PRE-FILED,
PRE-NUMBERED
EXHIBIT
COVER SHEET

Exhibit CY-5-
PANEL1-:___

For Reporters' Use Only

United States of America
Nuclear Regulatory Commission
before the
Atomic Safety and Licensing Board

In the Matter of

CONNECTICUT YANKEE ATOMIC POWER COMPANY

(Haddam Neck Plant)

Docket No. 50-213-LTP

ASLBP No. 01-787-02-OLA

PANEL ATTACHMENT 4: "HEALTH PHYSICS DEPARTMENT, TECHNICAL SUPPORT DOCUMENT, HP NUMBER: BCY-HP-0125 REV. 0: DOSE ESTIMATE FOR AN INGESTED PARTICLE" (12/05/02).

Submitted by:

R. K. Gad III
Martin J. Newhouse
Ropes & Gray
One International Place
Boston, MA 02110
Counsel to CY

Dated: February 7, 2003.

J-248

UNCONTROLLED
COPY

BECHTEL HEALTH PHYSICS
TECHNICAL SUPPORT DOCUMENT

DOCUMENT No.
24265-000-G65-GEHH-P0125-000

Connecticut Yankee Decommissioning

Health Physics Department Technical Support Document

HP Number: BCY-HP-0125 Revision #: 0

Subject: Dose Estimate for an Ingested Particle

Date: 12/05/02

Performed By: _____ Date: 12/19/2002

Reviewed By: _____ Date: 12/19/02

Approved By: _____ Date: 12/19/02

PURPOSE

To provide a dose estimate from the ingestion of a 1 μCi particle.

DISCUSSION

Assumptions and Basis

This assessment was performed using the following assumptions:

1. The particle is insoluble and therefore does not enter the blood stream but rather passes through the gastrointestinal (GI) tract, similar to a bolus of material.
2. The ingestion pathway is the only pathway considered since a hot particle is likely to exceed 10 micron activity median aerodynamic diameter (AMAD).
3. The only progeny nuclide included in this assessment is Y-90 (Sr-90 progeny) because its half life is short enough to result in secular equilibrium. The remaining nuclides half lives are too long to reach secular equilibrium.

The number of disintegrations for each segment of the GI tract for each nuclide in the License Termination Plan (LTP) in Table 2-12, Radionuclides Potentially Present at HNP, was determined by using INDOS®. Even though the particle is expected to be eliminated within 42 hours (based upon the sum of the mean residence times for each of the organs along the GI tract), the total number of disintegrations calculated over 50 years was used for conservatism. The input parameters used are illustrated in Table 1. The number of disintegrations for each segment of the GI tract is listed in Table 2 for a 1 Bq activity of each radionuclide. Note that the number of disintegrations for each segment of the GI tract for each nuclide is essentially the same. The reason for this is that the half-lives of the radionuclides in the LTP are long compared to the passage time through the GI tract. Therefore, the number of disintegrations is determined primarily by the clearance time assumed, as stated previously, for conservatism the total number of disintegrations over 50 years was used. A copy of the INDOS runs for the shortest half-life nuclide and longest half-life nuclide in the LTP is included as Attachment 1.

Table 1. INDOS Input Parameters and Values

Parameter	Value	Comment
f1	0	Zero value assumes particle is insoluble
Intake Pathway	Ingestion	Only considered pathway
Exposure Condition	Acute	Appropriate for particle ingestion.
Systemic Compartments	1	INDOS requires at least one systemic compartment.
Systemic Half Life	2.00E-06 Days	Compartment half life was deliberately set low, since this assessment only evaluates the dose to the GI tract. Therefore, this parameter does not effect the dose to the GI tract.
Fraction of Systemic Excreted through urine	0	Since the particle is considered to be representative of a bolus (i.e., insoluble), the particle will travel through the GI and be eliminated through feces.
Fraction of Systemic Excreted through feces	1	Since the particle is considered to be representative of a bolus (i.e., insoluble), the particle will travel through the GI and be eliminated through feces.
Time post intake days (T1)	0	INDOS calculates the number of disintegrations post intake between time, T1 and T2. Setting T1 to 0 and T2 to 1.75 days gives the total # of disintegrations that occur while the particle passes through the body. However, the fifty year value was used in this assessment for the estimate of CEDE.
Time post intake days (T2)	1.75	

Table 2. Number of Disintegrations for each Segment of the GI Tract for an Intake Activity of 1 Bq.

