

RPR 10

RADIONUCLIDE DATA

PURPOSE

This procedure provides radiation protection data for radionuclides. Information for radionuclides not listed may be obtained from the Radiological Health Department (RHD).

POLICY

Radionuclide data used for radiation protection calculations shall be obtained from regulatory authority documents or from reputable scientific organizations. Data for radionuclides not specifically listed in this document should first be vetted through the Radiation Safety Officer (RSO) before being used for regulatory compliance purposes.

DEFINITIONS

"ALI (Annual Limit on Intake)" means the activity of a single radionuclide (expressed in millicuries [mCi]) which, if ingested or inhaled by a single individual, would result in an effective dose equivalent equal to that individual of a whole body dose of 5 rem. The ALI is dependent on the route of intake. For most laboratory purposes, involving contamination control and bioassay procedures, the ALI for ingestion is used. Ingestion is the most common route of accidental intake of radionuclides. For gases, the inhalation ALI is used.

"Exempt Quantity" refers to radioactive material in individual quantities, each of which does not exceed the applicable quantity set forth in Table 10. May also be called "Reference Quantity" or RQ.

"External Dose" refers to the dose rate, in $\mu\text{rem/hr}$, calculated at a distance of 1 meter from a 1 mCi point source containing only one radionuclide.

"Half life" means the period of time for a quantity (activity) of a radionuclide to diminish by a factor of one half. Half life is expressed in units of years (yr), days (dy), minutes (min) or seconds (sec).

"Removable Contamination Limit (RCL)" means a certain quantity of radioactive material contamination, measured in units of activity per area, used to guide appropriate actions to take during surveys.

"Skin Dose" means the dose rate, in mrem/hr , calculated at a skin depth of 0.07 mm from 1 μCi of only one radionuclide distributed over 10 cm^2 of skin surface.

TABLES

Tables 1-10 include the radionuclide data. Table 11 lists actions that should be taken by those using radionuclides and conducting contamination surveys.

LAB SURVEYS AND SHIELDING

When conducting lab surveys for regulatory compliance, or when determining necessary shielding, an individual should be aware of the different types and intensities of radioactive

emissions. Be sure to use shielding material and detection instruments that are appropriate for the radiation emitted.

TABLE 1 – COMMONLY USED "LO-BETA" EMITTERS*

Element	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Carbon	C-14	5700 yr	2	N/A	120
Calcium	Ca-45	160 dy	2	N/A	330
Chlorine	Cl-36	3.0E5 yr	2	0.08	720
Chromium	Cr-51	28 dy	40	18	0
Iron	Fe-55	2.7 yr	9	N/A	0
Hydrogen	H-3	12 yr	80	N/A	0
Nickel	Ni-63	100 yr	9	N/A	N/A
Phosphorus	P-33	25 dy	6	N/A	320
Promethium	Pm-147	2.6 yr	4	N/A	230
Sulfur	S-35	88 dy	10	N/A	130
Technetium	Tc-99	2.1E5 yr	4	N/A	360

*Lo-Beta emitters are low energy beta or electron emitters with a negligible external exposure potential.

TABLE 2 – COMMONLY USED "HI-BETA" EMITTERS*

Element	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Phosphorus	P-32	14 dy	0.6	N/A	890
Rubidium	Rb-86	19 dy	0.5	50	850
Strontium	Sr-90	29 yr	0.03	N/A	680
Yttrium	Y-90	64 hr	0.4	N/A	890

*Hi-Beta emitters are high energy beta emitters with negligible gamma emission but are capable of significant bremsstrahlung production if not properly shielded. Emphasis should be on control of dose to extremities and prevention of intake.

TABLE 3 – IODINES*

Element	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Iodine	I-125	60 dy	0.04	175	0
	I-129	1.6E7 yr	0.005	69	80
	I-131	8 dy	0.03	220	630

*Emphasis is on prevention of intake by ingestion or inhalation.

TABLE 4 – GASES*

Element	Isotope	Half Life	Inhalation ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Krypton	Kr-85	11 yr	N/A	1.3	N/A
Xenon	Xe-133	5.2 dy	N/A	57	N/A

*Gases present minimal exposure potential or waste disposal issues.

TABLE 5 – NATURALLY OCCURRING

Element ¹	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Thorium	(α) Th-232	1.4E10 yr	7E-4	14.3	1
Uranium	(α) U-238	4.5E9 yr	0.01	15.4	1

¹ Elements listed with (α) are primarily alpha emitters. Other elements are primarily beta, gamma or positron emitters.

