RI-10 RADIONUCLIDE DATA

PURPOSE

This procedure provides a ready reference to radiation protection data for commonly used radionuclides. The quick reference guide provides equations for calculating doses. Use of these equations and examples are covered in Module-5 training. Data for nuclides not listed herein may be obtained from the RCO.

RULES AND REGULATIONS

Radionuclide data used for radiation protection calculations shall be obtained from regulatory authorities or reputable scientific advisory organizations.

DEFINITIONS

Reference Quantity (RQ): A quantity of a radionuclide (expressed in microcuries) related to its relative hazard potential and used to prescribe requirements for handling, monitoring, labeling and disposal.

Annual Limit on Intake (ALI): The quantity of a radionuclide (expressed in millicuries) which, if taken into the body, produces an effective dose equivalent in risk to the annual whole body dose limit of 5 rem or the annual dose limit to an individual organ of 50 rem, whichever is lower. Because of differences in physiological transport mechanisms, the ALIs vary depending on the route of intake. For purposes of contamination control and bioassay procedures, the ALI for ingestion is used, since that is the most common route of accidental intake in research laboratories.

Sewer Release Limits: The maximum concentration (expressed in μCi/mL) that can be released via the sanitary sewer. Sewer release is limited to radionuclides with half-lives $\leq$ 16 days and at a concentration at or below the sewer release limit before pouring is initiated.

Gamma Ray Constants (mrem*m²/hr*mCi):
Penetrating - the dose rate from photons at 1 meter from a point source of 1 millicurie, assumed to be proportional to the inverse of the square of the distance between the point source and the receptor.

Skin Dose Constant CF (rem*cm²/μCi*hr) - dose rate to the basal epidermal cells from contamination on the skin, expressed in microcuries per unit area of skin (μCi/cm²) over an area of at least 1 cm².

Action Level: A level of contamination in which immediate action is required. The appropriate action depends on the type of radiation emitted, the radionuclide ALI, the location of contamination and the level of contamination compared to the action level.

THIS PAGE IS A QUICK REFERENCE GUIDE FOR DOSIMETRY CALCULATIONS. PLEASE MAKE A COPY OF THIS PAGE AND POST IT IN YOUR LABORATORY FOR EASY REFERENCE.

Useful Equations

1. Radioactive decay, where A is current activity from starting activity of A_o and $t_{1/2}$ is the half life:

$$A = A_o e^{-\lambda t} \text{ where } \lambda = \frac{\ln(2)}{t_{1/2}}$$

2. External absorbed dose rate from a point β source of activity (A) at a distance (d):

$$\dot{D} = \left(27 \frac{rad \cdot m^2}{Ci \cdot h} \right) \cdot \frac{A}{d^2}$$

3. Skin absorbed dose rate from an area β source on the skin surface, where A is the activity, α is the area covered, and C_f is the dose rate conversion factor from the Varskin Chart, above:

$$\dot{D} = C_f \frac{A}{\alpha}$$

4. External exposure rate ($\dot{X}$) from a point γ source of activity (A) at a distance (d). Γ is the exposure rate constant.

$$\dot{X} = \Gamma \frac{A}{d^2}$$

5. Internal dose equivalents for effective (E) whole body or a target (T) organ:

$$H_{E,50} = \frac{A}{ALI}(5 \cdot rem) \text{ or } H_{T,50} = \frac{A}{ALI}(50 \cdot rem)$$

6. Dose Equivalent (H) (rem) from Absorbed Dose (D_A) (rad) and a Quality Factor (Q) (rem/rad):

$$H = D_A \cdot Q$$

RADIONUCLIDE CATEGORIES AND DATA

(For data on radionuclides not listed below, contact the RCO.)