Nuclide	Half-Life (days)	Intake pathway	T1 Post Intake (days)	T2 Post Intake (days)	# Distint. Stomach	# Distint. Upper Large Intestine	# Distint. Small Intestine	# Distint. Lower Large Intestine	# Distint. GI Total
Ag-108m	4.64E+04	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Am-241	1.58E+05	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
C-14	2.09E+06	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Cm-243	1.04E+04	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Co-60	1.92E+03	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Cs-134	7.53E+02	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.63E+04	1.51E+05
Cs-137	1.10E+04	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Eu-152	3.21E+03	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Eu-154	3.21E+03	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Eu-155	1.81E+03	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Fe-55	9.86E+02	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
H-3	4.49E+03	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Mn-54	3.12E+02	Ingestion	0	18250	3.60E+03	4.67E+04	1.44E+04	8.61E+04	1.51E+05
Nb-94	7.30E+06	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Ni-63	3.65E+04	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Pu-238	3.20E+04	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Pu-239	8.80E+06	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Pu-241	5.26E+03	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Sr-90	1.04E+04	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05
Tc-99	7.77E+07	Ingestion	0	18250	3.60E+03	4.68E+04	1.44E+04	8.64E+04	1.51E+05

Organ Dose

The Specific Effective Energy (SEE) terms were used from ICRP-30 (Reference 1) to determine the dose to other target organs from the disintegrations in the GI tract. Attachments 2 through 5 list the specific absorbed dose factors (Mev per gram per Becquerel) for each organ and each nuclide in the LTP for the small intestine (SI), upper large intestine (ULI), lower large intestine (LLI), and stomach, respectively. Table 3 lists the sum of the specific absorbed dose factors (Mev per gram per Becquerel) for each of the GI tract components, which is converted to dose equivalent factor (rem per bequerel) by multiplying by the conversion factor provided in ICRP 30 of 1.6E-10 Sievert (Sv) per MeV per gram and 100 to convert Sv to rem.

It should be noted that the SEE Values in ICRP 30 assume instantaneous uniform mixing of the radionuclide within the compartment (organ). This actually overestimates the dose, since this evaluation is for a discrete particle (i.e., uniform mixing will not occur) and uniform irradiation of the compartment (organ) will not occur. This represents a significant overestimate of dose for alpha emitting nuclides since most of the alpha energy is absorbed in the GI tract content. This is evident in Table 3 since the alpha transuranics illustrate a substantially higher dose than other beta/gamma

emitting nuclides. However, no adjustments are made in this assessment to account for these conservative assumptions.

Table 3. Absorbed Dose and Dose Equivalent Factors for LTP nuclides

Nuclide	Absorbed Dose Factor (Mev/gram/bq)	Dose Equivalent Factor (Rem/bq)
Ag-108m	2.39E+01	3.82E-07
Am-241	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00
Cm-243	0.00E+00	0.00E+00
Co-60	1.18E+01	1.88E-07
Cs-134	0.00E+00	0.00E+00
Cs-137	0.00E+00	0.00E+00
Eu-152	8.30E+00	1.33E-07
Eu-154	1.24E+01	1.99E-07
Eu-155	1.94E+00	3.11E-08
Fe-55	1.18E-01	1.88E-09
H-3	0.00E+00	0.00E+00
Mn-54	3.58E+00	5.75E-08
Nb-94	7.92E+00	1.27E-07
Ni-63	4.61E-01	7.39E-09
Pu-238	2.83E+01	4.53E-07
Pu-239	2.61E+01	4.19E-07
Pu-241	9.84E-02	1.58E-09
Sr-90	2.90E+01	4.65E-07
Tc-99	3.21E+00	5.14E-08
Total	1.57E+02	2.52E-06