TABLE 6 – COMMONLY USED "GAMMA" EMITTERS*

Element	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Cobalt	Co-57	270 dy	8	56	29
Gallium	Ga-67	78 hr	7	80	110
Germanium	Ge-68	270 dy	5	N/A	N/A
Iodine	I-123	13 hr	3	178	140
Indium	In-111	67 hr	4	346	140
Manganese	Mn-54	310 dy	2	463	0
Molybdenum	Mo-99	66 hr	2	92	800
Sodium	Na-24	15 hr	4	1820	N/A
Niobium	Nb-95	35 dy	2	429	100
Nickel	Ni-63	100 yr	9	N/A	N/A
Ruthenium	Ru-103	39 dy	2	287	250
Tin	Sn-113	115 dy	2	121	0
Strontium	Sr-85	65 dy	3	286	10
Technetium	Tc-99m	6.0 hr	80	80	90
Thallium	Tl-201	73 hr	20	45	100

*Emphasis is on external exposure control and monitoring.

TABLE 7 – COMMON RESEARCH RADIONUCLIDES

Element ¹	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Actinium	Ac-227	22 yr	2E-4	6.4	0
Americium	(α) Am-241	430 yr	8E-4	75	1
Barium	Ba-133	11 yr	2	304	N/A
Bismuth	(α) Bi-210	5 dy	0.8	N/A	800
Carbon	C-11	20 min	400	586	850

TABLE 7 – COMMON RESEARCH RADIONUCLIDES

Element ¹	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
	C-14	5700 yr	2	N/A	120
Calcium	Ca-45	160 dy	2	N/A	330
Cadmium	Cd-109	460 dy	0.3	189	0
Cerium	Ce-141	33 dy	2	45	720
Californium	(α) Cf-249	350 yr	5E-4	214	80
	(α) Cf-252	2.7 yr	2E-3	231	0
Chlorine	Cl-36	3.0E5 yr	2	0.1	720
Curium	(α) Cm-243	29 yr	1E-3	136	470
	(α) Cm-244	18 yr	1E-3	14	0
Cobalt	Co-57	270 dy	8	56	29
	Co-60	5.3 yr	0.5	1290	420
Chromium	Cr-51	28 dy	40	18	0
Cesium	Cs-137	30 yr	0.1	343	590
Copper	Cu-67	62 hr	5	57	N/A
Europium	Eu-152	14 yr	0.8	644	330
Fluorine	F-18	110 min	50	568	760
Iron	Fe-55	2.7 yr	9	N/A	0
	Fe-59	45 dy	0.8	620	460
Gallium	Ga-67	78 hr	7	80	110
Hydrogen	H-3	12 yr	80	N/A	0
Iodine	I-123	13 hr	3	178	140
	I-125	60 dy	0.04	175	0
	I-129	1.6E7 yr	5E-3	69	80
Indium	In-114m	50 dy	0.3	98	N/A
Potassium	K-42	12 hr	5	137	N/A
Krypton	Kr-85	11 yr	N/A	2	N/A
Manganese	Mn-54	312 dy	2	463	0
Sodium	Na-22	2.6 yr	0.4	1180	720
	Na-24	15 hr	4	1820	N/A
Niobium	Nb-95	35 dy	2	429	100
Nickel	Ni-63	100 yr	9	N/A	N/A
Neptunium	(α) Np-237	2.1E6 yr	5E-4	120	30
Phosphorus	P-32	14 dy	0.6	N/A	890
	P-33	25 dy	6	N/A	320
Protactinium	Pa-234	6.7 hr	2	944	2000
Lead	Pb-210	22 yr	6E-4	9	0
Promethium	Pm-147	2.6 yr	4	N/A	230
Polonium	(α) Po-210	138 dy	3E-3	N/A	0
Plutonium	(α) Pu-236	2.9 yr	2E-3	21	0
	(α) Pu-238	88 yr	9E-4	19	0
	(α) Pu-239	2.4E4 yr	8E-4	8	0

