E+03	0.45	**Np235**	1.43E-06	4.59E-08	0
Ce143	1.16E+03	1.40E+03	0.452	**Np236m**	7.04E-05	4.13E-05	0
Pm148	6.89E+02	6.91E+02	0.223	**Np237**	1.84E-04	2.10E-04	0
Te127	4.20E+02	4.21E+02	0.136	**Np238**	6.29E+01	9.65E+01	0.031
Pm147	4.00E+02	4.00E+02	0.129	**Np239**	1.94E+02	4.51E+02	0.146
Sb127	3.91E+02	4.13E+02	0.134	**Np240m**	3.64E-06	5.65E-06	0
Te129m	3.33E+02	3.37E+02	0.109	**Pu236**	8.83E-05	2.88E-05	0
Rh106	2.95E+02	2.96E+02	0.096	**Pu237**	5.10E-05	4.49E-06	0
Ru106	2.95E+02	0.00E+00	0	**Pu238**	2.29E-01	3.99E-02	0
Sm153	2.78E+02	4.45E+02	0.144	**Pu239**	3.18E-03	2.48E-04	0
Eu156	2.44E+02	3.32E+02	0.107	**Pu240**	1.87E-03	3.09E-04	0
Te129	2.17E+02	2.52E+02	0.081	**Pu241**	3.35E-01	2.17E-05	0
Rh105	1.79E+02	1.80E+02	0.058	**Pu242**	9.97E-07	1.37E-07	0
Cs137	1.62E+02	1.62E+02	0.052	**Am241**	2.47E-05	1.81E-05	0
Sr090	1.56E+02	1.56E+02	0.051	**Am242m**	5.39E-07	5.39E-07	0
Y090	1.56E+02	1.56E+02	0.05	**Am242**	1.84E-05	1.88E-05	0
Ba137m	1.53E+02	1.69E+01	0.005	**Am243**	2.46E-06	7.67E-07	0
Nb095m	1.49E+02	1.11E+02	0.036	**Cm242**	2.15E-03	3.38E-04	0
Ag111	7.89E+01	7.91E+01	0.026	**Cm244**	6.01E-05	4.04E-06	0
Cs134	7.27E+01	5.36E+01	0.017				
Cs136	7.27E+01	9.55E+01	0.031	**Total**	2.87E+05	3.09E+05	100
Pm148m	6.73E+01	7.76E+01	0.025				

Table C.1 Day 9 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	3.63E+04	3.73E+04	12.68	**Pm148m**	6.61E+01	7.63E+01	0.026
Pr143	3.35E+04	3.35E+04	11.378	**Pr144m**	6.13E+01	4.23E+01	0.014
Ba140	3.17E+04	3.77E+04	12.827	**Sn125**	5.49E+01	5.48E+01	0.019
Ce141	2.70E+04	3.33E+04	11.32	**Te127m**	4.68E+01	4.80E+01	0.016
Zr095	2.07E+04	2.07E+04	7.051	**Te131m**	3.05E+01	3.62E+01	0.012
Y091	2.02E+04	2.02E+04	6.864	**Th231**	2.69E-04	5.72E-04	0
Sr089	1.74E+04	1.74E+04	5.929	**Th234**	3.57E-06	3.28E-06	0
Ru103	1.28E+04	1.29E+04	4.391	**Pa232**	1.86E-06	4.29E-06	0
Rh103m	1.15E+04	1.04E+04	3.527	**Pa233**	6.61E-05	1.19E-04	0
Nd147	1.07E+04	1.73E+04	5.878	**Pa234m**	3.57E-06	3.61E-06	0
Nb095	1.05E+04	1.05E+04	3.585	**U234**	5.58E-04	1.55E-04	0
Mo099	6.67E+03	6.81E+03	2.316	**U235**	2.68E-04	1.33E-04	0
Te132	6.64E+03	8.36E+03	2.845	**U236**	7.33E-04	1.91E-04	0
Tc099m	6.43E+03	7.09E+02	0.241	**U237**	4.13E+03	9.24E+03	3.141
Pr144	5.11E+03	5.11E+03	1.738	**U238**	4.35E-06	9.97E-07	0
Ce144	5.11E+03	5.93E+03	2.018	**U240**	1.11E-06	1.47E-06	0
Pm149	1.01E+03	1.02E+03	0.346	**Np235**	1.42E-06	4.58E-08	0
Ce143	7.00E+02	8.45E+02	0.287	**Np236m**	3.36E-05	1.97E-05	0
Pm148	6.06E+02	6.08E+02	0.207	**Np237**	1.88E-04	2.14E-04	0
Pm147	4.08E+02	4.08E+02	0.139	**Np238**	4.54E+01	6.95E+01	0.024
Te127	3.59E+02	3.59E+02	0.122	**Np239**	1.45E+02	3.36E+02	0.114
Sb127	3.27E+02	3.45E+02	0.117	**Np240m**	1.12E-06	1.74E-06	0
Te129m	3.26E+02	3.30E+02	0.112	**Pu236**	8.82E-05	2.87E-05	0
Rh106	2.95E+02	2.95E+02	0.1	**Pu237**	5.02E-05	4.42E-06	0
Ru106	2.95E+02	0.00E+00	0	**Pu238**	2.30E-01	4.01E-02	0
Eu156	2.33E+02	3.18E+02	0.108	**Pu239**	3.19E-03	2.49E-04	0
Te129	2.12E+02	2.47E+02	0.084	**Pu240**	1.87E-03	3.09E-04	0
Sm153	1.95E+02	3.12E+02	0.106	**Pu241**	3.35E-01	2.17E-05	0
Cs137	1.62E+02	1.62E+02	0.055	**Pu242**	9.97E-07	1.37E-07	0
Sr090	1.56E+02	1.56E+02	0.053	**Am241**	2.61E-05	1.92E-05	0
Y090	1.56E+02	1.56E+02	0.053	**Am242m**	5.39E-07	5.39E-07	0
Ba137m	1.53E+02	1.69E+01	0.006	**Am242**	6.86E-06	7.01E-06	0
Nb095m	1.49E+02	1.10E+02	0.037	**Am243**	2.46E-06	7.67E-07	0
Rh105	1.12E+02	1.13E+02	0.038	**Cm242**	2.14E-03	3.37E-04	0
Cs134	7.26E+01	5.36E+01	0.018	**Cm244**	6.01E-05	4.04E-06	0
Ag111	7.19E+01	7.21E+01	0.025				
Cs136	6.89E+01	9.06E+01	0.031	**Total**	2.73E+05	2.94E+05	100

Table C.1 Day 10 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	3.44E+04	3.54E+04	12.613	**Cs136**	6.54E+01	8.59E+01	0.031
Pr143	3.18E+04	3.18E+04	11.34	**Pm148m**	6.50E+01	7.50E+01	0.027
Ba140	3.00E+04	3.57E+04	12.734	**Pr144m**	6.12E+01	4.22E+01	0.015
Ce141	2.64E+04	3.26E+04	11.615	**Sn125**	5.11E+01	5.10E+01	0.018
Zr095	2.05E+04	2.05E+04	7.308	**Te127m**	4.67E+01	4.79E+01	0.017
Y091	2.00E+04	2.00E+04	7.112	**Th231**	2.69E-04	5.72E-04	0
Sr089	1.72E+04	1.72E+04	6.128	**Th234**	3.59E-06	3.31E-06	0
Ru103	1.25E+04	1.27E+04	4.524	**Pa232**	1.10E-06	2.53E-06	0
Rh103m	1.13E+04	1.02E+04	3.633	**Pa233**	6.93E-05	1.25E-04	0
Nb095	1.07E+04	1.07E+04	3.829	**Pa234m**	3.59E-06	3.63E-06	0
Nd147	1.00E+04	1.62E+04	5.786	**U234**	5.58E-04	1.55E-04	0
Te132	5.37E+03	6.76E+03	2.41	**U235**	2.68E-04	1.33E-04	0
Mo099	5.19E+03	5.29E+03	1.887	**U236**	7.33E-04	1.91E-04	0
Pr144	5.10E+03	5.10E+03	1.817	**U237**	3.73E+03	8.33E+03	2.971
Ce144	5.10E+03	5.92E+03	2.11	**U238**	4.35E-06	9.97E-07	0
Tc099m	5.00E+03	5.51E+02	0.197	**Np235**	1.42E-06	4.57E-08	0
Pm149	7.41E+02	7.43E+02	0.265	**Np236m**	1.61E-05	9.41E-06	0
Pm148	5.33E+02	5.34E+02	0.191	**Np237**	1.91E-04	2.18E-04	0
Ce143	4.23E+02	5.10E+02	0.182	**Np238**	3.27E+01	5.01E+01	0.018
Pm147	4.15E+02	4.15E+02	0.148	**Np239**	1.08E+02	2.51E+02	0.089
Te129m	3.19E+02	3.23E+02	0.115	**Pu236**	8.82E-05	2.87E-05	0
Te127	3.07E+02	3.07E+02	0.11	**Pu237**	4.94E-05	4.35E-06	0
Rh106	2.94E+02	2.95E+02	0.105	**Pu238**	2.31E-01	4.03E-02	0
Ru106	2.94E+02	0.00E+00	0	**Pu239**	3.20E-03	2.50E-04	0
Sb127	2.73E+02	2.88E+02	0.103	**Pu240**	1.87E-03	3.09E-04	0
Eu156	2.23E+02	3.03E+02	0.108	**Pu241**	3.35E-01	2.17E-05	0
Te129	2.08E+02	2.42E+02	0.086	**Pu242**	9.97E-07	1.37E-07	0
Cs137	1.62E+02	1.62E+02	0.058	**Am241**	2.76E-05	2.02E-05	0
Sr090	1.56E+02	1.56E+02	0.056	**Am242m**	5.39E-07	5.39E-07	0
Y090	1.56E+02	1.56E+02	0.056	**Am242**	2.78E-06	2.84E-06	0
Ba137m	1.53E+02	1.69E+01	0.006	**Am243**	2.46E-06	7.67E-07	0
Nb095m	1.48E+02	1.10E+02	0.039	**Cm242**	2.13E-03	3.35E-04	0
Sm153	1.36E+02	2.18E+02	0.078	**Cm244**	6.01E-05	4.04E-06	0
Cs134	7.25E+01	5.35E+01	0.019				
Rh105	7.00E+01	7.03E+01	0.025				
Ag111	6.55E+01	6.57E+01	0.023	**Total**	2.60E+05	2.81E+05	100

Table C.1 Day 11 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	3.26E+04	3.36E+04	12.501	**Pr144m**	6.10E+01	4.21E+01	0.016
Pr143	3.03E+04	3.03E+04	11.268	**Ag111**	5.97E+01	5.98E+01	0.022
Ba140	2.85E+04	3.38E+04	12.601	**Sn125**	4.76E+01	4.74E+01	0.018
Ce141	2.58E+04	3.19E+04	11.879	**Te127m**	4.67E+01	4.79E+01	0.018
Zr095	2.03E+04	2.03E+04	7.554	**Rh105**	4.37E+01	4.39E+01	0.016
Y091	1.97E+04	1.97E+04	7.342	**Th231**	2.69E-04	5.72E-04	0
Sr089	1.70E+04	1.70E+04	6.317	**Th234**	3.61E-06	3.32E-06	0
Ru103	1.23E+04	1.25E+04	4.645	**Pa232**	6.46E-07	1.49E-06	0
Rh103m	1.11E+04	1.00E+04	3.729	**Pa233**	7.24E-05	1.30E-04	0
Nb095	1.09E+04	1.09E+04	4.071	**Pa234m**	3.61E-06	3.65E-06	0
Nd147	9.40E+03	1.53E+04	5.68	**U234**	5.58E-04	1.55E-04	0
Pr144	5.08E+03	5.08E+03	1.894	**U235**	2.68E-04	1.33E-04	0
Ce144	5.08E+03	5.90E+03	2.199	**U236**	7.33E-04	1.91E-04	0
Te132	4.34E+03	5.47E+03	2.036	**U237**	3.36E+03	7.52E+03	2.801
Mo099	4.03E+03	4.11E+03	1.532	**U238**	4.35E-06	9.97E-07	0
Tc099m	3.88E+03	4.28E+02	0.16	**Np235**	1.42E-06	4.56E-08	0
Pm149	5.42E+02	5.43E+02	0.202	**Np236m**	7.66E-06	4.49E-06	0
Pm148	4.69E+02	4.70E+02	0.175	**Np237**	1.94E-04	2.21E-04	0
Pm147	4.22E+02	4.22E+02	0.157	**Np238**	2.36E+01	3.61E+01	0.013
Te129m	3.13E+02	3.17E+02	0.118	**Np239**	8.04E+01	1.87E+02	0.07
Rh106	2.94E+02	2.94E+02	0.11	**Pu236**	8.81E-05	2.87E-05	0
Ru106	2.94E+02	0.00E+00	0	**Pu237**	4.87E-05	4.29E-06	0
Te127	2.64E+02	2.64E+02	0.098	**Pu238**	2.32E-01	4.04E-02	0
Ce143	2.55E+02	3.08E+02	0.115	**Pu239**	3.21E-03	2.51E-04	0
Sb127	2.28E+02	2.41E+02	0.09	**Pu240**	1.87E-03	3.09E-04	0
Eu156	2.13E+02	2.90E+02	0.108	**Pu241**	3.35E-01	2.17E-05	0
Te129	2.04E+02	2.37E+02	0.088	**Pu242**	9.97E-07	1.37E-07	0
Cs137	1.62E+02	1.62E+02	0.06	**Am241**	2.91E-05	2.13E-05	0
Sr090	1.56E+02	1.56E+02	0.058	**Am242m**	5.39E-07	5.39E-07	0
Y090	1.56E+02	1.56E+02	0.058	**Am242**	1.33E-06	1.36E-06	0
Ba137m	1.53E+02	1.69E+01	0.006	**Am243**	2.46E-06	7.67E-07	0
Nb095m	1.47E+02	1.09E+02	0.041	**Cm242**	2.13E-03	3.34E-04	0
Sm153	9.55E+01	1.53E+02	0.057	**Cm244**	6.01E-05	4.04E-06	0
Cs134	7.25E+01	5.35E+01	0.02				
Pm148m	6.40E+01	7.37E+01	0.027				
Cs136	6.20E+01	8.15E+01	0.03	**Total**	2.49E+05	2.68E+05	100