Determination of Nuclide Scaling

Nuclide scaling was performed using the same conservative waste stream mixture used in calculating annual doses from contaminated embedded piping as described in the LTP (reference 2). The sample was a composite of Dry Activated Waste (DAW) in the WDB from 2000. This sample was shipped off site and analyzed by Duke Engineering and Services Environmental Laboratory (DES). The analysis results are provided in Attachment 6. A summary of the results for the nuclides in the LTP is provided in Table 4. The activity results were used to scale the dose in order to determine the dose relative to the worst case expected radionuclide mix. A nuclide fraction was determined by dividing each individual nuclide activity by the total activity in the sample. If the nuclide activity did not exceed the Minimum Detectable Activity (MDA) of the sample, than the reported MDA was used as the activity amount. The sample was analyzed on December 6, 2000. Therefore the nuclides were decay corrected to

determine the scaling fraction. Europium-152, Euriopium-154, and Europium-155 were not listed in the Part 61 analysis provided by DES.

Table 4. Part 61 Results of Composite Sample of DAW from WDB in 2000

Nuclide	Activity (uCi/sample)	Comments	Nuclide Fraction	Decayed Activity (uCi/sample)	Decay Corrected Nuclide Fraction
H-3	1.50E-03	Reported MDA	2.73E-02	1.35E-03	2.67E-02
C-14	1.80E-03	Reported MDA	3.27E-02	1.80E-03	3.55E-02
Mn-54	4.70E-04	Reported MDA	8.54E-03	1.07E-04	2.11E-03
Fe-55	7.30E-04	Reported MDA	1.33E-02	4.57E-04	9.01E-03
Co-60	1.52E-03		2.76E-02	1.20E-03	2.36E-02
Ni-63	3.45E-03		6.27E-02	3.41E-03	6.72E-02
Sr-90	2.09E-03		3.80E-02	2.00E-03	3.94E-02
Nb-94	4.60E-04	Reported MDA	8.36E-03	4.60E-04	9.07E-03
Tc-99	6.10E-03	Reported MDA	1.11E-01	6.10E-03	1.20E-01
Ag-108m	5.30E-04	Reported MDA	9.63E-03	5.25E-04	1.03E-02
Eu-152	[redacted]	Not Provided	0.00E+00	N/A	N/A
Eu-154	[redacted]	Not Provided	0.00E+00	N/A	N/A
Eu-155	[redacted]	Not Provided	0.00E+00	N/A	N/A
Cs-134	1.67E-03		3.04E-02	9.03E-04	1.78E-02
Cs-137	1.17E-02		2.12E-01	1.12E-02	2.21E-01
Pu-238	9.89E-04		1.80E-02	9.75E-04	1.92E-02
Pu-239	3.53E-04		6.42E-03	3.53E-04	6.96E-03
Pu-241	2.13E-02		3.87E-01	1.95E-02	3.85E-01
Am-241	3.05E-04		5.54E-03	3.04E-04	6.00E-03
Cm-243	8.10E-05		1.47E-03	7.75E-05	1.53E-03
Total	**5.50E-02**		**1.00E+00**	**5.07E-02**	**1.00E+00**

Calculated Scaled Dose

Table 5 lists the scaled dose using the rem per Becquerel values from Table 3 and the nuclide scaling fractions in Table 4. The total dose equivalent per unit intake for the scaled dose is 4.69E-08 rem per bq or 1.74 mrem per μCi. Therefore, for a nominal activity of 1 μCi, the estimated dose would be 1.74 mrem. For a Co-60 particle with an activity of 1 μCi, the estimated dose would be 6.96 mrem.