TABLE 7 – COMMON RESEARCH RADIONUCLIDES

Element ¹	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
	(α) Pu-240	6560 yr	8E-4	18	0
	Pu-241	14 yr	0.04	N/A	0
	(α) Pu-242	3.8E5 yr	8E-4	16	0
Radium	(α) Ra-226	1600 yr	2E-3	4	20
Rubidium	Rb-86	19 dy	0.5	50	850
Ruthenium	Ru-103	39 dy	2	287	250
Sulfur	S-35	88 dy	10	N/A	130
Antimony	Sb-125	2.8 yr	2	303	310
Scandium	Sc-46	84 dy	0.9	1080	510
Selenium	Se-75	120 dy	0.5	203	40
Silicon	Si-32	153 yr	2	N/A	N/A
Tin	Sn-113	115 dy	2	121	0
Strontium	Sr-85	65 dy	3	286	10
	Sr-89	51 dy	0.6	N/A	850
	Sr-90	29 yr	0.03	N/A	680
Technetium	Tc-99	2.1E5 yr	4	N/A	360
Thorium	(α) Th-228	2 yr	6E-3	19	20
	(α) Th-229	7340 yr	6E-4	163	210
	(α) Th-230	7.5E4 yr	4E-3	16	0
	(α) Th-232	1.4E10 yr	7E-4	14	1
Thallium	Tl-204	3.8 yr	2	0.6	720
Uranium	(α) U-232	69 yr	2E-3	23	1
	(α) U-233	1.6E5 yr	0.01	11	0
	(α) U-235	7E8 yr	0.01	136	50
	(α) U-238	4.5E9 yr	0.01	15	1

¹ Elements listed with (α) are primarily alpha emitters. Other elements are primarily beta, gamma or positron emitters.

TABLE 8 – COMMON MEDICAL RADIONUCLIDES

Element	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Barium	Ba-133	11 yr	2	304	N/A
Carbon	C-11	20 min	400	586	850
	C-14	5700 yr	2	N/A	120
Cobalt	Co-57	270 dy	8	56	29
	Co-60	5.3 dy	0.5	1290	420
Cesium	Cs-137	30 yr	0.1	343	590
Copper	Cu-67	62 hr	5	57	N/A
Europium	Eu-152	14 yr	0.8	644	330
Fluorine	F-18	110 min	50	568	760

TABLE 8 – COMMON MEDICAL RADIONUCLIDES

Element	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Gallium	Ga-67	78 hr	7	80	110
Gadolinium	Gd-153	240 dy	5	N/A	50
Germanium	Ge-68	270 dy	5	N/A	N/A
Iodine	I-131	8 dy	0.03	220	630
Indium	In-111	67 hr	4	346	140
Iridium	Ir-192	74 dy	0.9	460	720
Lutetium	Lu-177	160 hr	2	18	1.82
Molybdenum	Mo-99	66 hr	2	92	800
Sodium	Na-22	2.6 yr	0.4	1180	720
Samarium	Sm-153	46 hr	2	48	N/A
Strontium	Sr-85	65 dy	3	286	10
	Sr-89	51 dy	0.6	N/A	850
Technetium	Tc-99	2.1E5 yr	4	N/A	360
	Tc-99m	6.0 hr	80	80	90
Thallium	Tl-201	73 hr	20	45	100
Xenon	Xe-133	5.3 dy	N/A	57	N/A
Yttrium	Y-90	64 hr	0.4	N/A	890

TABLE 9 – POSITRON EMISSION TOMOGRAPHY/CYCLOTRON RADIONUCLIDES

Element	Isotope	Half Life	Ingestion ALI [mCi]	External Dose [μrem/hr]	Skin Dose [mrem/hr]
Carbon	C-11	20 min	400	586	850
Copper	Cu-64	13 hr	10	105	N/A
Europium	Eu-152	14 yr	0.8	644	330
Fluorine	F-18	110 min	50	568	760
Gallium	Ga-68	68 min	20	543	800
Iodine	I-124	4.2 dy	0.05	659	N/A
Nitrogen	N-13	10 min	N/A	586	N/A
Sodium	Na-22	2.6 yr	0.4	1180	720
Oxygen	O-15	122 sec	N/A	586	N/A
Zinc	Zn-62	9.2 hr	1	259	N/A
	Zn-65	244 dy	0.4	307	10

TABLE 10 – EXEMPT QUANTITY (REFERENCE QUANTITY) OF RADIONUCLIDES*

Nuclide	Exempt Quantity [μCi]	Nuclide	Exempt Quantity [μCi]	Nuclide	Exempt Quantity [μCi]
Ba-133	10	H-3	1000	Rb-86	10
Bi-210	1	I-123	100	Ru-103	10
C-11	0.1	I-125	1	S-35	100
C-14	100	I-129	0.1	Sb-125	10
Ca-45	10	I-131	1	Sc-46	10
Cd-109	10	In-111	100	Se-75	10
Ce-141	100	In-114m	10	Si-32	100
Cl-36	10	Ir-192	10	Sm-153	100
Co-57	100	K-42	10	Sn-113	10
Co-60	1	Kr-85	100	Sr-85	10
Cr-51	1000	Lu-177	100	Sr-89	1
Cs-137	10	Mn-54	10	Sr-90	0.1
Cu-64	100	Mo-99	100	Tc-99	10
Eu-152	1	Na-22	10	Tc-99m	100
F-18	1000	Na-24	10	Tl-201	100
Fe-55	100	Nb-95	10	Tl-204	10
Fe-59	10	Ni-63	10	Xe-133	100
Ga-67	100	P-32	10	Y-90	10
Gd-153	10	Pm-147	10	Zn-65	10
Ge-68	10	Po-210	0.1		