Table C.1 Day 12 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	3.09E+04	3.18E+04	12.354	**Cs136**	5.88E+01	7.73E+01	0.03
Pr143	2.88E+04	2.88E+04	11.162	**Ag111**	5.44E+01	5.45E+01	0.021
Ba140	2.70E+04	3.21E+04	12.443	**Te127m**	4.66E+01	4.78E+01	0.019
Ce141	2.53E+04	3.12E+04	12.121	**Sn125**	4.43E+01	4.41E+01	0.017
Zr095	2.00E+04	2.01E+04	7.792	**Rh105**	2.73E+01	2.74E+01	0.011
Y091	1.95E+04	1.95E+04	7.563	**Th231**	2.68E-04	5.71E-04	0
Sr089	1.67E+04	1.67E+04	6.491	**Th234**	3.63E-06	3.34E-06	0
Ru103	1.21E+04	1.23E+04	4.756	**Pa232**	3.81E-07	8.78E-07	0
Nb095	1.11E+04	1.11E+04	4.313	**Pa233**	7.55E-05	1.36E-04	0
Rh103m	1.09E+04	9.83E+03	3.818	**Pa234m**	3.63E-06	3.67E-06	0
Nd147	8.83E+03	1.43E+04	5.56	**U232**	3.30E-07	1.10E-07	0
Pr144	5.07E+03	5.07E+03	1.969	**U234**	5.58E-04	1.55E-04	0
Ce144	5.07E+03	5.89E+03	2.287	**U235**	2.68E-04	1.33E-04	0
Te132	3.51E+03	4.42E+03	1.715	**U236**	7.33E-04	1.91E-04	0
Mo099	3.13E+03	3.20E+03	1.241	**U237**	3.04E+03	6.79E+03	2.635
Tc099m	3.02E+03	3.33E+02	0.129	**U238**	4.35E-06	9.97E-07	0
Pm147	4.28E+02	4.28E+02	0.166	**Np235**	1.42E-06	4.55E-08	0
Pm148	4.12E+02	4.14E+02	0.161	**Np236m**	3.66E-06	2.15E-06	0
Pm149	3.96E+02	3.97E+02	0.154	**Np237**	1.97E-04	2.25E-04	0
Te129m	3.06E+02	3.10E+02	0.12	**Np238**	1.70E+01	2.60E+01	0.01
Rh106	2.93E+02	2.94E+02	0.114	**Np239**	5.99E+01	1.39E+02	0.054
Ru106	2.93E+02	0.00E+00	0	**Pu236**	8.80E-05	2.87E-05	0
Te127	2.28E+02	2.28E+02	0.089	**Pu237**	4.80E-05	4.22E-06	0
Eu156	2.03E+02	2.77E+02	0.108	**Pu238**	2.32E-01	4.05E-02	0
Te129	1.99E+02	2.32E+02	0.09	**Pu239**	3.21E-03	2.51E-04	0
Sb127	1.90E+02	2.01E+02	0.078	**Pu240**	1.87E-03	3.09E-04	0
Cs137	1.62E+02	1.62E+02	0.063	**Pu241**	3.35E-01	2.17E-05	0
Sr090	1.56E+02	1.56E+02	0.061	**Pu242**	9.97E-07	1.37E-07	0
Y090	1.56E+02	1.56E+02	0.061	**Am241**	3.05E-05	2.24E-05	0
Ce143	1.54E+02	1.86E+02	0.072	**Am242m**	5.39E-07	5.39E-07	0
Ba137m	1.53E+02	1.69E+01	0.007	**Am242**	8.17E-07	8.35E-07	0
Nb095m	1.46E+02	1.08E+02	0.042	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.24E+01	5.34E+01	0.021	**Cm242**	2.12E-03	3.32E-04	0
Sm153	6.69E+01	1.07E+02	0.042	**Cm244**	6.01E-05	4.04E-06	0
Pm148m	6.29E+01	7.25E+01	0.028				
Pr144m	6.09E+01	4.20E+01	0.016	**Total**	2.38E+05	2.58E+05	100

Table C.1 Day 13 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	2.93E+04	3.02E+04	12.18	**Cs136**	5.58E+01	7.33E+01	0.03
Pr143	2.73E+04	2.73E+04	11.033	**Ag111**	4.96E+01	4.97E+01	0.02
Ba140	2.55E+04	3.04E+04	12.26	**Sm153**	4.69E+01	7.49E+01	0.03
Ce141	2.48E+04	3.06E+04	12.341	**Te127m**	4.64E+01	4.76E+01	0.019
Zr095	1.98E+04	1.99E+04	8.016	**Sn125**	4.12E+01	4.11E+01	0.017
Y091	1.93E+04	1.93E+04	7.774	**Th231**	2.68E-04	5.71E-04	0
Sr089	1.65E+04	1.65E+04	6.663	**Th234**	3.65E-06	3.36E-06	0
Ru103	1.19E+04	1.20E+04	4.858	**Pa233**	7.86E-05	1.42E-04	0
Nb095	1.13E+04	1.13E+04	4.555	**Pa234m**	3.65E-06	3.69E-06	0
Rh103m	1.07E+04	9.66E+03	3.902	**U232**	3.32E-07	1.11E-07	0
Nd147	8.29E+03	1.35E+04	5.432	**U234**	5.58E-04	1.55E-04	0
Pr144	5.06E+03	5.06E+03	2.043	**U235**	2.68E-04	1.33E-04	0
Ce144	5.06E+03	5.88E+03	2.373	**U236**	7.33E-04	1.91E-04	0
Te132	2.83E+03	3.57E+03	1.442	**U237**	2.74E+03	6.12E+03	2.473
Mo099	2.43E+03	2.49E+03	1.004	**U238**	4.35E-06	9.97E-07	0
Tc099m	2.35E+03	2.59E+02	0.105	**Np235**	1.41E-06	4.55E-08	0
Pm147	4.34E+02	4.34E+02	0.175	**Np236m**	1.75E-06	1.02E-06	0
Pm148	3.63E+02	3.64E+02	0.147	**Np237**	2.00E-04	2.28E-04	0
Te129m	3.00E+02	3.04E+02	0.123	**Np238**	1.22E+01	1.88E+01	0.008
Rh106	2.93E+02	2.93E+02	0.118	**Np239**	4.46E+01	1.04E+02	0.042
Ru106	2.93E+02	0.00E+00	0	**Pu236**	8.80E-05	2.87E-05	0
Pm149	2.89E+02	2.90E+02	0.117	**Pu237**	4.72E-05	4.16E-06	0
Te127	1.98E+02	1.98E+02	0.08	**Pu238**	2.33E-01	4.05E-02	0
Te129	1.95E+02	2.27E+02	0.092	**Pu239**	3.22E-03	2.52E-04	0
Eu156	1.94E+02	2.65E+02	0.107	**Pu240**	1.87E-03	3.09E-04	0
Cs137	1.62E+02	1.62E+02	0.065	**Pu241**	3.35E-01	2.17E-05	0
Sb127	1.59E+02	1.68E+02	0.068	**Pu242**	9.97E-07	1.37E-07	0
Sr090	1.56E+02	1.56E+02	0.063	**Am241**	3.20E-05	2.35E-05	0
Y090	1.56E+02	1.56E+02	0.063	**Am242m**	5.39E-07	5.39E-07	0
Ba137m	1.53E+02	1.69E+01	0.007	**Am242**	6.36E-07	6.50E-07	0
Nb095m	1.45E+02	1.07E+02	0.043	**Am243**	2.46E-06	7.67E-07	0
Ce143	9.32E+01	1.13E+02	0.045	**Cm242**	2.11E-03	3.31E-04	0
Cs134	7.23E+01	5.34E+01	0.022	**Cm244**	6.01E-05	4.04E-06	0
Pm148m	6.18E+01	7.13E+01	0.029				
Pr144m	6.07E+01	4.19E+01	0.017	**Total**	2.29E+05	2.48E+05	100

Table C.1 Day 14 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	2.78E+04	2.86E+04	11.982	**Cs136**	5.29E+01	6.95E+01	0.029
Pr143	2.60E+04	2.60E+04	10.887	**Te127m**	4.62E+01	4.74E+01	0.02
Ce141	2.42E+04	2.99E+04	12.543	**Ag111**	4.51E+01	4.53E+01	0.019
Ba140	2.42E+04	2.88E+04	12.057	**Sn125**	3.84E+01	3.82E+01	0.016
Zr095	1.96E+04	1.96E+04	8.234	**Sm153**	3.28E+01	5.25E+01	0.022
Y091	1.90E+04	1.90E+04	7.974	**Th231**	2.68E-04	5.71E-04	0
Sr089	1.63E+04	1.63E+04	6.821	**Th234**	3.67E-06	3.38E-06	0
Ru103	1.17E+04	1.18E+04	4.955	**Pa233**	8.17E-05	1.47E-04	0
Nb095	1.14E+04	1.15E+04	4.8	**Pa234m**	3.67E-06	3.71E-06	0
Rh103m	1.05E+04	9.49E+03	3.98	**U232**	3.34E-07	1.11E-07	0
Nd147	7.79E+03	1.26E+04	5.295	**U234**	5.58E-04	1.55E-04	0
Pr144	5.05E+03	5.05E+03	2.116	**U235**	2.68E-04	1.33E-04	0
Ce144	5.05E+03	5.86E+03	2.457	**U236**	7.33E-04	1.91E-04	0
Te132	2.29E+03	2.89E+03	1.21	**U237**	2.47E+03	5.53E+03	2.317
Mo099	1.89E+03	1.93E+03	0.81	**U238**	4.35E-06	9.97E-07	0
Tc099m	1.82E+03	2.01E+02	0.084	**Np235**	1.41E-06	4.54E-08	0
Pm147	4.39E+02	4.39E+02	0.184	**Np236m**	8.34E-07	4.89E-07	0
Pm148	3.19E+02	3.20E+02	0.134	**Np237**	2.02E-04	2.30E-04	0
Te129m	2.94E+02	2.98E+02	0.125	**Np238**	8.83E+00	1.35E+01	0.006
Rh106	2.92E+02	2.93E+02	0.123	**Np239**	3.32E+01	7.72E+01	0.032
Ru106	2.92E+02	0.00E+00	0	**Pu236**	8.79E-05	2.87E-05	0
Pm149	2.12E+02	2.12E+02	0.089	**Pu237**	4.65E-05	4.10E-06	0
Te129	1.91E+02	2.23E+02	0.093	**Pu238**	2.33E-01	4.05E-02	0
Eu156	1.85E+02	2.53E+02	0.106	**Pu239**	3.22E-03	2.52E-04	0
Te127	1.72E+02	1.73E+02	0.072	**Pu240**	1.87E-03	3.09E-04	0
Cs137	1.62E+02	1.62E+02	0.068	**Pu241**	3.35E-01	2.17E-05	0
Sr090	1.56E+02	1.56E+02	0.066	**Pu242**	9.97E-07	1.37E-07	0
Y090	1.56E+02	1.56E+02	0.066	**Am241**	3.35E-05	2.45E-05	0
Ba137m	1.53E+02	1.69E+01	0.007	**Am242m**	5.39E-07	5.39E-07	0
Nb095m	1.44E+02	1.06E+02	0.045	**Am242**	5.72E-07	5.84E-07	0
Sb127	1.33E+02	1.40E+02	0.059	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.23E+01	5.33E+01	0.022	**Cm242**	2.10E-03	3.30E-04	0
Pm148m	6.08E+01	7.01E+01	0.029	**Cm244**	6.01E-05	4.04E-06	0
Pr144m	6.06E+01	4.18E+01	0.018				
Ce143	5.63E+01	6.80E+01	0.028	**Total**	2.21E+05	2.39E+05	100

Table C.1 Day 15 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	2.63E+04	2.71E+04	11.768	**Te127m**	4.61E+01	4.72E+01	0.021
Pr143	2.47E+04	2.47E+04	10.72	**Ag111**	4.11E+01	4.12E+01	0.018
Ce141	2.37E+04	2.93E+04	12.728	**Sn125**	3.57E+01	3.56E+01	0.015
Ba140	2.29E+04	2.72E+04	11.837	**Ce143**	3.40E+01	4.10E+01	0.018
Zr095	1.94E+04	1.94E+04	8.439	**Sm153**	2.30E+01	3.67E+01	0.016
Y091	1.88E+04	1.88E+04	8.169	**Th231**	2.68E-04	5.71E-04	0
Sr089	1.61E+04	1.61E+04	6.974	**Th234**	3.69E-06	3.40E-06	0
Nb095	1.16E+04	1.16E+04	5.045	**Pa233**	8.48E-05	1.53E-04	0
Ru103	1.15E+04	1.16E+04	5.049	**Pa234m**	3.69E-06	3.73E-06	0
Rh103m	1.03E+04	9.33E+03	4.053	**U232**	3.37E-07	1.12E-07	0
Nd147	7.31E+03	1.19E+04	5.158	**U234**	5.58E-04	1.55E-04	0
Pr144	5.03E+03	5.03E+03	2.188	**U235**	2.68E-04	1.33E-04	0
Ce144	5.03E+03	5.85E+03	2.541	**U236**	7.33E-04	1.91E-04	0
Te132	1.85E+03	2.33E+03	1.014	**U237**	2.23E+03	4.99E+03	2.167
Mo099	1.47E+03	1.50E+03	0.652	**U238**	4.35E-06	9.97E-07	0
Tc099m	1.42E+03	1.56E+02	0.068	**Np235**	1.41E-06	4.53E-08	0
Pm147	4.45E+02	4.45E+02	0.193	**Np236m**	3.98E-07	2.33E-07	0
Rh106	2.92E+02	2.92E+02	0.127	**Np237**	2.04E-04	2.33E-04	0
Ru106	2.92E+02	0.00E+00	0	**Np238**	6.36E+00	9.75E+00	0.004
Te129m	2.88E+02	2.92E+02	0.127	**Np239**	2.48E+01	5.75E+01	0.025
Pm148	2.81E+02	2.82E+02	0.122	**Pu236**	8.79E-05	2.86E-05	0
Te129	1.87E+02	2.18E+02	0.095	**Pu237**	4.58E-05	4.03E-06	0
Eu156	1.77E+02	2.41E+02	0.105	**Pu238**	2.33E-01	4.06E-02	0
Cs137	1.62E+02	1.62E+02	0.07	**Pu239**	3.22E-03	2.52E-04	0
Sr090	1.56E+02	1.56E+02	0.068	**Pu240**	1.87E-03	3.09E-04	0
Y090	1.56E+02	1.56E+02	0.068	**Pu241**	3.35E-01	2.17E-05	0
Pm149	1.55E+02	1.55E+02	0.067	**Pu242**	9.97E-07	1.37E-07	0
Ba137m	1.53E+02	1.69E+01	0.007	**Am241**	3.49E-05	2.56E-05	0
Te127	1.51E+02	1.51E+02	0.066	**Am242m**	5.39E-07	5.39E-07	0
Nb095m	1.42E+02	1.06E+02	0.046	**Am242**	5.49E-07	5.61E-07	0
Sb127	1.11E+02	1.17E+02	0.051	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.22E+01	5.33E+01	0.023	**Cm242**	2.09E-03	3.28E-04	0
Pr144m	6.04E+01	4.17E+01	0.018	**Cm244**	6.00E-05	4.04E-06	0
Pm148m	5.98E+01	6.90E+01	0.03				
Cs136	5.02E+01	6.59E+01	0.029	**Total**	2.13E+05	2.30E+05	100