Table 5. Scaled Dose Based Upon WDB Composite Sample.

Nuclide	Total (Mev/gram/bq)	Total (Rem/bq)	Nuclide Fraction	Scaled Total (Rem/bq)	Scaled Total (mRem/μCi)
Ag-108m	2.39E+01	3.82E-07	1.03E-02	3.94E-09	1.46E-01
Am-241	0.00E+00	0.00E+00	6.00E-03	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00	3.55E-02	0.00E+00	0.00E+00
Cm-243	0.00E+00	0.00E+00	1.53E-03	0.00E+00	0.00E+00
Co-60	1.18E+01	1.88E-07	2.36E-02	4.45E-09	1.65E-01
Cs-134	0.00E+00	0.00E+00	1.78E-02	0.00E+00	0.00E+00
Cs-137	0.00E+00	0.00E+00	2.21E-01	0.00E+00	0.00E+00
Eu-152	8.30E+00	1.33E-07	0	0.00E+00	0.00E+00
Eu-154	1.24E+01	1.99E-07	0	0.00E+00	0.00E+00
Eu-155	1.94E+00	3.11E-08	0	0.00E+00	0.00E+00
Fe-55	1.18E-01	1.88E-09	9.01E-03	1.70E-11	6.29E-04
H-3	0.00E+00	0.00E+00	2.67E-02	0.00E+00	0.00E+00
Mn-54	3.58E+00	5.75E-08	2.11E-03	1.21E-10	4.48E-03
Nb-94	7.92E+00	1.27E-07	9.07E-03	1.15E-09	4.26E-02
Ni-63	4.61E-01	7.39E-09	6.72E-02	4.97E-10	1.84E-02
Pu-238	2.83E+01	4.53E-07	1.92E-02	8.70E-09	3.22E-01
Pu-239	2.61E+01	4.19E-07	6.96E-03	2.92E-09	1.08E-01
Pu-241	9.84E-02	1.58E-09	3.85E-01	6.07E-10	2.25E-02
Sr-90	2.90E+01	4.65E-07	3.94E-02	1.83E-08	6.77E-01
Tc-99	3.21E+00	5.14E-08	1.20E-01	6.17E-09	2.28E-01
Total	1.57E+02	2.52E-06	1.00E+00	4.69E-08	1.74E+00

Conclusion

At a nominal activity of 1 μCi, composed of a conservative radionuclide mix, an ingested particle would result in a conservative estimated dose of 1.7 mrem. For ingestion of a 1 μCi Co-60 particle, the CEDE is conservatively estimated as 6.96 mrem.

ATTACHMENTS

1. INDOS runs for the shortest and longest half-life nuclides listed in the LTP.
2. Mev/g for Target Organs from Disintegrations in the Small Intestine.
3. Mev/g for Target Organs from Disintegrations in the Upper Large Intestine.
4. Mev/g for Target Organs from Disintegrations in the Lower Large Intestine.
5. Mev/g for Target Organs from Disintegrations in the Stomach.
6. Part 61 Analysis of Waste Disposal Building Composite in 2000.

REFERENCES

1. Internal Commission on Radiological Protection, 1977-1982, Annals of the ICRP, Limits for Intakes of Radionuclides by Workers, ICRP Publication 30.

2. Connecticut Yankee License Termination Plan. August 2002, Revision 1. pages 5-22 to 5-24.

RADIATION SAFETY & CONTROL SERVICES, INC.

