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Protective Action

Decontamination

Ionizing Radiation

Public Exposure

Medical Exposure

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Normal Exposure

Potential Exposure ()

Occupational Exposure

Exposure

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Safety Assessment

Contamination

Activation

Safety Culture

Effective Dose

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$$E = \sum_T W_T H_T$$

$W_{T, T}$

H_T

(Sv) " " /

Equivalent Dose

$H_{T \cdot R}$

$$H_{T \cdot R} = D_{T \cdot R} W_R$$

R

$D_{T \cdot R}$

. R

W_R T

W_R

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$$H_T = \sum_R W_R D_{T \cdot R}$$

(Sv) " " /

Entrance Surface Dose

Dose

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Accident

Dose limit

Emergency plan

Defense in Depth

Monitoring

Worker

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Critical Group

Radiation Protection Officer

Guidance Level Medical Exposure

Intervention Level

Clearance Level

Practice

Sealed Source

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Source

Radioactivity

(dN)

A

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$$A = dN/dt$$

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Radioactive Waste

Protection and Safety

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H-3	1×10^6	1×10^9	Fe-52	1×10^1	1×10^6
Be-7	1×10^3	1×10^7	Fe-55	1×10^4	1×10^6
C-14	1×10^4	1×10^7	Fe-59	1×10^1	1×10^6
O-15	1×10^2	1×10^9	Co-55	1×10^1	1×10^6
F-18	1×10^1	1×10^6	Co-56	1×10^1	1×10^5
Na-22	1×10^1	1×10^6	Co-57	1×10^2	1×10^6

Na-24	1x10 ¹	1x10 ⁵	Co-58	1x10 ¹	1x10 ⁶
Si-31	1x10 ³	1x10 ⁶	Co-58m	1x10 ⁴	1x10 ⁷
P-32	1x10 ³	1x10 ⁵	Co-60	1x10 ¹	1x10 ⁵
P-33	1x10 ⁵	1x10 ⁸	Co-60m	1x10 ³	1x10 ⁶
S-35	1x10 ⁵	1x10 ⁸	Co-61	1x10 ²	1x10 ⁶
Cl-36	1x10 ⁴	1x10 ⁶	Co-62m	1x10 ¹	1x10 ⁵
Cl-38	1x10 ¹	1x10 ⁵	Ni-59	1x10 ⁴	1x10 ⁸
Ar-37	1x10 ⁶	1x10 ⁸	Ni-63	1x10 ⁵	1x10 ⁸
Ar-41	1x10 ²	1x10 ⁹	Ni-65	1x10 ¹	1x10 ⁶
K-40	1x10 ²	1x10 ⁶	Cu-64	1x10 ²	1x10 ⁶
K-42	1x10 ²	1x10 ⁶	Zn-65	1x10 ¹	1x10 ⁶
K-43	1x10 ¹	1x10 ⁶	Zn-69	1x10 ⁴	1x10 ⁶
Ca-45	1x10 ⁴	1x10 ⁷	Zn-69m	1x10 ²	1x10 ⁶
Ca-47	1x10 ¹	1x10 ⁶	Ga-72	1x10 ¹	1x10 ⁵
Sc-46	1x10 ¹	1x10 ⁶	Ge-71	1x10 ⁴	1x10 ⁸
Sc-47	1x10 ²	1x10 ⁶	As-73	1x10 ³	1x10 ⁷
Sc-48	1x10 ¹	1x10 ⁵	As-74	1x10 ¹	1x10 ⁶
V-48	1x10 ¹	1x10 ⁵	As-76	1x10 ²	1x10 ⁵
Cr-51	1x10 ³	1x10 ⁷	As-77	1x10 ³	1x10 ⁶
Mn-51	1x10 ¹	1x10 ⁵	Se-75	1x10 ²	1x10 ⁶
Mn-52	1x10 ¹	1x10 ⁵	Br-82	1x10 ¹	1x10 ⁶
Mn-52m	1x10 ¹	1x10 ⁵	Kr-74	1x10 ²	1x10 ⁹
Mn-53	1x10 ⁴	1x10 ⁹	Kr-76	1x10 ²	1x10 ⁹
Mn-54	1x10 ¹	1x10 ⁶	Kr-77	1x10 ²	1x10 ⁹
Mn-56	1x10 ¹	1x10 ⁵	Kr-79	1x10 ³	1x10 ⁵
Kr-81	1x10 ⁴	1x10 ⁷	Tc-97	1x10 ³	1x10 ⁸
Kr-83m	1x10 ⁵	1x10 ¹²	Tc-97m	1x10 ³	1x10 ⁷
Kr-85	1x10 ⁵	1x10 ⁴	Tc-99	1x10 ⁴	1x10 ⁷
Kr-85m	1x10 ³	1x10 ¹⁰	Tc-99m	1x10 ²	1x10 ⁷
Kr-87	1x10 ²	1x10 ⁹	Ru-97	1x10 ²	1x10 ⁷
Kr-88	1x10 ²	1x10 ⁹	Ru-103	1x10 ²	1x10 ⁶
Rb-86	1x10 ²	1x10 ⁵	Rh-105	1x10 ¹	1x10 ⁶
Sr-85	1x10 ²	1x10 ⁶	Ru-106a	1x10 ²	1x10 ⁵
Sr-85m	1x10 ²	1x10 ⁷	Rh-103m	1x10 ⁴	1x10 ⁸
Sr-87m	1x10 ²	1x10 ⁶	Rh-105	1x10 ²	1x10 ⁷
Sr-89	1x10 ³	1x10 ⁶	Pd-103	1x10 ³	1x10 ⁸
Sr-90a	1x10 ²	1x10 ⁴	Pd-109	1x10 ³	1x10 ⁶
Sr-91	1x10 ¹	1x10 ⁵	Ag-105	1x10 ²	1x10 ⁶
Sr-92	1x10 ¹	1x10 ⁶	Ag-110m	1x10 ¹	1x10 ⁶
Y-90	1x10 ³	1x10 ⁵	Ag-111	1x10 ³	1x10 ⁶