* For values of radionuclides not listed contact the Radiological Health Department.

TABLE 11 – CONTAMINATION LIMITS AND ACTION LEVELS

<u>Radionuclide Category</u>		<u>Removable Contamination Limit (RCL)*</u>
Alpha-particle emitter		20 dpm per 100 cm ²
Non alpha-particle emitter (ALI < 1mCi)		200 dpm per 100 cm ²
Non alpha-particle emitter (ALI ≥ 1mCi)		2000 dpm per 100 cm ²
<u>Location</u>	<u>Quantity</u>	<u>Required Action</u>
Skin or hair	Any	Immediate removal by gentle washing.
	>1 RCL	Immediate removal by gentle washing and a screening bioassay within a normal interval.
	>10 RCL	Immediate removal by gentle washing and a screening bioassay within 5 days.
Personal or protective clothing	>1 RCL	Clothing must be decontaminated, or stored for decay, within the lab.
(Skin contact likely)	>10 RCL	Perform a screening bioassay within 5 days.
(Skin contact unlikely)	>10 RCL	Perform a screening bioassay within normal interval.
Surfaces or objects that are readily accessible or normally touched (handles, phones, knobs, etc.)	>1 RCL	Isolate, cover, label, etc, to prevent personnel contact until decontamination is performed. Indicate location and activity in survey record.
	>10 RCL	Decontaminate immediately and perform a screening bioassay within a normal interval for potentially exposed individuals.
	>100 RCL	Decontaminate immediately and perform a screening bioassay within 5 days for potentially exposed individuals.
Surfaces or objects that are not readily accessible or normally touched (radiation equipment, pipettes, equipment behind shielding, etc.)	>1 RCL	Ensure the contaminated area or object is indicated as such. Indicate location and activity in survey record.
	>10 RCL	Decontamination should be performed at the end of experiments using radioactive material.
Equipment, areas and/or facilities which are to be released for unrestricted use	>0.5 RCL (removable)	Ensure that all removable contamination is decontaminated to this standard before an area is released.
	>5 RCL (fixed)	Ensure fixed contamination does not result in dose rates greater than allowed. Remove, replace, hold for decay, etc., as appropriate to ensure no fixed contamination is present, greater than this standard, before an area is released.

*** All contamination is presumed to be removable unless proven otherwise. These limits are expressed as activity per 100 cm² rounded to one significant figure. For all surfaces, except skin, the contamination may be averaged over no more than 300 cm² for determining an appropriate action.**

REFERENCES

International Commission on Radiological Protection, Recommendations of the ICRP, Publ. No. 26, 1977

Kocher, D.C.; Eckerman, K.F., Electron dose-rate conversion factors for external exposure of the skin from uniformly deposited activity on the body surface, Health Physics 53:135-141, 1987

Lockheed Martin, Nuclides and Isotopes Sixteenth Edition, 2002

National Council on Radiation Protection and Measurements, A Handbook of Radioactivity Measurements Procedures, Report No. 58, 1978

Smith, David S.; Stabin, Michael G., Exposure Rate Constants and Lead Shielding Values for Over 1,100 Radionuclides, Health Physics Volume 103:271-291, 2012

Stabin, Michael G.; da Luz, Lydia C.Q.P., Decay Data for Internal and External Dose Assessment, Health Physics Volume 83:471-475, 2002

State of Utah Department of Environmental Quality, Division of Radiation Control, Utah Radiation Control Rules (R313)

U.S. Environmental Protection Agency, Limiting of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11, EPA-520/1-88-020, September 1988

U.S. Nuclear Regulatory Commission Chapter 10, Code of Federal Regulations (CFR) 30.71 Schedule B (2007)

U.S. Nuclear Regulatory Commission Regulatory Guide 8.23 Radiation Safety Surveys at Medical Institutions, Rev 1, Jan. 1981

Utah Radioactive Material License UT1800001