Shortest Half Life

NUMBER OF DISINTEGRATION TABLE

********** RADIONUCLIDE **********

Shortest
PHYSICAL HALF-LIFE = 3.120E+002 DAYS

********** RESPIRATORY AND GI TRACT MODELS **********

ACUTE INGESTION INTAKE
STANDARD ICRP 30. GI TRACT MODEL USED

FRACTION OF INTAKE DEPOSITED IN STOMACH = 1.000

********** PARAMETERS FOR SYSTEMIC MODEL **********

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.000E+000	2.200E-006

********** INTAKE **********

NUMBER OF DISINTEGRATIONS IN REFERENCE MAN CALCULATED
WITH INTAKE OF 1.0 Bq

********** PARAMETERS FOR LUNG AND GI TRACT MODELS **********

GI TRACT PARAMETERS

GI TRACT REGION	REMOVAL HALF-TIME (DAYS)
S	2.888E-002
SI	1.155E-001
ULI	3.755E-001
LLI	6.931E-001

NUCLEAR TRANSFORMATIONS IN BODY RESULTING
FROM A 1.0 Bq INGESTION INTAKE OF Shortest

COMPARTMENT	NUMBER OF TRANSFORMATIONS IN COMPARTMENTS FROM 0.000E+000 DAYS TO FIFTY YEARS	0.000E+000 DAYS TO 2.000E+000 DAYS	RATIO
SYSTEMIC COMPARTMENT 1	0.000E+000	0.000E+000	
TOTAL SYSTEMIC	0.000E+000	0.000E+000	
STOMACH	3.600E+003	3.600E+003	1.000E+000
SMALL INTESTINE	1.439E+004	1.439E+004	1.000E+000
UPPER LARGE INTESTINE	4.672E+004	4.491E+004	9.612E-001
LOWER LARGE INTESTINE	8.607E+004	5.829E+004	6.773E-001
TOTAL GI TRACT	1.508E+005	1.212E+005	8.038E-001
NASAL PASSAGE	0.000E+000	0.000E+000	
LUNGS	0.000E+000	0.000E+000	

19-DEC-02

RADIATION SAFETY & CONTROL SERVICES, INC.

Longest Half Life

NUMBER OF DISINTEGRATION TABLE

********** RADIONUCLIDE **********

Longest
PHYSICAL HALF-LIFE = 7.770E+007 DAYS

********** RESPIRATORY AND GI TRACT MODELS **********

ACUTE INGESTION INTAKE
STANDARD ICRP 30 GI TRACT MODEL USED

FRACTION OF INTAKE DEPOSITED IN STOMACH = 1.000

********** PARAMETERS FOR SYSTEMIC MODEL **********

COMPARTMENT	COEFFICIENT	BIOLOGICAL HALF-LIFE (DAYS)
1	1.000E+000	2.200E-006

********** INTAKE **********

NUMBER OF DISINTEGRATIONS IN REFERENCE MAN CALCULATED
WITH INTAKE OF 1.0 Bq

********** PARAMETERS FOR LUNG AND GI TRACT MODELS **********

GI TRACT PARAMETERS

GI TRACT REGION	REMOVAL HALF-TIME (DAYS)
S	2.888E-002
SI	1.155E-001
ULI	3.755E-001
LLI	6.931E-001

NUCLEAR TRANSFORMATIONS IN BODY RESULTING
FROM A 1.0 Bq INGESTION INTAKE OF Longest

COMPARTMENT	NUMBER OF TRANSFORMATIONS IN COMPARTMENTS FROM 0.000E+000 DAYS TO FIFTY YEARS	NUMBER OF TRANSFORMATIONS IN COMPARTMENTS FROM 0.000E+000 DAYS TO 2.000E+000 DAYS	RATIO
SYSTEMIC COMPARTMENT 1	0.000E+000	0.000E+000	
TOTAL SYSTEMIC	0.000E+000	0.000E+000	
STOMACH	3.600E+003	3.600E+003	1.000E+000
SMALL INTESTINE	1.440E+004	1.440E+004	1.000E+000
UPPER LARGE INTESTINE	4.680E+004	4.498E+004	9.610E-001
LOWER LARGE INTESTINE	8.640E+004	5.844E+004	6.763E-001
TOTAL GI TRACT	1.512E+005	1.214E+005	8.030E-001
NASAL PASSAGE	0.000E+000	0.000E+000	
LUNGS	0.000E+000	0.000E+000	