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Y-91	1×10^3	1×10^6	cd-109	1×10^4	1×10^6
Y-91m	1×10^2	1×10^6	cd-115	1×10^2	1×10^6
Y-92	1×10^2	1×10^5	cd-115m	1×10^3	1×10^6
Y-93	1×10^2	1×10^5	In-111	1×10^2	1×10^6
Zr-93 ^a	1×10^3	1×10^7	In-113m	1×10^2	1×10^6
Zr-95	1×10^1	1×10^6	In-114m	1×10^2	1×10^6
Zr-97 ^a	1×10^1	1×10^5	In-115m	1×10^2	1×10^6
Nb-93m	1×10^4	1×10^7	Sn-113	1×10^3	1×10^7
Nb-94	1×10^1	1×10^6	Sn-125	1×10^2	1×10^5
Nb-95	1×10^1	1×10^6	Sb-122	1×10^2	1×10^4
Nb-97	1×10^1	1×10^6	Sb-124	1×10^1	1×10^6
Nb-98	1×10^1	1×10^5	Sb-125	1×10^2	1×10^6
Mo-90	1×10^1	1×10^6	Te-123m	1×10^2	1×10^7
Mo-93	1×10^3	1×10^8	Te-125m	1×10^3	1×10^7
Mo-99	1×10^2	1×10^6	Te-127	1×10^3	1×10^6
Mo-101	1×10^1	1×10^6	Te-127m	1×10^3	1×10^7
Tc-96	1×10^1	1×10^6	Te-129	1×10^2	1×10^6
Tc-96m	1×10^3	1×10^7	Te-129m	1×10^3	1×10^6
Te-131	1×10^2	1×10^5	Ce-143	1×10^2	1×10^6
Te-131m	1×10^1	1×10^6	Ce-144 ^a	1×10^2	1×10^5
Te-132	1×10^2	1×10^7	Pr-142	1×10^2	1×10^5
Te-133	1×10^1	1×10^5	Pr-143	1×10^4	1×10^6
Te-133m	1×10^1	1×10^5	Nd-147	1×10^2	1×10^6
Te-134	1×10^1	1×10^6	Nd-149	1×10^2	1×10^6
I-123	1×10^2	1×10^7	Pm-147	1×10^4	1×10^7
I-125	1×10^3	1×10^6	Pm-149	1×10^3	1×10^6
I-126	1×10^2	1×10^6	Sm-151	1×10^4	1×10^8
I-129	1×10^2	1×10^5	Sm-153	1×10^2	1×10^6
I-130	1×10^1	1×10^6	Eu-152	1×10^1	1×10^6
I-131	1×10^2	1×10^6	Eu-152m	1×10^2	1×10^6
I-132	1×10^1	1×10^5	Eu-154	1×10^1	1×10^6
I-133	1×10^1	1×10^6	Eu-155	1×10^2	1×10^7
I-134	1×10^1	1×10^5	Gd-153	1×10^2	1×10^7
I-135	1×10^1	1×10^6	Gd-159	1×10^3	1×10^6
Xe-131m	1×10^4	1×10^4	Tb-160	1×10^1	1×10^6
Xe-133	1×10^3	1×10^4	Dy-165	1×10^3	1×10^6
Xe-135	1×10^3	1×10^{10}	Dy-166	1×10^3	1×10^6
Cs-129	1×10^2	1×10^5	Ho-166	1×10^3	1×10^5
Cs-131	1×10^3	1×10^6	Er-169	1×10^4	1×10^7
Cs-132	1×10^1	1×10^5	Er-171	1×10^2	1×10^6
Cs-134m	1×10^3	1×10^5	Tm-170	1×10^3	1×10^6
Cs-134	1×10^1	1×10^4	Tm-171	1×10^4	1×10^8