Table C.1 Day 16 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	2.50E+04	2.57E+04	11.543	**Te127m**	4.59E+01	4.70E+01	0.021
Pr143	2.35E+04	2.35E+04	10.549	**Ag111**	3.75E+01	3.76E+01	0.017
Ce141	2.32E+04	2.87E+04	12.898	**Sn125**	3.32E+01	3.31E+01	0.015
Ba140	2.17E+04	2.58E+04	11.606	**Ce143**	2.05E+01	2.48E+01	0.011
Zr095	1.92E+04	1.92E+04	8.642	**Th231**	2.68E-04	5.71E-04	0
Y091	1.86E+04	1.86E+04	8.358	**Th234**	3.71E-06	3.42E-06	0
Sr089	1.58E+04	1.58E+04	7.121	**Pa233**	8.79E-05	1.58E-04	0
Nb095	1.17E+04	1.18E+04	5.29	**Pa234m**	3.71E-06	3.75E-06	0
Ru103	1.13E+04	1.14E+04	5.133	**U232**	3.39E-07	1.13E-07	0
Rh103m	1.02E+04	9.16E+03	4.123	**U234**	5.58E-04	1.55E-04	0
Nd147	6.87E+03	1.12E+04	5.016	**U235**	2.68E-04	1.33E-04	0
Pr144	5.02E+03	5.02E+03	2.259	**U236**	7.33E-04	1.91E-04	0
Ce144	5.02E+03	5.83E+03	2.624	**U237**	2.01E+03	4.50E+03	2.025
Te132	1.50E+03	1.89E+03	0.848	**U238**	4.35E-06	9.97E-07	0
Mo099	1.14E+03	1.17E+03	0.525	**Np235**	1.41E-06	4.52E-08	0
Tc099m	1.10E+03	1.22E+02	0.055	**Np237**	2.06E-04	2.35E-04	0
Pm147	4.49E+02	4.49E+02	0.202	**Np238**	4.59E+00	7.03E+00	0.003
Rh106	2.91E+02	2.91E+02	0.131	**Np239**	1.85E+01	4.29E+01	0.019
Ru106	2.91E+02	0.00E+00	0	**Pu236**	8.78E-05	2.86E-05	0
Te129m	2.82E+02	2.86E+02	0.128	**Pu237**	4.51E-05	3.97E-06	0
Pm148	2.47E+02	2.48E+02	0.112	**Pu238**	2.33E-01	4.06E-02	0
Te129	1.84E+02	2.14E+02	0.096	**Pu239**	3.22E-03	2.52E-04	0
Eu156	1.69E+02	2.31E+02	0.104	**Pu240**	1.87E-03	3.09E-04	0
Cs137	1.62E+02	1.62E+02	0.073	**Pu241**	3.34E-01	2.17E-05	0
Y090	1.56E+02	1.56E+02	0.07	**Pu242**	9.97E-07	1.37E-07	0
Sr090	1.56E+02	1.56E+02	0.07	**Am241**	3.64E-05	2.67E-05	0
Ba137m	1.53E+02	1.69E+01	0.008	**Am242m**	5.39E-07	5.39E-07	0
Nb095m	1.41E+02	1.05E+02	0.047	**Am242**	5.41E-07	5.53E-07	0
Te127	1.34E+02	1.34E+02	0.06	**Am243**	2.46E-06	7.67E-07	0
Pm149	1.13E+02	1.13E+02	0.051	**Cm242**	2.08E-03	3.27E-04	0
Sb127	9.26E+01	9.78E+01	0.044	**Cm243**	2.24E-07	2.85E-07	0
Cs134	7.21E+01	5.32E+01	0.024	**Cm244**	6.00E-05	4.04E-06	0
Pr144m	6.03E+01	4.16E+01	0.019				
Pm148m	5.88E+01	6.78E+01	0.031				
Cs136	4.76E+01	6.25E+01	0.028	**Total**	2.06E+05	2.22E+05	100

Table C.1 Day 17 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	2.36E+04	2.43E+04	11.307	**Te127m**	4.56E+01	4.68E+01	0.022
Ce141	2.27E+04	2.81E+04	13.051	**Cs136**	4.51E+01	5.93E+01	0.028
Pr143	2.23E+04	2.23E+04	10.363	**Ag111**	3.42E+01	3.42E+01	0.016
Ba140	2.06E+04	2.44E+04	11.367	**Sn125**	3.09E+01	3.08E+01	0.014
Zr095	1.90E+04	1.90E+04	8.842	**Th231**	2.68E-04	5.71E-04	0
Y091	1.84E+04	1.84E+04	8.54	**Th234**	3.73E-06	3.43E-06	0
Sr089	1.56E+04	1.56E+04	7.265	**Pa233**	9.09E-05	1.64E-04	0
Nb095	1.19E+04	1.19E+04	5.535	**Pa234m**	3.73E-06	3.77E-06	0
Ru103	1.11E+04	1.12E+04	5.214	**U232**	3.41E-07	1.14E-07	0
Rh103m	9.99E+03	9.00E+03	4.188	**U234**	5.58E-04	1.55E-04	0
Nd147	6.45E+03	1.05E+04	4.87	**U235**	2.68E-04	1.33E-04	0
Pr144	5.01E+03	5.01E+03	2.33	**U236**	7.33E-04	1.91E-04	0
Ce144	5.01E+03	5.82E+03	2.707	**U237**	1.82E+03	4.06E+03	1.889
Te132	1.21E+03	1.53E+03	0.709	**U238**	4.35E-06	9.97E-07	0
Mo099	8.88E+02	9.07E+02	0.422	**Np235**	1.40E-06	4.51E-08	0
Tc099m	8.56E+02	9.44E+01	0.044	**Np237**	2.08E-04	2.37E-04	0
Pm147	4.54E+02	4.54E+02	0.211	**Np238**	3.31E+00	5.06E+00	0.002
Rh106	2.90E+02	2.91E+02	0.135	**Np239**	1.38E+01	3.19E+01	0.015
Ru106	2.90E+02	0.00E+00	0	**Pu236**	8.78E-05	2.86E-05	0
Te129m	2.76E+02	2.80E+02	0.13	**Pu237**	4.44E-05	3.91E-06	0
Pm148	2.18E+02	2.18E+02	0.102	**Pu238**	2.33E-01	4.06E-02	0
Te129	1.80E+02	2.09E+02	0.097	**Pu239**	3.23E-03	2.52E-04	0
Eu156	1.62E+02	2.20E+02	0.103	**Pu240**	1.87E-03	3.09E-04	0
Cs137	1.61E+02	1.61E+02	0.075	**Pu241**	3.34E-01	2.17E-05	0
Y090	1.56E+02	1.56E+02	0.073	**Pu242**	9.97E-07	1.37E-07	0
Sr090	1.56E+02	1.56E+02	0.073	**Am241**	3.79E-05	2.78E-05	0
Ba137m	1.53E+02	1.69E+01	0.008	**Am242m**	5.39E-07	5.39E-07	0
Nb095m	1.40E+02	1.04E+02	0.048	**Am242**	5.38E-07	5.50E-07	0
Te127	1.19E+02	1.19E+02	0.055	**Am243**	2.46E-06	7.67E-07	0
Pm149	8.26E+01	8.29E+01	0.039	**Cm242**	2.07E-03	3.25E-04	0
Sb127	7.74E+01	8.17E+01	0.038	**Cm243**	2.24E-07	2.85E-07	0
Cs134	7.21E+01	5.32E+01	0.025	**Cm244**	6.00E-05	4.04E-06	0
Pr144m	6.01E+01	4.15E+01	0.019				
Pm148m	5.78E+01	6.67E+01	0.031	**Total**	2.00E+05	2.15E+05	100

Table C.1 Day 18 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	2.24E+04	2.30E+04	11.062	**Te127m**	4.54E+01	4.66E+01	0.022
Ce141	2.23E+04	2.75E+04	13.195	**Cs136**	4.28E+01	5.63E+01	0.027
Pr143	2.12E+04	2.12E+04	10.169	**Ag111**	3.11E+01	3.12E+01	0.015
Ba140	1.95E+04	2.32E+04	11.12	**Sn125**	2.88E+01	2.87E+01	0.014
Zr095	1.88E+04	1.88E+04	9.03	**Th231**	2.68E-04	5.71E-04	0
Y091	1.81E+04	1.81E+04	8.713	**Th234**	3.75E-06	3.45E-06	0
Sr089	1.54E+04	1.54E+04	7.397	**Pa233**	9.39E-05	1.69E-04	0
Nb095	1.20E+04	1.20E+04	5.783	**Pa234m**	3.75E-06	3.78E-06	0
Ru103	1.09E+04	1.10E+04	5.293	**U232**	3.44E-07	1.14E-07	0
Rh103m	9.81E+03	8.85E+03	4.249	**U234**	5.58E-04	1.55E-04	0
Nd147	6.06E+03	9.83E+03	4.723	**U235**	2.68E-04	1.33E-04	0
Pr144	5.00E+03	5.00E+03	2.401	**U236**	7.33E-04	1.91E-04	0
Ce144	5.00E+03	5.80E+03	2.788	**U237**	1.64E+03	3.67E+03	1.76
Te132	9.78E+02	1.23E+03	0.592	**U238**	4.35E-06	9.97E-07	0
Mo099	6.90E+02	7.05E+02	0.338	**Np235**	1.40E-06	4.51E-08	0
Tc099m	6.65E+02	7.34E+01	0.035	**Np237**	2.09E-04	2.38E-04	0
Pm147	4.58E+02	4.58E+02	0.22	**Np238**	2.38E+00	3.65E+00	0.002
Rh106	2.90E+02	2.90E+02	0.139	**Np239**	1.02E+01	2.38E+01	0.011
Ru106	2.90E+02	0.00E+00	0	**Pu236**	8.77E-05	2.86E-05	0
Te129m	2.71E+02	2.74E+02	0.132	**Pu237**	4.38E-05	3.85E-06	0
Pm148	1.92E+02	1.92E+02	0.092	**Pu238**	2.33E-01	4.06E-02	0
Te129	1.76E+02	2.05E+02	0.098	**Pu239**	3.23E-03	2.52E-04	0
Cs137	1.61E+02	1.61E+02	0.078	**Pu240**	1.87E-03	3.09E-04	0
Y090	1.56E+02	1.56E+02	0.075	**Pu241**	3.34E-01	2.17E-05	0
Sr090	1.56E+02	1.56E+02	0.075	**Pu242**	9.97E-07	1.37E-07	0
Eu156	1.54E+02	2.11E+02	0.101	**Am241**	3.93E-05	2.89E-05	0
Ba137m	1.53E+02	1.69E+01	0.008	**Am242m**	5.39E-07	5.39E-07	0
Nb095m	1.38E+02	1.03E+02	0.049	**Am242**	5.37E-07	5.49E-07	0
Te127	1.06E+02	1.06E+02	0.051	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.20E+01	5.31E+01	0.026	**Cm242**	2.06E-03	3.24E-04	0
Sb127	6.46E+01	6.83E+01	0.033	**Cm243**	2.24E-07	2.85E-07	0
Pm149	6.04E+01	6.06E+01	0.029	**Cm244**	6.00E-05	4.03E-06	0
Pr144m	6.00E+01	4.14E+01	0.02				
Pm148m	5.69E+01	6.56E+01	0.031	**Total**	1.94E+05	2.08E+05	100

Table C.1 Day 19 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	2.18E+04	2.69E+04	13.325	**Pm149**	4.42E+01	4.43E+01	0.022
La140	2.12E+04	2.18E+04	10.813	**Cs136**	4.06E+01	5.34E+01	0.026
Pr143	2.01E+04	2.01E+04	9.97	**Ag111**	2.84E+01	2.84E+01	0.014
Zr095	1.86E+04	1.86E+04	9.217	**Sn125**	2.68E+01	2.67E+01	0.013
Ba140	1.84E+04	2.19E+04	10.867	**Th231**	2.68E-04	5.71E-04	0
Y091	1.79E+04	1.79E+04	8.885	**Th234**	3.76E-06	3.46E-06	0
Sr089	1.52E+04	1.52E+04	7.527	**Pa233**	9.68E-05	1.74E-04	0
Nb095	1.22E+04	1.22E+04	6.031	**Pa234m**	3.76E-06	3.80E-06	0
Ru103	1.07E+04	1.08E+04	5.362	**U232**	3.46E-07	1.15E-07	0
Rh103m	9.64E+03	8.69E+03	4.307	**U234**	5.58E-04	1.55E-04	0
Nd147	5.69E+03	9.24E+03	4.576	**U235**	2.68E-04	1.33E-04	0
Pr144	4.99E+03	4.99E+03	2.471	**U236**	7.33E-04	1.91E-04	0
Ce144	4.99E+03	5.79E+03	2.869	**U237**	1.48E+03	3.31E+03	1.639
Te132	7.91E+02	9.97E+02	0.494	**U238**	4.35E-06	9.97E-07	0
Mo099	5.37E+02	5.48E+02	0.271	**Np235**	1.40E-06	4.50E-08	0
Tc099m	5.17E+02	5.70E+01	0.028	**Np237**	2.11E-04	2.40E-04	0
Pm147	4.62E+02	4.62E+02	0.229	**Np238**	1.72E+00	2.63E+00	0.001
Rh106	2.89E+02	2.90E+02	0.144	**Np239**	7.63E+00	1.77E+01	0.009
Ru106	2.89E+02	0.00E+00	0	**Pu236**	8.76E-05	2.86E-05	0
Te129m	2.65E+02	2.69E+02	0.133	**Pu237**	4.31E-05	3.80E-06	0
Te129	1.73E+02	2.01E+02	0.1	**Pu238**	2.33E-01	4.06E-02	0
Pm148	1.69E+02	1.69E+02	0.084	**Pu239**	3.23E-03	2.52E-04	0
Cs137	1.61E+02	1.61E+02	0.08	**Pu240**	1.87E-03	3.09E-04	0
Y090	1.56E+02	1.56E+02	0.077	**Pu241**	3.34E-01	2.17E-05	0
Sr090	1.56E+02	1.56E+02	0.077	**Pu242**	9.97E-07	1.37E-07	0
Ba137m	1.53E+02	1.69E+01	0.008	**Am241**	4.08E-05	2.99E-05	0
Eu156	1.48E+02	2.01E+02	0.1	**Am242m**	5.39E-07	5.39E-07	0
Nb095m	1.37E+02	1.02E+02	0.05	**Am242**	5.37E-07	5.48E-07	0
Te127	9.59E+01	9.60E+01	0.048	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.19E+01	5.31E+01	0.026	**Cm242**	2.05E-03	3.23E-04	0
Pr144m	5.98E+01	4.13E+01	0.02	**Cm243**	2.24E-07	2.85E-07	0
Pm148m	5.59E+01	6.45E+01	0.032	**Cm244**	6.00E-05	4.03E-06	0
Sb127	5.40E+01	5.70E+01	0.028				
Te127m	4.52E+01	4.63E+01	0.023	**Total**	1.88E+05	2.02E+05	100