Nuclide	Half-life	Reference Quantity (μCi)	Ingestion ALI (mCi)	Gamma Ray Constant (mrem*m^2) (mCi*hr)	Sewer Release Limits (μCi/mL)	Skin Dose Rate Constant At 0.07 mm (mrem*cm^2) (μCi*hr)
"**LOW-BETAS"** - low-energy beta or electron emitters with negligible external exposure potential and ALI's ≥ 1 millicurie.						
^{3}H	12 yrs	1000	3.5$^{\tau}$	0	1E-3	
^{14}C	5730 yrs	100	0.875$^{\tau}$	0	3E-5	1.10
^{33}P	25.4 days	100	6	0	8E-5	2.99
^{35}S	87 days	100	6	0	1E-4	1.20
^{36}Cl	3x10^5 yrs	10	2	0	2E-5	7.20
^{45}Ca	165 days	10	2	0	2E-5	3.03
^{55}Fe	2.7 yrs	100	9	0	1E-4	
^{63}Ni	100 yrs	10	9	0	1E-4	
^{99}Tc	2x10^5 yrs	10	4	0	6E-5	
^{147}Pm	2.6 yrs	10	4	0	7E-7	
"HIGH-BETAS" - high-energy beta emitters with negligible gamma emission but capable of significant *bremsstrahlung* production if not properly shielded. Emphasis is on control of doses to extremities and prevention of intake.						
^{32}P	14.3 days	10	0.03$^{\tau}$	0	9E-6	6.03
^{86}Rb	18.7 days	100	0.5	0.05	7E-6	
^{90}Sr	28.6 yrs	0.1	0.03	0	5E-7	5.46
"IODINES" - radioiodines are treated as a separate category for exposure evaluation. Emphasis is on prevention of intake by ingestion or inhalation.						
^{125}I	60 days	1	0.04$^{\tau}$	0.07	2E-6	
^{129}I	6x10^9 yrs	0.1	0.005	0.13	2E-7	
^{131}I	8 days	1	0.008$^{\tau}$	0.22	1E-6	6.30
"GASES" - noble gases present minimal exposure potential or waste disposal problems.						
^{85}Kr	10.7 yrs	100	N/A	0	N/A	
^{133}Xe	5.2 days	100	N/A	0.1	N/A	
"ALPHAS" – includes naturally occurring as well as man-made radionuclides. Emphasis is on prevention of intake by ingestion or inhalation.						
^{232}Th (nat)	14x10^9 yrs	100	0.0007	0	3E-8	
^{238}U (nat)	4.5x10^9 yrs	100	0.01	0	3E-8	
^{239}Pu	2.1x10^4 yrs	100	6x10^{-6}	0	2E-8	
^{241}Pu	14.4 yrs	100	0.0003	0	1E-6	
^{241}Am	458 yrs	100	0.01	0.15	2E-14	

Nuclide	Half-life	Reference Quantity (μCi)	Ingestion ALI (mCi)	Gamma Ray Constant (mrem*m^2) (mCi*hr)	Sewer Release Limits (μCi/mL)	Skin Dose Rate Constant At 0.07 mm (mrem*cm^2) (μCi*hr)
"GAMMAS" - gamma emitters with ALI's ≥ 1 millicurie; emphasis is on external exposure control and monitoring.						
^{24}Na	0.625 days	10	4	1.89	5E-5	
^{51}Cr	28 days	1000	*40	0.12	5E-4	
^{54}Mn	312 days	10	2	0.51	3E-5	
^{57}Co	271 days	100	*4	0.15	6E-5	0.29
^{67}Ga	3.3 days	100	7	0.11	1E-4	1.10
^{68}Ga	68 min	100	20	0.54	2E-4	
^{68}Ge	288 days	100	5	0.06	6E-5	
^{85}Sr	64.8 days	10	*3	0.75	4E-5	0.06
^{95}Nb	35 days	10	*2	0.48	3E-5	0.97
^{99}Mo	2.8 days	100	1	0.11	2E-5	
^{99m}Tc	0.25 days	100	80	0.12	1E-3	0.89
^{103}Ru	39 days	10	*2	0.33	3E-5	2.40
^{111}In	2.8 days	100	*4	0.5	6E-5	1.40
^{113}Sn	115 days	10	*2	0.18	3E-5	
^{123}I	0.542 days	100	3	0.28	1E-4	
^{153}Gd	242 days	10	*5	0.17	6E-5	0.46
^{195}Au	183 days	10	5	0.09	7E-5	
^{195m}Hg	1.7 days	10	2	0.1	3E-5	
^{197}Hg	2.7 days	100	3	0.07	8E-5	
^{198}Au	2.7 days	100	1	0.29	2E-5	
^{201}Tl	3 days	100	20	0.09	2E-4	0.97
^{203}Pb	2.2 days	10	5	0.68	7E-5	
ALL OTHER NUCLIDES - not included in one of the above groups are assumed to have significant potentials for both external and internal exposures and must be evaluated individually.						
^{22}Na	2.6 yrs	10	0.4	1.33	6E-6	7.20
^{46}Sc	84 days	10	*0.9	1.17	1E-5	5.10
^{59}Fe	44.6 days	10	0.8	0.66	1E-5	4.60
^{60}Co	5.27 yrs	1	0.2	1.37	3E-6	
^{65}Zn	244 days	10	0.4	0.33	5E-6	
^{75}Se	118 days	10	0.5	0.86	7E-6	0.36
^{106}Ru	367 days	1	0.2	0	3E-6	
^{109}Cd	453 days	10	*0.3	0.18	6E-6	
^{137}Cs	30.0 yrs	10	0.1	0.34	1E-5	
^{192}Ir	74 days	10	0.9	0.59	1E-5	
^{203}Hg	47 days	10	0.5	0.25	7E-6	