Attachment 2. Mev/g for Target Organs from Disintegrations in the Small Intestine

Nuclide	MeV per g / bq Adrenals	MeV per g / bq Bone Surf	MeV per g / bq Breast	MeV per g / bq Gonads	MeV per g / bq Kidneys	MeV per g / bq Liver	MeV per g / bq LLI Wall	MeV per g / bq Lungs	MeV per g / bq Pancreas	MeV per g / bq R Marrow	MeV per g / bq SI Wall	MeV per g / bq Spleen	MeV per g / bq ST Wall	MeV per g / bq Thymus	MeV per g / bq Thyroid	MeV per g / bq ULI wall	MeV per g / bq Uterus
Ag-108m	5.94E-03	0.00E+00	1.88E-02	1.86E-01	1.49E-02	8.74E-03	3.32E-02	3.14E-03	9.61E-03	2.45E-02	8.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.14E-01	0.00E+00
Am-241	N/A[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
C-14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cm-243	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Co-60	8.21E-03	0.00E+00	2.59E-02	2.56E-01	0.00E+00	1.30E-02	4.58E-02	4.84E-03	0.00E+00	3.28E-02	3.02E-01	0.00E+00	0.00E+00	1.21E-03	0.00E+00	1.47E-01	5.53E-02
Cs-134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Eu-152	3.89E-03	1.38E-03	1.27E-02	1.30E-01	1.04E-02	6.05E-03	2.25E-02	2.25E-03	6.22E-03	1.73E-02	2.51E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.60E-02	0.00E+00
Eu-154	4.15E-03	1.43E-03	0.00E+00	1.40E-01	0.00E+00	6.48E-03	2.42E-02	2.42E-03	0.00E+00	1.73E-02	4.23E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.86E-02	0.00E+00
Eu-155	0.00E+00	1.60E-04	0.00E+00	1.08E-02	0.00E+00	3.72E-04	1.73E-03	6.91E-05	0.00E+00	2.25E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.88E-03	0.00E+00
Fe-55	1.90E-14	0.00E+00	1.51E-06	5.04E-05	0.00E+00	6.85E-08	2.42E-05	7.78E-18	0.00E+00	1.57E-06	5.18E-03	1.81E-10	0.00E+00	0.00E+00	0.00E+00	3.89E-04	0.00E+00
H-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mn-54	2.85E-03	9.50E-04	9.28E-03	9.72E-02	7.60E-03	4.41E-03	1.64E-02	1.68E-03	4.84E-03	1.18E-02	7.69E-02	0.00E+00	0.00E+00	3.72E-04	0.00E+00	5.36E-02	1.99E-02
Nb-94	0.00E+00	0.00E+00	0.00E+00	9.00E-03	0.00E+00	0.00E+00	3.02E-02	3.11E-03	0.00E+00	2.25E-02	3.20E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.04E-01	0.00E+00
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1]Values Not Provided in ICRP 30

Attachment 3. Mev/g for Target Organs from Disintegrations in the Upper Large Intestine