Table C.1 Day 20 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	2.13E+04	2.63E+04	13.445	**Cs136**	3.85E+01	5.06E+01	0.026
La140	2.01E+04	2.07E+04	10.559	**Pm149**	3.23E+01	3.24E+01	0.017
Pr143	1.91E+04	1.91E+04	9.762	**Ag111**	2.58E+01	2.59E+01	0.013
Zr095	1.84E+04	1.84E+04	9.399	**Sn125**	2.49E+01	2.48E+01	0.013
Y091	1.77E+04	1.77E+04	9.052	**Th231**	2.68E-04	5.71E-04	0
Ba140	1.75E+04	2.08E+04	10.61	**Th234**	3.78E-06	3.48E-06	0
Sr089	1.50E+04	1.50E+04	7.657	**Pa233**	9.97E-05	1.80E-04	0
Nb095	1.23E+04	1.23E+04	6.278	**Pa234m**	3.78E-06	3.82E-06	0
Ru103	1.05E+04	1.06E+04	5.43	**U232**	3.48E-07	1.16E-07	0
Rh103m	9.47E+03	8.54E+03	4.363	**U234**	5.58E-04	1.55E-04	0
Nd147	5.35E+03	8.67E+03	4.431	**U235**	2.68E-04	1.33E-04	0
Pr144	4.97E+03	4.97E+03	2.54	**U236**	7.33E-04	1.91E-04	0
Ce144	4.97E+03	5.78E+03	2.951	**U237**	1.34E+03	2.99E+03	1.525
Te132	6.39E+02	8.06E+02	0.411	**U238**	4.35E-06	9.97E-07	0
Pm147	4.66E+02	4.66E+02	0.238	**Np235**	1.40E-06	4.49E-08	0
Mo099	4.17E+02	4.26E+02	0.217	**Np237**	2.12E-04	2.41E-04	0
Tc099m	4.02E+02	4.43E+01	0.023	**Np238**	1.24E+00	1.90E+00	0.001
Rh106	2.89E+02	2.89E+02	0.148	**Np239**	5.69E+00	1.32E+01	0.007
Ru106	2.89E+02	0.00E+00	0	**Pu236**	8.76E-05	2.85E-05	0
Te129m	2.60E+02	2.63E+02	0.134	**Pu237**	4.25E-05	3.74E-06	0
Te129	1.69E+02	1.97E+02	0.1	**Pu238**	2.33E-01	4.06E-02	0
Cs137	1.61E+02	1.61E+02	0.082	**Pu239**	3.23E-03	2.52E-04	0
Y090	1.56E+02	1.56E+02	0.08	**Pu240**	1.87E-03	3.09E-04	0
Sr090	1.56E+02	1.56E+02	0.08	**Pu241**	3.34E-01	2.17E-05	0
Ba137m	1.53E+02	1.69E+01	0.009	**Pu242**	9.97E-07	1.37E-07	0
Pm148	1.49E+02	1.49E+02	0.076	**Am241**	4.23E-05	3.10E-05	0
Eu156	1.41E+02	1.92E+02	0.098	**Am242m**	5.39E-07	5.39E-07	0
Nb095m	1.36E+02	1.01E+02	0.051	**Am242**	5.37E-07	5.48E-07	0
Te127	8.72E+01	8.72E+01	0.045	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.19E+01	5.30E+01	0.027	**Cm242**	2.05E-03	3.21E-04	0
Pr144m	5.97E+01	4.12E+01	0.021	**Cm243**	2.24E-07	2.85E-07	0
Pm148m	5.50E+01	6.34E+01	0.032	**Cm244**	6.00E-05	4.03E-06	0
Sb127	4.51E+01	4.76E+01	0.024				
Te127m	4.49E+01	4.61E+01	0.024	**Total**	1.82E+05	1.96E+05	100

Table C.1 Day 21 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	2.09E+04	2.58E+04	13.558	**Cs136**	3.65E+01	4.80E+01	0.025
La140	1.90E+04	1.96E+04	10.301	**Pm149**	2.36E+01	2.37E+01	0.012
Zr095	1.82E+04	1.82E+04	9.575	**Ag111**	2.35E+01	2.36E+01	0.012
Pr143	1.82E+04	1.82E+04	9.554	**Sn125**	2.32E+01	2.31E+01	0.012
Y091	1.75E+04	1.75E+04	9.212	**Th231**	2.68E-04	5.71E-04	0
Ba140	1.65E+04	1.97E+04	10.354	**Th234**	3.80E-06	3.49E-06	0
Sr089	1.48E+04	1.48E+04	7.776	**Pa233**	1.03E-04	1.85E-04	0
Nb095	1.24E+04	1.24E+04	6.529	**Pa234m**	3.80E-06	3.83E-06	0
Ru103	1.03E+04	1.05E+04	5.498	**U232**	3.51E-07	1.17E-07	0
Rh103m	9.30E+03	8.39E+03	4.414	**U234**	5.58E-04	1.55E-04	0
Nd147	5.02E+03	8.15E+03	4.286	**U235**	2.68E-04	1.33E-04	0
Pr144	4.96E+03	4.96E+03	2.61	**U236**	7.33E-04	1.91E-04	0
Ce144	4.96E+03	5.76E+03	3.031	**U237**	1.20E+03	2.69E+03	1.417
Te132	5.17E+02	6.51E+02	0.343	**U238**	4.35E-06	9.97E-07	0
Pm147	4.69E+02	4.69E+02	0.247	**Np235**	1.39E-06	4.48E-08	0
Mo099	3.24E+02	3.31E+02	0.174	**Np237**	2.13E-04	2.43E-04	0
Tc099m	3.12E+02	3.45E+01	0.018	**Np238**	8.92E-01	1.37E+00	0.001
Rh106	2.88E+02	2.89E+02	0.152	**Np239**	4.24E+00	9.84E+00	0.005
Ru106	2.88E+02	0.00E+00	0	**Pu236**	8.75E-05	2.85E-05	0
Te129m	2.54E+02	2.58E+02	0.136	**Pu237**	4.18E-05	3.68E-06	0
Te129	1.66E+02	1.93E+02	0.101	**Pu238**	2.33E-01	4.06E-02	0
Cs137	1.61E+02	1.61E+02	0.085	**Pu239**	3.23E-03	2.52E-04	0
Y090	1.56E+02	1.56E+02	0.082	**Pu240**	1.87E-03	3.09E-04	0
Sr090	1.56E+02	1.56E+02	0.082	**Pu241**	3.34E-01	2.17E-05	0
Ba137m	1.53E+02	1.69E+01	0.009	**Pu242**	9.97E-07	1.37E-07	0
Eu156	1.35E+02	1.84E+02	0.097	**Am241**	4.37E-05	3.21E-05	0
Nb095m	1.34E+02	9.96E+01	0.052	**Am242m**	5.39E-07	5.39E-07	0
Pm148	1.31E+02	1.31E+02	0.069	**Am242**	5.37E-07	5.48E-07	0
Te127	7.98E+01	7.99E+01	0.042	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.18E+01	5.30E+01	0.028	**Cm242**	2.04E-03	3.20E-04	0
Pr144m	5.95E+01	4.11E+01	0.022	**Cm243**	2.24E-07	2.85E-07	0
Pm148m	5.41E+01	6.24E+01	0.033	**Cm244**	6.00E-05	4.03E-06	0
Te127m	4.47E+01	4.58E+01	0.024				
Sb127	3.77E+01	3.98E+01	0.021	**Total**	1.77E+05	1.90E+05	100

Table C.1 Day 22 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	2.04E+04	2.52E+04	13.661	**Sb127**	3.14E+01	3.32E+01	0.018
La140	1.80E+04	1.85E+04	10.039	**Sn125**	2.16E+01	2.15E+01	0.012
Zr095	1.80E+04	1.80E+04	9.752	**Ag111**	2.15E+01	2.15E+01	0.012
Y091	1.73E+04	1.73E+04	9.367	**Pm149**	1.72E+01	1.73E+01	0.009
Pr143	1.73E+04	1.73E+04	9.346	**Th231**	2.68E-04	5.71E-04	0
Ba140	1.57E+04	1.86E+04	10.093	**Th234**	3.81E-06	3.51E-06	0
Sr089	1.46E+04	1.46E+04	7.894	**Pa233**	1.05E-04	1.90E-04	0
Nb095	1.25E+04	1.25E+04	6.779	**Pa234m**	3.81E-06	3.85E-06	0
Ru103	1.01E+04	1.03E+04	5.561	**U232**	3.53E-07	1.17E-07	0
Rh103m	9.14E+03	8.24E+03	4.464	**U234**	5.58E-04	1.55E-04	0
Pr144	4.95E+03	4.95E+03	2.68	**U235**	2.68E-04	1.33E-04	0
Ce144	4.95E+03	5.75E+03	3.112	**U236**	7.33E-04	1.91E-04	0
Nd147	4.72E+03	7.65E+03	4.143	**U237**	1.09E+03	2.43E+03	1.316
Pm147	4.72E+02	4.72E+02	0.256	**U238**	4.35E-06	9.97E-07	0
Te132	4.18E+02	5.26E+02	0.285	**Np235**	1.39E-06	4.47E-08	0
Rh106	2.88E+02	2.88E+02	0.156	**Np237**	2.14E-04	2.44E-04	0
Ru106	2.88E+02	0.00E+00	0	**Np238**	6.43E-01	9.85E-01	0.001
Mo099	2.52E+02	2.57E+02	0.139	**Np239**	3.16E+00	7.33E+00	0.004
Te129m	2.49E+02	2.52E+02	0.137	**Pu236**	8.75E-05	2.85E-05	0
Tc099m	2.43E+02	2.68E+01	0.015	**Pu237**	4.12E-05	3.63E-06	0
Te129	1.62E+02	1.89E+02	0.102	**Pu238**	2.33E-01	4.06E-02	0
Cs137	1.61E+02	1.61E+02	0.087	**Pu239**	3.23E-03	2.52E-04	0
Y090	1.56E+02	1.56E+02	0.085	**Pu240**	1.87E-03	3.09E-04	0
Sr090	1.56E+02	1.56E+02	0.085	**Pu241**	3.34E-01	2.17E-05	0
Ba137m	1.53E+02	1.69E+01	0.009	**Pu242**	9.97E-07	1.37E-07	0
Nb095m	1.33E+02	9.86E+01	0.053	**Am241**	4.52E-05	3.32E-05	0
Eu156	1.29E+02	1.75E+02	0.095	**Am242m**	5.39E-07	5.39E-07	0
Pm148	1.16E+02	1.16E+02	0.063	**Am242**	5.37E-07	5.48E-07	0
Te127	7.36E+01	7.37E+01	0.04	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.17E+01	5.29E+01	0.029	**Cm242**	2.03E-03	3.19E-04	0
Pr144m	5.94E+01	4.10E+01	0.022	**Cm243**	2.24E-07	2.85E-07	0
Pm148m	5.32E+01	6.13E+01	0.033	**Cm244**	6.00E-05	4.03E-06	0
Te127m	4.44E+01	4.56E+01	0.025				
Cs136	3.46E+01	4.55E+01	0.025	**Total**	1.73E+05	1.85E+05	100

Table C.1 Day 23 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	2.00E+04	2.47E+04	13.75	**Sb127**	2.63E+01	2.77E+01	0.015
Zr095	1.78E+04	1.78E+04	9.918	**Sn125**	2.01E+01	2.00E+01	0.011
Y091	1.71E+04	1.71E+04	9.523	**Ag111**	1.95E+01	1.96E+01	0.011
La140	1.71E+04	1.76E+04	9.785	**Th231**	2.68E-04	5.71E-04	0
Pr143	1.64E+04	1.64E+04	9.133	**Th234**	3.83E-06	3.52E-06	0
Ba140	1.48E+04	1.77E+04	9.835	**Pa233**	1.08E-04	1.95E-04	0
Sr089	1.44E+04	1.44E+04	8.008	**Pa234m**	3.83E-06	3.87E-06	0
Nb095	1.26E+04	1.26E+04	7.034	**U232**	3.55E-07	1.18E-07	0
Ru103	9.96E+03	1.01E+04	5.619	**U234**	5.58E-04	1.55E-04	0
Rh103m	8.98E+03	8.10E+03	4.51	**U235**	2.68E-04	1.33E-04	0
Pr144	4.94E+03	4.94E+03	2.749	**U236**	7.33E-04	1.91E-04	0
Ce144	4.94E+03	5.73E+03	3.193	**U237**	9.81E+02	2.19E+03	1.221
Nd147	4.43E+03	7.19E+03	4.002	**U238**	4.35E-06	9.97E-07	0
Pm147	4.75E+02	4.75E+02	0.265	**Np235**	1.39E-06	4.47E-08	0
Te132	3.38E+02	4.26E+02	0.237	**Np237**	2.15E-04	2.45E-04	0
Rh106	2.87E+02	2.88E+02	0.16	**Np238**	4.63E-01	7.10E-01	0
Ru106	2.87E+02	0.00E+00	0	**Np239**	2.35E+00	5.46E+00	0.003
Te129m	2.44E+02	2.47E+02	0.138	**Pu236**	8.74E-05	2.85E-05	0
Mo099	1.96E+02	2.00E+02	0.111	**Pu237**	4.06E-05	3.57E-06	0
Tc099m	1.89E+02	2.08E+01	0.012	**Pu238**	2.33E-01	4.06E-02	0
Cs137	1.61E+02	1.61E+02	0.09	**Pu239**	3.23E-03	2.52E-04	0
Te129	1.59E+02	1.85E+02	0.103	**Pu240**	1.87E-03	3.09E-04	0
Y090	1.56E+02	1.56E+02	0.087	**Pu241**	3.34E-01	2.17E-05	0
Sr090	1.56E+02	1.56E+02	0.087	**Pu242**	9.97E-07	1.37E-07	0
Ba137m	1.53E+02	1.69E+01	0.009	**Am241**	4.67E-05	3.42E-05	0
Nb095m	1.32E+02	9.76E+01	0.054	**Am242m**	5.39E-07	5.39E-07	0
Eu156	1.23E+02	1.68E+02	0.093	**Am242**	5.37E-07	5.48E-07	0
Pm148	1.02E+02	1.02E+02	0.057	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.17E+01	5.29E+01	0.029	**Cm242**	2.02E-03	3.17E-04	0
Te127	6.84E+01	6.85E+01	0.038	**Cm243**	2.24E-07	2.85E-07	0
Pr144m	5.92E+01	4.09E+01	0.023	**Cm244**	6.00E-05	4.03E-06	0
Pm148m	5.23E+01	6.03E+01	0.034				
Te127m	4.42E+01	4.53E+01	0.025				
Cs136	3.29E+01	4.32E+01	0.024	**Total**	1.68E+05	1.80E+05	100

Table C.1 Day 24 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.96E+04	2.42E+04	13.836	**Sb127**	2.19E+01	2.32E+01	0.013
Zr095	1.76E+04	1.76E+04	10.086	**Sn125**	1.87E+01	1.86E+01	0.011
Y091	1.69E+04	1.69E+04	9.674	**Ag111**	1.78E+01	1.79E+01	0.01
La140	1.62E+04	1.66E+04	9.525	**Th231**	2.68E-04	5.71E-04	0
Pr143	1.56E+04	1.56E+04	8.919	**Th234**	3.84E-06	3.54E-06	0
Sr089	1.42E+04	1.42E+04	8.117	**Pa233**	1.11E-04	2.00E-04	0
Ba140	1.41E+04	1.67E+04	9.571	**Pa234m**	3.84E-06	3.88E-06	0
Nb095	1.27E+04	1.27E+04	7.287	**U232**	3.58E-07	1.19E-07	0
Ru103	9.79E+03	9.91E+03	5.673	**U234**	5.58E-04	1.55E-04	0
Rh103m	8.83E+03	7.96E+03	4.555	**U235**	2.68E-04	1.33E-04	0
Pr144	4.93E+03	4.93E+03	2.819	**U236**	7.33E-04	1.91E-04	0
Ce144	4.93E+03	5.72E+03	3.274	**U237**	8.85E+02	1.98E+03	1.133
Nd147	4.16E+03	6.75E+03	3.865	**U238**	4.35E-06	9.97E-07	0
Pm147	4.78E+02	4.78E+02	0.274	**Np235**	1.39E-06	4.46E-08	0
Rh106	2.87E+02	2.87E+02	0.164	**Np237**	2.16E-04	2.46E-04	0
Ru106	2.87E+02	0.00E+00	0	**Np238**	3.34E-01	5.12E-01	0
Te132	2.73E+02	3.44E+02	0.197	**Np239**	1.75E+00	4.07E+00	0.002
Te129m	2.39E+02	2.42E+02	0.139	**Pu236**	8.73E-05	2.85E-05	0
Cs137	1.61E+02	1.61E+02	0.092	**Pu237**	4.00E-05	3.52E-06	0
Y090	1.56E+02	1.56E+02	0.089	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.089	**Pu239**	3.23E-03	2.52E-04	0
Te129	1.56E+02	1.81E+02	0.104	**Pu240**	1.87E-03	3.09E-04	0
Ba137m	1.53E+02	1.69E+01	0.01	**Pu241**	3.34E-01	2.17E-05	0
Mo099	1.52E+02	1.55E+02	0.089	**Pu242**	9.97E-07	1.37E-07	0
Tc099m	1.47E+02	1.62E+01	0.009	**Am241**	4.81E-05	3.53E-05	0
Nb095m	1.30E+02	9.66E+01	0.055	**Am242m**	5.39E-07	5.39E-07	0
Eu156	1.17E+02	1.60E+02	0.092	**Am242**	5.37E-07	5.48E-07	0
Pm148	8.98E+01	9.00E+01	0.052	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.16E+01	5.29E+01	0.03	**Cm242**	2.01E-03	3.16E-04	0
Te127	6.40E+01	6.41E+01	0.037	**Cm243**	2.24E-07	2.85E-07	0
Pr144m	5.91E+01	4.08E+01	0.023	**Cm244**	6.00E-05	4.03E-06	0
Pm148m	5.14E+01	5.93E+01	0.034				
Te127m	4.39E+01	4.50E+01	0.026				
Cs136	3.12E+01	4.10E+01	0.023	**Total**	1.64E+05	1.75E+05	100