* The ALI is not applicable to microspheres, which are highly insoluble particles, typically greater than 0.01 mm diameter. They require external exposure control and monitoring, but are not readily absorbed from the gastrointestinal tract. If inhaled, because of their size, they are most likely to be deposited in the upper respiratory tract, from which they would be cleared by the mucous transport and swallowed.

τ These ALI's reflect the radiation hazards associated with using various types of DNA-labeled compounds. The lowest values are listed to follow the ALARA principle; ALIs varied for different compounds. These values were taken from recommendations in NCRP Report #63 (Tritium and other Radionuclide Labeled Organic Compounds Incorporated in Genetic Material).

CONTAMINATION LIMITS AND ACTION LEVELS[1]

NUCLIDE CATEGORY	**ACTION LEVELS (AL)[2]**
Electron and/or photon emitters:	
with ingestion ALI ≥1 mCi	1 nCi (2,000 dpm; 40 Bq) per 100 cm^2
with ingestion ALI <1 mCi	0.1 nCi (200 dpm; 4 Bq) per 100 cm^2
Alpha-particle emitters:	0.01 nCi (20 dpm; 0.4 Bq) per 100 cm^2

LOCATION	**QUANTITY**	**REQUIRED ACTION**
Skin or hair	Any	Immediate removal by gentle washing
	>1 AL	Immediate removal and bioassay[3] within normal interval
	>10 AL	Immediate removal and bioassay[3] within 5 days
Clothing, personal or	>1 AL	Do not remove clothing from the lab; wash in the lab or store for decay
Skin contact likely	>10 AL	Bioassay[3] within five (5) days
Skin contact unlikely	>10 AL	Bioassay[3] within normal interval
Surfaces or objects that are readily accessible or normally touched, e.g. bench tops, handles, etc.	>1 AL	Until decontaminated, isolate, cover, label, etc. to prevent personnel contact; indicate location and activity in survey record
	>10 AL	Decontaminate immediately; bioassay[3] required within normal interval for potentially exposed individuals
	>100 AL	Decontaminate immediately; bioassay[3] required within 5 days for potentially exposed individuals
Equipment or facilities to be released for unrestricted use	>0.5 AL removable >5 AL fixed	Do not release until criteria are satisfied
Other surfaces or objects (not readily accessible or normally touched)	>1 AL	Label the contaminated area or object; indicate location and activity on survey record
	>10 AL	Decontaminate within one week

[1]Based on NRC Reg. Guide 8.23, Radiation Safety Surveys at Medical Institutions, Rev. 1, Jan. 1981.

[2]All contamination is presumed to be removable until proven otherwise. The limits arc expressed as activity per 100 square centimeters, rounded to one significant figure. For all surfaces except skin, the contamination may be averaged over no more than 300 cm^2 for determining the appropriate action.

[3]All requirements for bioassays in this table are for screening bioassays.