Nuclide	MeV per g / bq Adrenals	MeV per g / bq Bone Surf	MeV per g / bq Breast	MeV per g / bq Gonads	MeV per g / bq Kidneys	MeV per g / bq Liver	MeV per g / bq LLI Wall	MeV per g / bq Lungs	MeV per g / bq Pancreas	MeV per g / bq R Marrow	MeV per g / bq SI Wall	MeV per g / bq Spleen	MeV per g / bq ST Wall	MeV per g / bq Thymus	MeV per g / bq Thyroid	MeV per g / bq ULI wall	MeV per g / bq Uterus
Ag-108m	1.67E-02	0.00E+00	5.82E-02	7.45E-01	4.26E-02	3.97E-02	4.83E-02	1.13E-02	2.84E-02	6.81E-02	2.56E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.72E+00	0.00E+00
Am-241	N/A[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
C-14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cm-243	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Co-60	2.67E-02	0.00E+00	8.42E-02	6.08E-01	0.00E+00	5.61E-02	6.74E-02	1.97E-02	0.00E+00	8.98E-02	3.37E-01	0.00E+00	0.00E+00	4.21E-03	0.00E+00	1.54E+00	1.09E-01
Cs-134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Eu-152	1.21E-02	3.93E-03	3.93E-02	3.74E-01	3.09E-02	2.67E-02	3.37E-02	8.42E-03	2.19E-02	4.77E-02	1.71E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E+00	0.00E+00
Eu-154	1.35E-02	4.21E-03	0.00E+00	3.86E-01	0.00E+00	2.81E-02	3.65E-02	9.55E-03	0.00E+00	4.88E-02	1.80E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.36E+00	0.00E+00
Eu-155	0.00E+00	4.77E-04	0.00E+00	3.51E-02	0.00E+00	1.74E-03	2.33E-03	2.66E-04	0.00E+00	6.18E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.49E-01	0.00E+00
Fe-55	1.63E-14	0.00E+00	5.26E-07	2.34E-04	0.00E+00	4.48E-07	7.02E-06	2.25E-17	0.00E+00	3.93E-06	1.54E-05	1.63E-10	0.00E+00	0.00E+00	0.00E+00	2.78E-02	0.00E+00
H-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mn-54	9.25E-03	2.66E-03	2.87E-02	2.92E-01	2.19E-02	1.94E-02	2.50E-02	6.17E-03	1.54E-02	3.14E-02	1.23E-01	0.00E+00	0.00E+00	1.32E-03	0.00E+00	3.65E-01	3.65E-02
Nb-94	0.00E+00	0.00E+00	0.00E+00	3.39E-02	0.00E+00	0.00E+00	4.77E-02	1.12E-02	0.00E+00	6.18E-02	2.33E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.71E+00	0.00E+00
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-01	0.00E+00
Pu-238	0.00E+00	1.97E-06	0.00E+00	2.11E-07	0.00E+00	5.05E-06	3.37E-05	1.01E-07	0.00E+00	3.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.02E+00	0.00E+00
Pu-239	0.00E+00	1.02E-06	0.00E+00	8.07E-07	0.00E+00	3.37E-06	1.43E-05	3.37E-07	0.00E+00	1.57E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.46E+00	0.00E+00
Pu-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	1.17E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.55E-08	2.41E-14	0.00E+00	1.97E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.13E+00	0.00E+00
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.46E-01	0.00E+00

[1]Values Not Provided in ICRP 30

Attachment 4. Mev/g for Target Organs from Disintegrations in the Lower Large Intestine