Table C.1 Day 25 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.92E+04	2.37E+04	13.912	**Sb127**	1.83E+01	1.94E+01	0.011
Zr095	1.74E+04	1.74E+04	10.249	**Sn125**	1.74E+01	1.73E+01	0.01
Y091	1.67E+04	1.67E+04	9.82	**Ag111**	1.62E+01	1.63E+01	0.01
La140	1.53E+04	1.58E+04	9.267	**Th231**	2.68E-04	5.71E-04	0
Pr143	1.48E+04	1.48E+04	8.703	**Th234**	3.86E-06	3.55E-06	0
Sr089	1.40E+04	1.40E+04	8.226	**Pa233**	1.14E-04	2.04E-04	0
Ba140	1.33E+04	1.58E+04	9.314	**Pa234m**	3.86E-06	3.90E-06	0
Nb095	1.28E+04	1.28E+04	7.538	**U232**	3.60E-07	1.20E-07	0
Ru103	9.62E+03	9.74E+03	5.725	**U234**	5.58E-04	1.55E-04	0
Rh103m	8.67E+03	7.82E+03	4.598	**U235**	2.68E-04	1.33E-04	0
Pr144	4.91E+03	4.91E+03	2.889	**U236**	7.33E-04	1.91E-04	0
Ce144	4.91E+03	5.71E+03	3.355	**U237**	7.99E+02	1.79E+03	1.05
Nd147	3.91E+03	6.34E+03	3.729	**U238**	4.35E-06	9.97E-07	0
Pm147	4.81E+02	4.81E+02	0.283	**Np235**	1.38E-06	4.45E-08	0
Rh106	2.86E+02	2.87E+02	0.168	**Np237**	2.17E-04	2.47E-04	0
Ru106	2.86E+02	0.00E+00	0	**Np238**	2.41E-01	3.69E-01	0
Te129m	2.34E+02	2.37E+02	0.139	**Np239**	1.31E+00	3.03E+00	0.002
Te132	2.21E+02	2.78E+02	0.163	**Pu236**	8.73E-05	2.84E-05	0
Cs137	1.61E+02	1.61E+02	0.095	**Pu237**	3.94E-05	3.47E-06	0
Y090	1.56E+02	1.56E+02	0.092	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.092	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.01	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.53E+02	1.78E+02	0.104	**Pu241**	3.34E-01	2.17E-05	0
Nb095m	1.29E+02	9.55E+01	0.056	**Pu242**	9.97E-07	1.37E-07	0
Mo099	1.18E+02	1.21E+02	0.071	**Am241**	4.96E-05	3.64E-05	0
Tc099m	1.14E+02	1.26E+01	0.007	**Am242m**	5.39E-07	5.39E-07	0
Eu156	1.12E+02	1.53E+02	0.09	**Am242**	5.37E-07	5.48E-07	0
Pm148	7.92E+01	7.94E+01	0.047	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.15E+01	5.28E+01	0.031	**Cm242**	2.00E-03	3.15E-04	0
Te127	6.03E+01	6.04E+01	0.035	**Cm243**	2.24E-07	2.85E-07	0
Pr144m	5.90E+01	4.07E+01	0.024	**Cm244**	6.00E-05	4.03E-06	0
Pm148m	5.06E+01	5.83E+01	0.034				
Te127m	4.37E+01	4.48E+01	0.026	**Total**	1.60E+05	1.70E+05	100

Table C.1 Day 26 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.88E+04	2.32E+04	13.982	**Cs136**	2.80E+01	3.68E+01	0.022
Zr095	1.72E+04	1.72E+04	10.408	**Sn125**	1.62E+01	1.61E+01	0.01
Y091	1.65E+04	1.65E+04	9.961	**Th231**	2.68E-04	5.71E-04	0
La140	1.45E+04	1.49E+04	9.013	**Th234**	3.87E-06	3.56E-06	0
Pr143	1.41E+04	1.41E+04	8.494	**Pa233**	1.16E-04	2.09E-04	0
Sr089	1.38E+04	1.38E+04	8.331	**Pa234m**	3.87E-06	3.91E-06	0
Nb095	1.29E+04	1.29E+04	7.794	**U232**	3.62E-07	1.21E-07	0
Ba140	1.26E+04	1.50E+04	9.062	**U234**	5.58E-04	1.55E-04	0
Ru103	9.45E+03	9.57E+03	5.776	**U235**	2.68E-04	1.33E-04	0
Rh103m	8.52E+03	7.68E+03	4.638	**U236**	7.33E-04	1.91E-04	0
Pr144	4.90E+03	4.90E+03	2.959	**U237**	7.21E+02	1.61E+03	0.973
Ce144	4.90E+03	5.69E+03	3.436	**U238**	4.35E-06	9.97E-07	0
Nd147	3.67E+03	5.96E+03	3.595	**Np235**	1.38E-06	4.44E-08	0
Pm147	4.83E+02	4.83E+02	0.292	**Np237**	2.17E-04	2.47E-04	0
Rh106	2.86E+02	2.86E+02	0.173	**Np238**	1.74E-01	2.66E-01	0
Ru106	2.86E+02	0.00E+00	0	**Np239**	9.73E-01	2.26E+00	0.001
Te129m	2.29E+02	2.32E+02	0.14	**Pu236**	8.72E-05	2.84E-05	0
Te132	1.78E+02	2.25E+02	0.136	**Pu237**	3.88E-05	3.41E-06	0
Cs137	1.61E+02	1.61E+02	0.097	**Pu238**	2.33E-01	4.06E-02	0
Y090	1.56E+02	1.56E+02	0.094	**Pu239**	3.23E-03	2.52E-04	0
Sr090	1.56E+02	1.56E+02	0.094	**Pu240**	1.87E-03	3.09E-04	0
Ba137m	1.53E+02	1.69E+01	0.01	**Pu241**	3.34E-01	2.17E-05	0
Te129	1.49E+02	1.74E+02	0.105	**Pu242**	9.97E-07	1.37E-07	0
Nb095m	1.28E+02	9.45E+01	0.057	**Am241**	5.11E-05	3.75E-05	0
Eu156	1.07E+02	1.46E+02	0.088	**Am242m**	5.39E-07	5.39E-07	0
Mo099	9.19E+01	9.38E+01	0.057	**Am242**	5.37E-07	5.48E-07	0
Tc099m	8.85E+01	9.77E+00	0.006	**Am243**	2.46E-06	7.67E-07	0
Cs134	7.15E+01	5.28E+01	0.032	**Cm242**	1.99E-03	3.13E-04	0
Pm148	6.99E+01	7.01E+01	0.042	**Cm243**	2.24E-07	2.85E-07	0
Pr144m	5.88E+01	4.06E+01	0.024	**Cm244**	6.00E-05	4.03E-06	0
Te127	5.72E+01	5.72E+01	0.035				
Pm148m	4.97E+01	5.73E+01	0.035				
Te127m	4.34E+01	4.45E+01	0.027	**Total**	1.56E+05	1.66E+05	100

Table C.1 Day 27 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.84E+04	2.27E+04	14.043	**Te127m**	4.31E+01	4.42E+01	0.027
Zr095	1.70E+04	1.71E+04	10.568	**Cs136**	2.66E+01	3.50E+01	0.022
Y091	1.63E+04	1.63E+04	10.103	**Th231**	2.68E-04	5.71E-04	0
La140	1.38E+04	1.41E+04	8.759	**Th234**	3.88E-06	3.57E-06	0
Sr089	1.36E+04	1.36E+04	8.431	**Pa233**	1.19E-04	2.14E-04	0
Pr143	1.34E+04	1.34E+04	8.282	**Pa234m**	3.88E-06	3.92E-06	0
Nb095	1.30E+04	1.30E+04	8.047	**U232**	3.64E-07	1.21E-07	0
Ba140	1.20E+04	1.42E+04	8.809	**U234**	5.58E-04	1.55E-04	0
Ru103	9.28E+03	9.40E+03	5.822	**U235**	2.68E-04	1.33E-04	0
Rh103m	8.37E+03	7.55E+03	4.675	**U236**	7.33E-04	1.91E-04	0
Pr144	4.89E+03	4.89E+03	3.029	**U237**	6.50E+02	1.45E+03	0.901
Ce144	4.89E+03	5.68E+03	3.517	**U238**	4.35E-06	9.97E-07	0
Nd147	3.45E+03	5.59E+03	3.465	**Np235**	1.38E-06	4.44E-08	0
Pm147	4.85E+02	4.85E+02	0.301	**Np237**	2.18E-04	2.48E-04	0
Rh106	2.85E+02	2.86E+02	0.177	**Np238**	1.25E-01	1.92E-01	0
Ru106	2.85E+02	0.00E+00	0	**Np239**	7.25E-01	1.68E+00	0.001
Te129m	2.25E+02	2.28E+02	0.141	**Pu236**	8.72E-05	2.84E-05	0
Cs137	1.61E+02	1.61E+02	0.1	**Pu237**	3.82E-05	3.36E-06	0
Y090	1.56E+02	1.56E+02	0.097	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.097	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.01	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.46E+02	1.70E+02	0.105	**Pu241**	3.34E-01	2.17E-05	0
Te132	1.44E+02	1.82E+02	0.113	**Pu242**	9.97E-07	1.37E-07	0
Nb095m	1.26E+02	9.36E+01	0.058	**Am241**	5.25E-05	3.85E-05	0
Eu156	1.02E+02	1.40E+02	0.086	**Am242m**	5.39E-07	5.39E-07	0
Mo099	7.14E+01	7.29E+01	0.045	**Am242**	5.37E-07	5.48E-07	0
Cs134	7.14E+01	5.27E+01	0.033	**Am243**	2.46E-06	7.67E-07	0
Tc099m	6.88E+01	7.59E+00	0.005	**Cm242**	1.99E-03	3.12E-04	0
Pm148	6.17E+01	6.19E+01	0.038	**Cm243**	2.24E-07	2.85E-07	0
Pr144m	5.87E+01	4.05E+01	0.025	**Cm244**	6.00E-05	4.03E-06	0
Te127	5.45E+01	5.45E+01	0.034				
Pm148m	4.89E+01	5.64E+01	0.035	**Total**	1.52E+05	1.61E+05	100

Table C.1 Day 28 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.80E+04	2.22E+04	14.102	**Te127m**	4.29E+01	4.40E+01	0.028
Zr095	1.69E+04	1.69E+04	10.716	**Cs136**	2.52E+01	3.32E+01	0.021
Y091	1.61E+04	1.61E+04	10.233	**Th231**	2.68E-04	5.71E-04	0
Sr089	1.34E+04	1.34E+04	8.531	**Th234**	3.90E-06	3.59E-06	0
Nb095	1.31E+04	1.31E+04	8.302	**Pa233**	1.21E-04	2.18E-04	0
La140	1.30E+04	1.34E+04	8.512	**Pa234m**	3.90E-06	3.94E-06	0
Pr143	1.27E+04	1.27E+04	8.067	**U232**	3.67E-07	1.22E-07	0
Ba140	1.13E+04	1.35E+04	8.556	**U234**	5.58E-04	1.55E-04	0
Ru103	9.12E+03	9.24E+03	5.866	**U235**	2.68E-04	1.33E-04	0
Rh103m	8.22E+03	7.42E+03	4.71	**U236**	7.33E-04	1.91E-04	0
Pr144	4.88E+03	4.88E+03	3.098	**U237**	5.87E+02	1.31E+03	0.833
Ce144	4.88E+03	5.67E+03	3.598	**U238**	4.35E-06	9.97E-07	0
Nd147	3.24E+03	5.25E+03	3.337	**Np235**	1.38E-06	4.43E-08	0
Pm147	4.87E+02	4.87E+02	0.309	**Np237**	2.18E-04	2.49E-04	0
Rh106	2.85E+02	2.85E+02	0.181	**Np238**	9.01E-02	1.38E-01	0
Ru106	2.85E+02	0.00E+00	0	**Np239**	5.40E-01	1.25E+00	0.001
Te129m	2.20E+02	2.23E+02	0.142	**Pu236**	8.71E-05	2.84E-05	0
Cs137	1.61E+02	1.61E+02	0.102	**Pu237**	3.76E-05	3.31E-06	0
Y090	1.56E+02	1.56E+02	0.099	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.099	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.011	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.43E+02	1.67E+02	0.106	**Pu241**	3.34E-01	2.17E-05	0
Nb095m	1.25E+02	9.26E+01	0.059	**Pu242**	9.97E-07	1.37E-07	0
Te132	1.17E+02	1.47E+02	0.093	**Am241**	5.40E-05	3.96E-05	0
Eu156	9.79E+01	1.33E+02	0.085	**Am242m**	5.39E-07	5.39E-07	0
Cs134	7.13E+01	5.27E+01	0.033	**Am242**	5.37E-07	5.48E-07	0
Pr144m	5.85E+01	4.04E+01	0.026	**Am243**	2.46E-06	7.67E-07	0
Mo099	5.55E+01	5.67E+01	0.036	**Cm242**	1.98E-03	3.11E-04	0
Pm148	5.46E+01	5.47E+01	0.035	**Cm243**	2.24E-07	2.85E-07	0
Tc099m	5.35E+01	5.90E+00	0.004	**Cm244**	6.00E-05	4.03E-06	0
Te127	5.22E+01	5.23E+01	0.033				
Pm148m	4.81E+01	5.54E+01	0.035	**Total**	1.48E+05	1.57E+05	100

Table C.1 Day 29 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.76E+04	2.17E+04	14.149	**Tc099m**	4.16E+01	4.59E+00	0.003
Zr095	1.67E+04	1.67E+04	10.867	**Cs136**	2.39E+01	3.14E+01	0.02
Y091	1.59E+04	1.59E+04	10.366	**Th231**	2.68E-04	5.71E-04	0
Sr089	1.32E+04	1.32E+04	8.621	**Th234**	3.91E-06	3.60E-06	0
Nb095	1.31E+04	1.31E+04	8.556	**Pa233**	1.24E-04	2.23E-04	0
La140	1.23E+04	1.27E+04	8.263	**Pa234m**	3.91E-06	3.95E-06	0
Pr143	1.21E+04	1.21E+04	7.859	**U232**	3.69E-07	1.23E-07	0
Ba140	1.07E+04	1.28E+04	8.302	**U234**	5.58E-04	1.55E-04	0
Ru103	8.96E+03	9.07E+03	5.908	**U235**	2.68E-04	1.33E-04	0
Rh103m	8.08E+03	7.29E+03	4.744	**U236**	7.33E-04	1.91E-04	0
Pr144	4.87E+03	4.87E+03	3.168	**U237**	5.30E+02	1.18E+03	0.771
Ce144	4.87E+03	5.65E+03	3.68	**U238**	4.35E-06	9.97E-07	0
Nd147	3.04E+03	4.94E+03	3.213	**Np235**	1.37E-06	4.42E-08	0
Pm147	4.89E+02	4.89E+02	0.318	**Np237**	2.19E-04	2.49E-04	0
Rh106	2.84E+02	2.84E+02	0.185	**Np238**	6.50E-02	9.96E-02	0
Ru106	2.84E+02	0.00E+00	0	**Np239**	4.02E-01	9.35E-01	0.001
Te129m	2.16E+02	2.18E+02	0.142	**Pu236**	8.71E-05	2.84E-05	0
Cs137	1.61E+02	1.61E+02	0.105	**Pu237**	3.70E-05	3.26E-06	0
Y090	1.56E+02	1.56E+02	0.102	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.102	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.011	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.40E+02	1.63E+02	0.106	**Pu241**	3.34E-01	2.17E-05	0
Nb095m	1.24E+02	9.16E+01	0.06	**Pu242**	9.97E-07	1.37E-07	0
Te132	9.42E+01	1.19E+02	0.077	**Am241**	5.55E-05	4.07E-05	0
Eu156	9.35E+01	1.27E+02	0.083	**Am242m**	5.39E-07	5.39E-07	0
Cs134	7.13E+01	5.26E+01	0.034	**Am242**	5.37E-07	5.48E-07	0
Pr144m	5.84E+01	4.03E+01	0.026	**Am243**	2.46E-06	7.67E-07	0
Te127	5.03E+01	5.03E+01	0.033	**Cm242**	1.97E-03	3.09E-04	0
Pm148	4.82E+01	4.84E+01	0.031	**Cm243**	2.24E-07	2.85E-07	0
Pm148m	4.73E+01	5.45E+01	0.035	**Cm244**	6.00E-05	4.03E-06	0
Mo099	4.32E+01	4.40E+01	0.029				
Te127m	4.26E+01	4.37E+01	0.028	**Total**	1.45E+05	1.54E+05	100

Table C.1 Day 30 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.72E+04	2.13E+04	14.187	**Tc099m**	3.23E+01	3.57E+00	0.002
Zr095	1.65E+04	1.65E+04	11.012	**Cs136**	2.27E+01	2.98E+01	0.02
Y091	1.57E+04	1.57E+04	10.499	**Th231**	2.68E-04	5.71E-04	0
Nb095	1.32E+04	1.32E+04	8.811	**Th234**	3.92E-06	3.61E-06	0
Sr089	1.31E+04	1.31E+04	8.711	**Pa233**	1.26E-04	2.27E-04	0
La140	1.17E+04	1.20E+04	8.017	**Pa234m**	3.92E-06	3.96E-06	0
Pr143	1.15E+04	1.15E+04	7.65	**U232**	3.71E-07	1.24E-07	0
Ba140	1.02E+04	1.21E+04	8.057	**U234**	5.58E-04	1.55E-04	0
Ru103	8.81E+03	8.92E+03	5.946	**U235**	2.68E-04	1.33E-04	0
Rh103m	7.94E+03	7.16E+03	4.774	**U236**	7.33E-04	1.91E-04	0
Pr144	4.85E+03	4.85E+03	3.238	**U237**	4.78E+02	1.07E+03	0.713
Ce144	4.85E+03	5.64E+03	3.76	**U238**	4.35E-06	9.97E-07	0
Nd147	2.86E+03	4.64E+03	3.092	**Np235**	1.37E-06	4.41E-08	0
Pm147	4.91E+02	4.91E+02	0.327	**Np237**	2.19E-04	2.50E-04	0
Rh106	2.83E+02	2.84E+02	0.189	**Np238**	4.68E-02	7.18E-02	0
Ru106	2.83E+02	0.00E+00	0	**Np239**	3.00E-01	6.96E-01	0
Te129m	2.11E+02	2.14E+02	0.143	**Pu236**	8.70E-05	2.83E-05	0
Cs137	1.61E+02	1.61E+02	0.108	**Pu237**	3.65E-05	3.21E-06	0
Y090	1.56E+02	1.56E+02	0.104	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.104	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.011	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.38E+02	1.60E+02	0.107	**Pu241**	3.34E-01	2.17E-05	0
Nb095m	1.22E+02	9.06E+01	0.06	**Pu242**	9.97E-07	1.37E-07	0
Eu156	8.93E+01	1.22E+02	0.081	**Am241**	5.69E-05	4.18E-05	0
Te132	7.62E+01	9.60E+01	0.064	**Am242m**	5.39E-07	5.39E-07	0
Cs134	7.12E+01	5.26E+01	0.035	**Am242**	5.37E-07	5.48E-07	0
Pr144m	5.82E+01	4.02E+01	0.027	**Am243**	2.46E-06	7.67E-07	0
Te127	4.86E+01	4.86E+01	0.032	**Cm242**	1.96E-03	3.08E-04	0
Pm148m	4.65E+01	5.36E+01	0.036	**Cm243**	2.24E-07	2.85E-07	0
Pm148	4.27E+01	4.28E+01	0.029	**Cm244**	6.00E-05	4.03E-06	0
Te127m	4.23E+01	4.34E+01	0.029				
Mo099	3.35E+01	3.42E+01	0.023	**Total**	1.42E+05	1.50E+05	100

Table C.1 Day 31 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.69E+04	2.08E+04	14.22	**Tc099m**	2.51E+01	2.77E+00	0.002
Zr095	1.63E+04	1.63E+04	11.153	**Cs136**	2.15E+01	2.83E+01	0.019
Y091	1.56E+04	1.56E+04	10.621	**Th231**	2.68E-04	5.71E-04	0
Nb095	1.33E+04	1.33E+04	9.063	**Th234**	3.93E-06	3.62E-06	0
Sr089	1.29E+04	1.29E+04	8.804	**Pa233**	1.29E-04	2.31E-04	0
La140	1.11E+04	1.14E+04	7.779	**Pa234m**	3.93E-06	3.97E-06	0
Pr143	1.09E+04	1.09E+04	7.445	**U232**	3.74E-07	1.24E-07	0
Ba140	9.62E+03	1.14E+04	7.814	**U234**	5.58E-04	1.55E-04	0
Ru103	8.65E+03	8.76E+03	5.982	**U235**	2.68E-04	1.33E-04	0
Rh103m	7.80E+03	7.03E+03	4.804	**U236**	7.33E-04	1.91E-04	0
Pr144	4.84E+03	4.84E+03	3.307	**U237**	4.31E+02	9.65E+02	0.659
Ce144	4.84E+03	5.62E+03	3.841	**U238**	4.35E-06	9.97E-07	0
Nd147	2.68E+03	4.35E+03	2.973	**Np235**	1.37E-06	4.40E-08	0
Pm147	4.93E+02	4.93E+02	0.336	**Np237**	2.20E-04	2.50E-04	0
Rh106	2.83E+02	2.83E+02	0.193	**Np238**	3.38E-02	5.17E-02	0
Ru106	2.83E+02	0.00E+00	0	**Np239**	2.23E-01	5.19E-01	0
Te129m	2.07E+02	2.10E+02	0.143	**Pu236**	8.69E-05	2.83E-05	0
Cs137	1.61E+02	1.61E+02	0.11	**Pu237**	3.59E-05	3.16E-06	0
Y090	1.56E+02	1.56E+02	0.107	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.107	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.012	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.35E+02	1.57E+02	0.107	**Pu241**	3.34E-01	2.17E-05	0
Nb095m	1.21E+02	8.96E+01	0.061	**Pu242**	9.97E-07	1.37E-07	0
Eu156	8.53E+01	1.16E+02	0.079	**Am241**	5.84E-05	4.28E-05	0
Cs134	7.11E+01	5.25E+01	0.036	**Am242m**	5.39E-07	5.39E-07	0
Te132	6.16E+01	7.76E+01	0.053	**Am242**	5.37E-07	5.48E-07	0
Pr144m	5.81E+01	4.01E+01	0.027	**Am243**	2.46E-06	7.67E-07	0
Te127	4.72E+01	4.72E+01	0.032	**Cm242**	1.95E-03	3.07E-04	0
Pm148m	4.57E+01	5.27E+01	0.036	**Cm243**	2.24E-07	2.85E-07	0
Te127m	4.21E+01	4.32E+01	0.029	**Cm244**	5.99E-05	4.03E-06	0
Pm148	3.78E+01	3.79E+01	0.026				
Mo099	2.61E+01	2.66E+01	0.018	**Total**	1.38E+05	1.46E+05	100

Table C.1 Day 32 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.65E+04	2.04E+04	14.247	**Mo099**	2.03E+01	2.07E+01	0.014
Zr095	1.61E+04	1.62E+04	11.297	**Tc099m**	1.95E+01	2.15E+00	0.002
Y091	1.54E+04	1.54E+04	10.744	**Th231**	2.68E-04	5.71E-04	0
Nb095	1.33E+04	1.33E+04	9.318	**Th234**	3.94E-06	3.63E-06	0
Sr089	1.27E+04	1.27E+04	8.885	**Pa233**	1.31E-04	2.36E-04	0
La140	1.05E+04	1.08E+04	7.543	**Pa234m**	3.95E-06	3.99E-06	0
Pr143	1.04E+04	1.04E+04	7.235	**U232**	3.76E-07	1.25E-07	0
Ba140	9.12E+03	1.08E+04	7.578	**U234**	5.58E-04	1.55E-04	0
Ru103	8.50E+03	8.61E+03	6.016	**U235**	2.68E-04	1.33E-04	0
Rh103m	7.66E+03	6.91E+03	4.83	**U236**	7.33E-04	1.91E-04	0
Pr144	4.83E+03	4.83E+03	3.376	**U237**	3.89E+02	8.70E+02	0.608
Ce144	4.83E+03	5.61E+03	3.922	**U238**	4.35E-06	9.97E-07	0
Nd147	2.52E+03	4.09E+03	2.858	**Np235**	1.37E-06	4.40E-08	0
Pm147	4.94E+02	4.94E+02	0.345	**Np237**	2.20E-04	2.51E-04	0
Rh106	2.82E+02	2.83E+02	0.198	**Np238**	2.43E-02	3.73E-02	0
Ru106	2.82E+02	0.00E+00	0	**Np239**	1.66E-01	3.87E-01	0
Te129m	2.03E+02	2.05E+02	0.144	**Pu236**	8.69E-05	2.83E-05	0
Cs137	1.61E+02	1.61E+02	0.113	**Pu237**	3.54E-05	3.12E-06	0
Y090	1.56E+02	1.56E+02	0.109	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.109	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.012	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.32E+02	1.54E+02	0.107	**Pu241**	3.34E-01	2.17E-05	0
Nb095m	1.20E+02	8.87E+01	0.062	**Pu242**	9.97E-07	1.37E-07	0
Eu156	8.15E+01	1.11E+02	0.078	**Am241**	5.99E-05	4.39E-05	0
Cs134	7.11E+01	5.25E+01	0.037	**Am242m**	5.39E-07	5.39E-07	0
Pr144m	5.80E+01	4.00E+01	0.028	**Am242**	5.37E-07	5.48E-07	0
Te132	4.98E+01	6.27E+01	0.044	**Am243**	2.46E-06	7.67E-07	0
Te127	4.59E+01	4.60E+01	0.032	**Cm242**	1.94E-03	3.05E-04	0
Pm148m	4.50E+01	5.18E+01	0.036	**Cm243**	2.24E-07	2.85E-07	0
Te127m	4.18E+01	4.29E+01	0.03	**Cm244**	5.99E-05	4.03E-06	0
Pm148	3.35E+01	3.36E+01	0.023				
Cs136	2.04E+01	2.68E+01	0.019	**Total**	1.35E+05	1.43E+05	100

Table C.1 Day 33 After Irradiation

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce141	1.62E+04	2.00E+04	14.268	**Mo099**	1.57E+01	1.61E+01	0.011
Zr095	1.60E+04	1.60E+04	11.429	**Tc099m**	1.52E+01	1.67E+00	0.001
Y091	1.52E+04	1.52E+04	10.864	**Th231**	2.68E-04	5.71E-04	0
Nb095	1.34E+04	1.34E+04	9.57	**Th234**	3.96E-06	3.64E-06	0
Sr089	1.25E+04	1.25E+04	8.969	**Pa233**	1.33E-04	2.40E-04	0
La140	9.94E+03	1.02E+04	7.309	**Pa234m**	3.96E-06	4.00E-06	0
Pr143	9.84E+03	9.84E+03	7.036	**U232**	3.78E-07	1.26E-07	0
Ba140	8.63E+03	1.03E+04	7.345	**U234**	5.58E-04	1.55E-04	0
Ru103	8.35E+03	8.46E+03	6.047	**U235**	2.68E-04	1.33E-04	0
Rh103m	7.53E+03	6.79E+03	4.856	**U236**	7.33E-04	1.91E-04	0
Pr144	4.82E+03	4.82E+03	3.446	**U237**	3.51E+02	7.85E+02	0.562
Ce144	4.82E+03	5.60E+03	4.002	**U238**	4.35E-06	9.97E-07	0
Nd147	2.37E+03	3.84E+03	2.746	**Np235**	1.36E-06	4.39E-08	0
Pm147	4.96E+02	4.96E+02	0.354	**Np237**	2.20E-04	2.51E-04	0
Rh106	2.82E+02	2.82E+02	0.202	**Np238**	1.75E-02	2.69E-02	0
Ru106	2.82E+02	0.00E+00	0	**Np239**	1.24E-01	2.88E-01	0
Te129m	1.99E+02	2.01E+02	0.144	**Pu236**	8.68E-05	2.83E-05	0
Cs137	1.61E+02	1.61E+02	0.115	**Pu237**	3.49E-05	3.07E-06	0
Y090	1.56E+02	1.56E+02	0.112	**Pu238**	2.33E-01	4.06E-02	0
Sr090	1.56E+02	1.56E+02	0.112	**Pu239**	3.23E-03	2.52E-04	0
Ba137m	1.53E+02	1.69E+01	0.012	**Pu240**	1.87E-03	3.09E-04	0
Te129	1.29E+02	1.51E+02	0.108	**Pu241**	3.34E-01	2.16E-05	0
Nb095m	1.18E+02	8.77E+01	0.063	**Pu242**	9.97E-07	1.37E-07	0
Eu156	7.79E+01	1.06E+02	0.076	**Am241**	6.13E-05	4.50E-05	0
Cs134	7.10E+01	5.24E+01	0.037	**Am242m**	5.39E-07	5.39E-07	0
Pr144m	5.78E+01	3.99E+01	0.029	**Am242**	5.37E-07	5.48E-07	0
Te127	4.49E+01	4.49E+01	0.032	**Am243**	2.46E-06	7.67E-07	0
Pm148m	4.42E+01	5.10E+01	0.036	**Cm242**	1.94E-03	3.04E-04	0
Te127m	4.16E+01	4.26E+01	0.03	**Cm243**	2.24E-07	2.85E-07	0
Te132	4.02E+01	5.07E+01	0.036	**Cm244**	5.99E-05	4.03E-06	0
Pm148	2.97E+01	2.98E+01	0.021				
Cs136	1.94E+01	2.54E+01	0.018	**Total**	1.32E+05	1.40E+05	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release