Nuclide	MeV per g / bq Adrenals	MeV per g / bq Bone Surf	MeV per g / bq Breast	MeV per g / bq Gonads	MeV per g / bq Kidneys	MeV per g / bq Liver	MeV per g / bq LLI Wall	MeV per g / bq Lungs	MeV per g / bq Pancreas	MeV per g / bq R Marrow	MeV per g / bq SI Wall	MeV per g / bq Spleen	MeV per g / bq ST Wall	MeV per g / bq Thymus	MeV per g / bq Thyroid	MeV per g / bq ULI wall	MeV per g / bq Uterus
Ag-108m	1.42E-02	0.00E+00	1.23E-01	2.01E+00	2.46E-02	9.96E-03	1.37E+01	6.71E-03	2.15E-02	1.89E-01	2.62E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.21E-01	0.00E+00
Am-241	N/A[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
C-14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cm-243	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Co-60	2.07E-02	0.00E+00	1.68E-01	2.81E+00	0.00E+00	1.81E-02	3.89E+00	1.45E-02	0.00E+00	2.38E-01	3.57E-01	0.00E+00	0.00E+00	3.42E-03	0.00E+00	1.71E-01	2.33E-01
Cs-134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Eu-152	9.33E-03	1.09E-02	8.29E-02	1.42E+00	1.81E-02	7.77E-03	3.68E+00	5.80E-03	1.40E-02	1.35E-01	1.76E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.29E-02	0.00E+00
Eu-154	1.04E-02	1.11E-02	0.00E+00	1.47E+00	0.00E+00	8.29E-03	6.74E+00	6.53E-03	0.00E+00	1.35E-01	1.87E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.81E-02	0.00E+00
Eu-155	0.00E+00	1.40E-03	0.00E+00	1.04E-01	0.00E+00	2.28E-04	1.30E+00	1.45E-04	0.00E+00	1.87E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-03	0.00E+00
Fe-55	1.04E-16	0.00E+00	8.61E-07	8.85E-04	0.00E+00	1.50E-16	8.29E-02	2.69E-16	0.00E+00	1.87E-06	1.24E-05	7.77E-12	0.00E+00	0.00E+00	0.00E+00	5.18E-05	0.00E+00
H-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mn-54	7.23E-03	7.23E-03	6.07E-02	9.90E-01	1.29E-02	5.68E-03	8.27E-01	4.13E-03	1.06E-02	8.68E-02	1.24E-01	0.00E+00	0.00E+00	1.03E-03	0.00E+00	5.68E-02	7.75E-02
Nb-94	0.00E+00	0.00E+00	0.00E+00	1.96E-01	0.00E+00	0.00E+00	4.61E+00	7.67E-03	0.00E+00	1.66E-01	2.38E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-01	0.00E+00
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.26E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238	0.00E+00	1.40E-05	0.00E+00	7.99E-06	0.00E+00	7.77E-08	2.12E+01	4.46E-06	0.00E+00	2.28E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.33E-04	0.00E+00
Pu-239	0.00E+00	6.22E-06	0.00E+00	1.12E-05	0.00E+00	2.90E-07	1.97E+01	1.76E-07	0.00E+00	9.84E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.33E-05	0.00E+00
Pu-241	0.00E+00	3.11E-08	0.00E+00	2.81E-06	0.00E+00	7.25E-09	9.84E-02	4.56E-09	0.00E+00	3.94E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	1.01E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.19E+01	1.55E-15	0.00E+00	1.66E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.12E-07	0.00E+00
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.97E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1]Values Not Provided in ICRP 30

Attachment 5. Mev/g for Target Organs from Disintegrations in the Stomach

Nuclide	MeV per g / bq Adrenals	MeV per g / bq Bone Surf	MeV per g / bq Breast	MeV per g / bq Gonads	MeV per g / bq Kidneys	MeV per g / bq Liver	MeV per g / bq LLI Wall	MeV per g / bq Lungs	MeV per g / bq Pancreas	MeV per g / bq R Marrow	MeV per g / bq SI Wall	MeV per g / bq Spleen	MeV per g / bq ST Wall	MeV per g / bq Thymus	MeV per g / bq Thyroid	MeV per g / bq ULI wall	MeV per g / bq Uterus
Ag-108m	2.62E-03	0.00E+00	4.26E-03	3.82E-03	3.93E-03	2.40E-03	1.55E-03	4.37E-03	2.08E-02	2.53E-03	3.06E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E-03	0.00E+00
Am-241	N/A[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
C-14	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cm-243	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Eu-152	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-154	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Eu-155	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mn-54	1.27E-03	1.73E-04	2.11E-03	2.97E-03	1.94E-03	1.19E-03	7.99E-04	2.16E-03	9.94E-03	1.21E-03	1.53E-03	0.00E+00	0.00E+00	3.89E-04	0.00E+00	1.84E-03	5.62E-04
Nb-94	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.34E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu-241	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.32E-02	0.00E+00	5.51E-01	0.00E+00	0.00E+00

[1]Values Not Provided in ICRP 30