Day 1 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Nb097	2.90E+02	2.91E+02	13.209	**Sb129**	5.64E+00	5.72E+00	0.26
Zr097	2.70E+02	2.71E+02	12.295	**Sm153**	4.91E+00	7.86E+00	0.357
Nb097m	2.56E+02	5.30E+00	0.241	**Ag109m**	3.73E+00	3.60E+00	0.164
Y093	2.53E+02	2.54E+02	11.532	**Pd109**	3.73E+00	7.33E+00	0.333
Ce143	2.27E+02	2.74E+02	12.436	**Te131**	3.64E+00	4.29E+00	0.195
Sr091	2.21E+02	2.21E+02	10.05	**Rh105m**	3.21E+00	0.00E+00	0
Mo099	1.48E+02	1.52E+02	6.886	**Sb127**	3.00E+00	3.17E+00	0.144
Y091m	1.40E+02	7.01E+00	0.319	**Te127**	2.16E+00	2.16E+00	0.098
Tc099m	1.31E+02	1.45E+01	0.659	**Pr144**	1.66E+00	1.66E+00	0.075
Y092	1.03E+02	1.03E+02	4.691	**Ce144**	1.66E+00	1.93E+00	0.088
Te132	9.25E+01	1.17E+02	5.3	**Ag112**	6.86E-01	6.88E-01	0.031
Pr145	8.72E+01	8.80E+01	4.001	**Pd112**	5.86E-01	0.00E+00	0
La141	4.85E+01	4.85E+01	2.204	**Sm156**	5.56E-01	7.08E-01	0.032
Rh105	4.06E+01	4.08E+01	1.856	**Sn121**	5.41E-01	5.41E-01	0.025
Ba140	3.95E+01	4.70E+01	2.134	**Sb128**	3.87E-01	4.08E-01	0.019
Pm149	3.19E+01	3.19E+01	1.452	**Th231**	9.69E-03	2.06E-02	0.001
Pm151	1.71E+01	2.12E+01	0.961	**Th234**	6.20E-06	5.71E-06	0
Nd147	1.65E+01	2.67E+01	1.213	**Pa234m**	6.20E-06	6.27E-06	0
Te131m	1.62E+01	1.92E+01	0.873	**Pa234**	5.10E-09	1.72E-08	0
Ce141	1.52E+01	1.87E+01	0.851	**U234**	6.25E-04	1.74E-04	0
Pr143	1.44E+01	1.44E+01	0.655	**U235**	2.02E-02	1.00E-02	0
La140	1.39E+01	1.43E+01	0.649	**U236**	6.70E-06	1.75E-06	0
Ru105	1.14E+01	1.16E+01	0.527	**U237**	1.16E-02	2.60E-02	0.001
Sr092	9.78E+00	9.79E+00	0.445	**U238**	2.19E-04	5.01E-05	0
Zr095	8.70E+00	8.72E+00	0.396	**U240**	3.99E-07	5.30E-07	0
Rb088	8.15E+00	8.15E+00	0.371	**Np239**	3.65E+00	8.47E+00	0.385
Sr089	7.96E+00	7.96E+00	0.362	**Np240m**	4.03E-07	6.26E-07	0
Y091	6.97E+00	6.97E+00	0.317	**Pu239**	3.27E-07	2.56E-08	0
Te129	6.81E+00	7.93E+00	0.36				
Ru103	6.57E+00	6.66E+00	0.303				
Rh103m	5.93E+00	5.35E+00	0.243	**Total**	2.59E+03	2.20E+03	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release - Continued

Day 2 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Ce143	1.37E+02	1.65E+02	17.198	**Y092**	1.16E+00	1.16E+00	0.121
Mo099	1.15E+02	1.18E+02	12.246	**Ag109m**	1.09E+00	1.05E+00	0.109
Tc099m	1.10E+02	1.22E+01	1.267	**Pd109**	1.09E+00	2.13E+00	0.222
Nb097	1.02E+02	1.02E+02	10.592	**La141**	7.04E-01	7.04E-01	0.073
Zr097	1.01E+02	1.01E+02	10.519	**Nb095**	3.33E-01	3.34E-01	0.035
Nb097m	9.56E+01	1.98E+00	0.206	**Ag112**	3.03E-01	3.04E-01	0.032
Te132	7.48E+01	9.42E+01	9.804	**Sn121**	2.91E-01	2.91E-01	0.03
Y093	4.88E+01	4.89E+01	5.085	**Ru105**	2.69E-01	2.73E-01	0.028
Sr091	3.83E+01	3.84E+01	3.994	**Te129**	2.58E-01	3.00E-01	0.031
Ba140	3.74E+01	4.45E+01	4.627	**Pd112**	2.56E-01	0.00E+00	0
Rh105	2.64E+01	2.65E+01	2.756	**In115m**	2.56E-01	1.40E-01	0.015
Y091m	2.44E+01	1.22E+00	0.127	**Cd115**	2.35E-01	2.38E-01	0.025
Pm149	2.33E+01	2.34E+01	2.429	**As077**	1.95E-01	1.96E-01	0.02
Pr143	2.25E+01	2.25E+01	2.345	**Te129m**	1.76E-01	1.78E-01	0.019
La140	2.22E+01	2.28E+01	2.372	**Ag111**	1.69E-01	1.69E-01	0.018
Nd147	1.55E+01	2.51E+01	2.608	**Th231**	1.47E-02	3.14E-02	0.003
Ce141	1.51E+01	1.86E+01	1.938	**Th234**	1.22E-05	1.13E-05	0
Pm151	9.52E+00	1.18E+01	1.225	**Pa231**	1.03E-09	5.61E-10	0
Te131m	9.28E+00	1.10E+01	1.148	**Pa234m**	1.22E-05	1.24E-05	0
Zr095	8.61E+00	8.62E+00	0.897	**Pa234**	1.28E-08	4.31E-08	0
Y091	8.18E+00	8.18E+00	0.851	**U234**	6.25E-04	1.74E-04	0
Sr089	7.86E+00	7.86E+00	0.817	**U235**	2.02E-02	1.00E-02	0.001
Ru103	6.46E+00	6.54E+00	0.68	**U236**	6.70E-06	1.75E-06	0
Rh103m	5.82E+00	5.25E+00	0.546	**U237**	1.05E-02	2.35E-02	0.002
Pr145	5.40E+00	5.45E+00	0.567	**U238**	2.19E-04	5.01E-05	0
Sm153	3.44E+00	5.50E+00	0.572	**U240**	1.23E-07	1.63E-07	0
Sb127	2.51E+00	2.65E+00	0.275	**Np239**	2.72E+00	6.31E+00	0.657
Te127	2.28E+00	2.28E+00	0.238	**Np240m**	1.24E-07	1.92E-07	0
Te131	2.09E+00	2.46E+00	0.256	**Pu239**	5.76E-07	4.50E-08	0
Pr144	1.66E+00	1.66E+00	0.172				
Ce144	1.66E+00	1.92E+00	0.2	**Total**	1.09E+03	9.61E+02	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release – Continued

Day 3 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Mo099	8.97E+01	9.15E+01	14.958	**Pr145**	3.35E-01	3.38E-01	0.055
Tc099m	8.63E+01	9.53E+00	1.557	**Ag109m**	3.15E-01	3.04E-01	0.05
Ce143	8.27E+01	9.98E+01	16.318	**Pd109**	3.15E-01	6.19E-01	0.101
Te132	6.04E+01	7.62E+01	12.451	**In115m**	1.87E-01	1.03E-01	0.017
Nb097	3.79E+01	3.80E+01	6.21	**Te129m**	1.73E-01	1.75E-01	0.029
Zr097	3.77E+01	3.78E+01	6.175	**Cd115**	1.72E-01	1.74E-01	0.028
Nb097m	3.57E+01	7.40E-01	0.121	**Sn121**	1.56E-01	1.56E-01	0.026
Ba140	3.54E+01	4.21E+01	6.887	**Ag111**	1.54E-01	1.54E-01	0.025
La140	2.70E+01	2.77E+01	4.533	**Ag112**	1.33E-01	1.33E-01	0.022
Pr143	2.68E+01	2.68E+01	4.376	**As077**	1.32E-01	1.32E-01	0.022
Pm149	1.70E+01	1.71E+01	2.79	**Te129**	1.15E-01	1.34E-01	0.022
Rh105	1.65E+01	1.66E+01	2.71	**Pd112**	1.12E-01	0.00E+00	0
Ce141	1.48E+01	1.82E+01	2.981	**Rh106**	9.34E-02	9.35E-02	0.015
Nd147	1.45E+01	2.35E+01	3.848	**Ru106**	9.34E-02	0.00E+00	0
Y093	9.40E+00	9.41E+00	1.539	**Th231**	1.74E-02	3.70E-02	0.006
Zr095	8.52E+00	8.53E+00	1.394	**Th234**	1.81E-05	1.66E-05	0
Y091	8.31E+00	8.31E+00	1.359	**Pa231**	1.97E-09	1.07E-09	0
Sr089	7.75E+00	7.75E+00	1.267	**Pa234m**	1.81E-05	1.83E-05	0
Sr091	6.66E+00	6.66E+00	1.089	**Pa234**	2.04E-08	6.91E-08	0
Ru103	6.35E+00	6.43E+00	1.05	**U234**	6.25E-04	1.74E-04	0
Rh103m	5.72E+00	5.16E+00	0.843	**U235**	2.02E-02	1.00E-02	0.002
Te131m	5.33E+00	6.34E+00	1.036	**U236**	6.70E-06	1.75E-06	0
Pm151	5.30E+00	6.55E+00	1.071	**U237**	9.46E-03	2.12E-02	0.003
Y091m	4.23E+00	2.11E-01	0.035	**U238**	2.19E-04	5.01E-05	0
Sm153	2.41E+00	3.85E+00	0.63	**U240**	3.77E-08	5.00E-08	0
Sb127	2.09E+00	2.21E+00	0.361	**Np239**	2.03E+00	4.70E+00	0.769
Te127	1.99E+00	1.99E+00	0.325	**Np240m**	3.80E-08	5.91E-08	0
Pr144	1.65E+00	1.65E+00	0.27	**Pu239**	7.62E-07	5.96E-08	0
Ce144	1.65E+00	1.92E+00	0.314				
Te131	1.20E+00	1.42E+00	0.231				
Nb095	4.93E-01	4.94E-01	0.081	**Total**	6.66E+02	6.12E+02	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release - Continued

Day 4 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Mo099	6.97E+01	7.11E+01	15.704	**Nb095**	6.48E-01	6.49E-01	0.143
Tc099m	6.71E+01	7.41E+00	1.636	**Te129m**	1.69E-01	1.71E-01	0.038
Ce143	5.00E+01	6.03E+01	13.315	**Ag111**	1.40E-01	1.40E-01	0.031
Te132	4.89E+01	6.16E+01	13.595	**In115m**	1.37E-01	7.53E-02	0.017
Ba140	3.36E+01	3.99E+01	8.813	**Cd115**	1.26E-01	1.28E-01	0.028
La140	2.95E+01	3.03E+01	6.695	**Te129**	1.10E-01	1.28E-01	0.028
Pr143	2.87E+01	2.87E+01	6.329	**Rh106**	9.32E-02	9.33E-02	0.021
Ce141	1.45E+01	1.79E+01	3.944	**Ru106**	9.32E-02	0.00E+00	0
Nb097	1.42E+01	1.42E+01	3.136	**Ag109m**	9.16E-02	8.83E-02	0.019
Zr097	1.41E+01	1.41E+01	3.118	**Pd109**	9.16E-02	1.80E-01	0.04
Nd147	1.36E+01	2.21E+01	4.882	**As077**	8.70E-02	8.72E-02	0.019
Nb097m	1.34E+01	2.77E-01	0.061	**Sn121**	8.41E-02	8.41E-02	0.019
Pm149	1.24E+01	1.25E+01	2.756	**Sn125**	7.79E-02	7.76E-02	0.017
Rh105	1.03E+01	1.04E+01	2.288	**Eu156**	7.19E-02	9.80E-02	0.022
Zr095	8.42E+00	8.44E+00	1.863	**Th231**	1.87E-02	3.99E-02	0.009
Y091	8.25E+00	8.25E+00	1.822	**Th234**	2.38E-05	2.19E-05	0
Sr089	7.64E+00	7.64E+00	1.688	**Pa231**	3.02E-09	1.64E-09	0
Ru103	6.24E+00	6.31E+00	1.394	**Pa234m**	2.38E-05	2.40E-05	0
Rh103m	5.62E+00	5.07E+00	1.119	**Pa234**	2.79E-08	9.44E-08	0
Te131m	3.06E+00	3.64E+00	0.804	**U234**	6.25E-04	1.74E-04	0
Pm151	2.95E+00	3.65E+00	0.805	**U235**	2.02E-02	1.00E-02	0.002
Y093	1.81E+00	1.81E+00	0.4	**U236**	6.70E-06	1.75E-06	0
Sb127	1.75E+00	1.85E+00	0.408	**U237**	8.54E-03	1.91E-02	0.004
Sm153	1.69E+00	2.70E+00	0.596	**U238**	2.19E-04	5.01E-05	0
Te127	1.68E+00	1.68E+00	0.371	**U240**	1.16E-08	1.54E-08	0
Pr144	1.65E+00	1.65E+00	0.364	**Np239**	1.51E+00	3.51E+00	0.774
Ce144	1.65E+00	1.91E+00	0.423	**Np240m**	1.17E-08	1.82E-08	0
Sr091	1.16E+00	1.16E+00	0.255	**Pu239**	9.00E-07	7.04E-08	0
Y091m	7.34E-01	3.67E-02	0.008				
Te131	6.89E-01	8.13E-01	0.179	**Total**	4.78E+02	4.53E+02	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release - Continued

Day 5 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Mo099	5.42E+01	5.53E+01	15.213	**Sr091**	2.01E-01	2.01E-01	0.055
Tc099m	5.22E+01	5.76E+00	1.585	**Te129m**	1.66E-01	1.68E-01	0.046
Te132	3.95E+01	4.98E+01	13.699	**Ag111**	1.28E-01	1.28E-01	0.035
Ba140	3.18E+01	3.78E+01	10.404	**Y091m**	1.27E-01	6.36E-03	0.002
La140	3.05E+01	3.14E+01	8.646	**Te129**	1.08E-01	1.26E-01	0.035
Ce143	3.02E+01	3.64E+01	10.025	**In115m**	1.01E-01	5.52E-02	0.015
Pr143	2.92E+01	2.92E+01	8.032	**Rh106**	9.30E-02	9.32E-02	0.026
Ce141	1.42E+01	1.75E+01	4.811	**Ru106**	9.30E-02	0.00E+00	0
Nd147	1.28E+01	2.08E+01	5.717	**Cd115**	9.25E-02	9.34E-02	0.026
Pm149	9.09E+00	9.12E+00	2.51	**Sn125**	7.25E-02	7.22E-02	0.02
Zr095	8.33E+00	8.35E+00	2.297	**Eu156**	6.88E-02	9.37E-02	0.026
Y091	8.16E+00	8.16E+00	2.246	**As077**	5.69E-02	5.70E-02	0.016
Sr089	7.54E+00	7.54E+00	2.075	**Pm147**	5.41E-02	5.41E-02	0.015
Rh105	6.44E+00	6.47E+00	1.781	**Th231**	1.94E-02	4.14E-02	0.011
Ru103	6.13E+00	6.20E+00	1.707	**Th234**	2.93E-05	2.70E-05	0
Rh103m	5.52E+00	4.98E+00	1.371	**Pa231**	4.13E-09	2.24E-09	0
Nb097	5.29E+00	5.31E+00	1.46	**Pa234m**	2.93E-05	2.96E-05	0
Zr097	5.27E+00	5.28E+00	1.452	**Pa234**	3.52E-08	1.19E-07	0
Nb097m	4.99E+00	1.03E-01	0.028	**U234**	6.25E-04	1.74E-04	0
Te131m	1.76E+00	2.09E+00	0.575	**U235**	2.02E-02	1.00E-02	0.003
Pr144	1.64E+00	1.64E+00	0.453	**U236**	6.70E-06	1.75E-06	0
Ce144	1.64E+00	1.91E+00	0.525	**U237**	7.71E-03	1.72E-02	0.005
Pm151	1.64E+00	2.03E+00	0.558	**U238**	2.19E-04	5.01E-05	0
Sb127	1.46E+00	1.54E+00	0.424	**U240**	3.56E-09	4.73E-09	0
Te127	1.41E+00	1.41E+00	0.388	**Np239**	1.12E+00	2.61E+00	0.719
Sm153	1.18E+00	1.89E+00	0.52	**Np240m**	3.59E-09	5.58E-09	0
Nb095	7.99E-01	8.00E-01	0.22	**Pu239**	1.00E-06	7.84E-08	0
Te131	3.96E-01	4.67E-01	0.128				
Y093	3.49E-01	3.49E-01	0.096	**Total**	3.76E+02	3.63E+02	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release - Continued

Day 6 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Mo099	4.21E+01	4.30E+01	14.046	**Te129**	1.06E-01	1.23E-01	0.04
Tc099m	4.06E+01	4.48E+00	1.463	**Rh106**	9.28E-02	9.30E-02	0.03
Te132	3.19E+01	4.02E+01	13.153	**Ru106**	9.28E-02	0.00E+00	0
La140	3.07E+01	3.15E+01	10.305	**In115m**	7.37E-02	4.04E-02	0.013
Ba140	3.01E+01	3.58E+01	11.708	**Cd115**	6.78E-02	6.84E-02	0.022
Pr143	2.89E+01	2.89E+01	9.452	**Sn125**	6.74E-02	6.72E-02	0.022
Ce143	1.82E+01	2.20E+01	7.193	**Y093**	6.72E-02	6.73E-02	0.022
Ce141	1.39E+01	1.71E+01	5.594	**Eu156**	6.57E-02	8.96E-02	0.029
Nd147	1.20E+01	1.95E+01	6.379	**Pm147**	6.31E-02	6.31E-02	0.021
Zr095	8.24E+00	8.26E+00	2.699	**Cs137**	4.90E-02	4.90E-02	0.016
Y091	8.07E+00	8.07E+00	2.637	**Sr090**	4.87E-02	4.87E-02	0.016
Sr089	7.44E+00	7.44E+00	2.431	**Ba137m**	4.63E-02	5.12E-03	0.002
Pm149	6.65E+00	6.67E+00	2.179	**Th230**	9.25E-11	2.15E-11	0
Ru103	6.02E+00	6.09E+00	1.992	**Th231**	1.98E-02	4.22E-02	0.014
Rh103m	5.43E+00	4.89E+00	1.6	**Th234**	3.47E-05	3.19E-05	0
Rh105	4.02E+00	4.04E+00	1.322	**Pa231**	5.27E-09	2.86E-09	0
Nb097	1.98E+00	1.98E+00	0.648	**Pa234m**	3.47E-05	3.50E-05	0
Zr097	1.97E+00	1.97E+00	0.644	**Pa234**	4.22E-08	1.43E-07	0
Nb097m	1.87E+00	3.86E-02	0.013	**U234**	6.25E-04	1.74E-04	0
Pr144	1.64E+00	1.64E+00	0.536	**U235**	2.02E-02	1.00E-02	0.003
Ce144	1.64E+00	1.90E+00	0.623	**U236**	6.70E-06	1.75E-06	0
Sb127	1.22E+00	1.29E+00	0.421	**U237**	6.95E-03	1.56E-02	0.005
Te127	1.18E+00	1.18E+00	0.385	**U238**	2.19E-04	5.01E-05	0
Te131m	1.01E+00	1.20E+00	0.393	**U240**	1.09E-09	1.45E-09	0
Nb095	9.45E-01	9.46E-01	0.309	**Np239**	8.37E-01	1.95E+00	0.636
Pm151	9.13E-01	1.13E+00	0.369	**Np240m**	1.10E-09	1.72E-09	0
Sm153	8.28E-01	1.32E+00	0.433	**Pu239**	1.08E-06	8.44E-08	0
Te131	2.27E-01	2.68E-01	0.088				
Te129m	1.62E-01	1.64E-01	0.054				
Ag111	1.16E-01	1.17E-01	0.038	**Total**	3.12E+02	3.06E+02	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release - Continued

Day 7 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
Mo099	3.27E+01	3.34E+01	12.572	**Te129**	1.04E-01	1.20E-01	0.045
Tc099m	3.15E+01	3.48E+00	1.31	**Rh106**	9.27E-02	9.28E-02	0.035
La140	3.02E+01	3.10E+01	11.683	**Ru106**	9.27E-02	0.00E+00	0
Ba140	2.85E+01	3.39E+01	12.771	**Pm147**	7.14E-02	7.14E-02	0.027
Pr143	2.82E+01	2.82E+01	10.61	**Eu156**	6.28E-02	8.56E-02	0.032
Te132	2.58E+01	3.25E+01	12.244	**Sn125**	6.28E-02	6.26E-02	0.024
Ce141	1.36E+01	1.68E+01	6.307	**In115m**	5.40E-02	2.96E-02	0.011
Nd147	1.13E+01	1.83E+01	6.898	**Cd115**	4.97E-02	5.01E-02	0.019
Ce143	1.10E+01	1.33E+01	5.004	**Cs137**	4.90E-02	4.90E-02	0.018
Zr095	8.16E+00	8.17E+00	3.075	**Sr090**	4.87E-02	4.87E-02	0.018
Y091	7.97E+00	7.97E+00	3.002	**Ba137m**	4.63E-02	5.12E-03	0.002
Sr089	7.34E+00	7.34E+00	2.762	**Nb095m**	4.36E-02	3.23E-02	0.012
Ru103	5.91E+00	5.99E+00	2.254	**Y090**	4.08E-02	4.09E-02	0.015
Rh103m	5.33E+00	4.81E+00	1.81	**Th230**	1.08E-10	2.51E-11	0
Pm149	4.86E+00	4.87E+00	1.834	**Th231**	2.00E-02	4.26E-02	0.016
Rh105	2.51E+00	2.53E+00	0.951	**Th234**	3.99E-05	3.67E-05	0
Pr144	1.64E+00	1.64E+00	0.616	**Pa231**	6.42E-09	3.48E-09	0
Ce144	1.64E+00	1.90E+00	0.715	**Pa234m**	3.99E-05	4.03E-05	0
Nb095	1.09E+00	1.09E+00	0.41	**Pa234**	4.91E-08	1.66E-07	0
Sb127	1.02E+00	1.08E+00	0.405	**U234**	6.25E-04	1.74E-04	0
Te127	9.86E-01	9.87E-01	0.372	**U235**	2.02E-02	1.00E-02	0.004
Nb097	7.39E-01	7.41E-01	0.279	**U236**	6.70E-06	1.75E-06	0
Zr097	7.36E-01	7.37E-01	0.277	**U237**	6.28E-03	1.40E-02	0.005
Nb097m	6.97E-01	1.44E-02	0.005	**U238**	2.19E-04	5.01E-05	0
Te131m	5.80E-01	6.90E-01	0.26	**U240**	3.36E-10	4.46E-10	0
Sm153	5.80E-01	9.27E-01	0.349	**Np239**	6.24E-01	1.45E+00	0.546
Pm151	5.08E-01	6.29E-01	0.237	**Np240m**	3.39E-10	5.27E-10	0
Te129m	1.59E-01	1.61E-01	0.061	**Pu239**	1.14E-06	8.89E-08	0
Te131	1.31E-01	1.54E-01	0.058				
Ag111	1.06E-01	1.06E-01	0.04	**Total**	2.67E+02	2.66E+02	100

Table C.2 Activity (Ci) of Solid Radionuclides Produced in the Criticality Event of October 16, 1959, and Fractional Contribution to (ß-I) Aerosol Release - Continued

Day 8 After The Criticality Event

Nuclide	Activity Ci	Effective Activity Ci	Contribution %	Nuclide	Activity Ci	Effective Activity Ci	Contribution %
La140	2.93E+01	3.02E+01	12.805	**Ru106**	9.25E-02	0.00E+00	0
Pr143	2.72E+01	2.72E+01	11.549	**Pm147**	7.93E-02	7.93E-02	0.034
Ba140	2.70E+01	3.21E+01	13.637	**Te131**	7.50E-02	8.85E-02	0.038
Mo099	2.54E+01	2.60E+01	11.014	**Eu156**	6.00E-02	8.18E-02	0.035
Tc099m	2.45E+01	2.70E+00	1.147	**Sn125**	5.84E-02	5.82E-02	0.025
Te132	2.09E+01	2.63E+01	11.158	**Cs137**	4.90E-02	4.90E-02	0.021
Ce141	1.33E+01	1.64E+01	6.961	**Sr090**	4.87E-02	4.87E-02	0.021
Nd147	1.06E+01	1.72E+01	7.304	**Ba137m**	4.63E-02	5.12E-03	0.002
Zr095	8.07E+00	8.08E+00	3.428	**Nb095m**	4.59E-02	3.40E-02	0.014
Y091	7.88E+00	7.88E+00	3.344	**Y090**	4.26E-02	4.26E-02	0.018
Sr089	7.24E+00	7.24E+00	3.071	**In115m**	3.96E-02	2.17E-02	0.009
Ce143	6.65E+00	8.03E+00	3.407	**Cd115**	3.64E-02	3.67E-02	0.016
Ru103	5.81E+00	5.88E+00	2.497	**Th230**	1.23E-10	2.86E-11	0
Rh103m	5.24E+00	4.72E+00	2.005	**Th231**	2.01E-02	4.28E-02	0.018
Pm149	3.55E+00	3.56E+00	1.512	**Th234**	4.49E-05	4.14E-05	0
Pr144	1.63E+00	1.63E+00	0.693	**Pa231**	7.58E-09	4.11E-09	0
Ce144	1.63E+00	1.90E+00	0.804	**Pa234m**	4.49E-05	4.54E-05	0
Rh105	1.57E+00	1.58E+00	0.669	**Pa234**	5.57E-08	1.89E-07	0
Nb095	1.22E+00	1.23E+00	0.52	**U234**	6.25E-04	1.74E-04	0
Sb127	8.50E-01	8.98E-01	0.381	**U235**	2.02E-02	1.00E-02	0.004
Te127	8.27E-01	8.27E-01	0.351	**U236**	6.70E-06	1.75E-06	0
Sm153	4.06E-01	6.49E-01	0.275	**U237**	5.66E-03	1.27E-02	0.005
Te131m	3.33E-01	3.96E-01	0.168	**U238**	2.19E-04	5.01E-05	0
Pm151	2.83E-01	3.50E-01	0.148	**U240**	1.03E-10	1.37E-10	0
Nb097	2.76E-01	2.77E-01	0.117	**Np237**	6.23E-11	7.10E-11	0
Zr097	2.75E-01	2.75E-01	0.117	**Np239**	4.65E-01	1.08E+00	0.458
Nb097m	2.60E-01	5.40E-03	0.002	**Np240m**	1.04E-10	1.62E-10	0
Te129m	1.56E-01	1.58E-01	0.067	**Pu239**	1.18E-06	9.22E-08	0
Te129	1.01E-01	1.18E-01	0.05				
Ag111	9.64E-02	9.67E-02	0.041				
Rh106	9.25E-02	9.26E-02	0.039	**Total**	2.34E+02	2.36E+02	100

APPENDIX D

EFFECT OF ELECTRON-EMITTING NUCLIDES AND LOW ENERGY BETA-EMITTERS ON THE BETA-MINUS IODINE READING

APPENDIX D: EFFECT OF ELECTRON-EMITTING NUCLIDES AND LOW ENERGY BETA-EMITTERS ON THE BETA-MINUS IODINE READING

Beta-detectors may count both betas emitted by β-decay of the nucleus and so-called Auger and internal conversion electrons, provided they are sufficiently energetic to pass through the detector window.

The first edition of Price (1958), Nuclear Radiation Detection, provides a description of contemporary radiation detection technology. Price states that 30 mg/cm^2 was the common thickness of commercial, thin-walled glass tubes designed for β-counting. This rather hefty thickness can only be penetrated by relatively high-energy betas of about 150 keV (ICRU Report 56, 1997).

Price also states that special, thin window tubes were commercially available for counting soft s with windows at thin as 1.4 mg/cm^2. At that time, the thin windows were made either of Mylar, mica, or stainless steel. Assuming Mylar, for which data are available in ICRU Report 56, will result in a cutoff energy of 25 keV (ICRU Report 56, 1997). Consequently, it is assumed that betas or electrons of less than 25 keV would not have been counted by the β-detectors in use at the ICPP in 1957-1959. This is the assumption used for the determination of the values in the EFFECTIVE ACTIVITY column of Appendix C.

The metastable transition to the ground state may result in the emission of an orbital electron from the inner, K shell. Secondary electrons may also be emitted as a final result of the shifting of the orbital electrons to fill the vacancy in the K-shell. Some fraction of these electrons may be counted by the β-counters in use at the ICPP in 1957-1959 and thus contribute to the (β-I) reading in the stack monitor.

Some nuclides may emit sufficiently low energy betas at least a fraction of the time such that only a fraction of their disintegrations are counted by the 1957-1959 vintage β-detectors. The fraction of electron-emitting metastable nuclides and low energy β-emitters that would not have been counted by the 1957-1959 β-detectors may be determined by comparing the β-energy spectra per disintegration for each nuclide (Eckerman, 1993) with the cutoff energy of 25 keV of the detector. The cutoff energy is the β-energy below which penetration through the detector window does not occur.

Note that some values of EFFECTIVE ACTIVITY in the Appendix C tables are higher than the listed ACTIVITY value. This occurs when, on the average, more than one β plus electron greater than 25 keV is emitted per disintegration.

The Appendix C tables show overwhelmingly that betas emitted by β-decay are predominantly more energetic than 25 keV, and thus would have penetrated the 1.4 mg/cm^2 window and be counted. Thus generally, the values of ACTIVITY and EFFECTIVE ACTIVITY are usually very close, with a few exceptions.