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Cs-135	1x10 ⁴	1x10 ⁷	Yb-175	1x10 ³	1x10 ⁷
Cs-136	1x10 ¹	1x10 ⁵	Lu-177	1x10 ³	1x10 ⁷
Cs-137 ^a	1x10 ¹	1x10 ⁴	Hf-181	1x10 ¹	1x10 ⁶
Cs-138	1x10 ¹	1x10 ⁴	Ta-182	1x10 ¹	1x10 ⁴
Ba-131	1x10 ²	1x10 ⁶	W -181	1x10 ³	1x10 ⁷
Ba- 140 ^a	1x10 ¹	1x10 ⁵	W- 185	1x10 ⁴	1x10 ⁷
La-140	1x10 ¹	1x10 ⁵	W-187	1x10 ²	1x10 ⁶
Ce-139	1x10 ²	1x10 ⁶	Re-186	1x10 ³	1x10 ⁶
Ce- 141	1x10 ²	1x10 ⁷	Re-188	1x10 ²	1x10 ⁵
Os-185	1x10 ¹	1x10 ⁶	Rn-222 ^a	1x10 ¹	1x10 ⁸
Os-191	1x10 ²	1x10 ⁷	Ra- 223 ^a	1x10 ²	1x10 ⁵
Os-191m	1x10 ³	1x10 ⁷	Ra- 224 ^a	1x10 ¹	1x10 ⁵
Os- 193	1x10 ²	1x10 ⁶	Ra -225	1x10 ²	1x10 ⁵
Ir- 190	1x10 ¹	1x10 ⁶	Ra-226 ^a	1x10 ¹	1x10 ⁴
Ir- 192	1x10 ¹	1x10 ⁴	Ra-227	1x10 ²	1x10 ⁶
Ir- 194	1x10 ²	1x10 ⁵	Ra-228 ^a	1x10 ¹	1x10 ⁵
Pt- 191	1x10 ²	1x10 ⁶	Ac-228	1x10 ¹	1x10 ⁶
Pt- 193m	1x10 ³	1x10 ⁷	Th-226 ^a	1x10 ³	1x10 ⁷
Pt- 197	1x10 ³	1x10 ⁶	Th-227	1x10 ¹	1x10 ⁴
Pt-197m	1x10 ²	1x10 ⁶	Th-228 ^a	1x10 ⁰	1x10 ⁴
Au- 198	1x10 ²	1x10 ⁶	Th-229 ^a	1x10 ⁰	1x10 ³
Au- 199	1x10 ²	1x10 ⁶	Th- 230	1x10 ⁰	1x10 ⁴
Hg- 197	1x10 ²	1x10 ⁷	Th- 231	1x10 ³	1x10 ⁷
Hg- 197m	1x10 ²	1x10 ⁶	Th-nat	1x10 ⁰	1x10 ³
Hg- 203	1x10 ²	1x10 ⁵	(incl.Th-232)		
Tl- 200	1x10 ¹	1x10 ⁶	Th-234 ^a	1x10 ³	1x10 ⁵
Tl- 201	1x10 ²	1x10 ⁶	Pa-230	1x10 ¹	1x10 ⁶
Tl- 202	1x10 ²	1x10 ⁶	Pa-231	1x10 ⁰	1x10 ³
Tl- 204	1x10 ⁴	1x10 ⁴	Pa-233	1x10 ²	1x10 ⁷
Pb- 203	1x10 ²	1x10 ⁶	U- 230 ^a	1x10 ¹	1x10 ⁵
Pb- 210 ^a	1x10 ¹	1x10 ⁴	U -231	1x10 ²	1x10 ⁷
Pb- 212	1x10 ¹	1x10 ⁵	U -232 ^a	1x10 ⁰	1x10 ³
Bi-206	1x10 ¹	1x10 ⁵	U -233	1x10 ¹	1x10 ⁴
Bi- 207	1x10 ¹	1x10 ⁶	U - 234	1x10 ¹	1x10 ⁴
Bi- 210	1x10 ³	1x10 ⁶	U -235 ^a	1x10 ¹	1x10 ⁴
Bi- 212 ^a	1x10 ¹	1x10 ⁵	U - 236	1x10 ¹	1x10 ⁴
Po- 203	1x10 ¹	1x10 ⁶	U -237	1x10 ²	1x10 ⁶
Po- 205	1x10 ¹	1x10 ⁶	U - 238 ^a	1x10 ¹	1x10 ⁴
Po- 207	1x10 ¹	1x10 ⁶	U -nat	1x10 ⁰	1x10 ³
Po- 210	1x10 ¹	1x10 ⁴	U -239	1x10 ²	1x10 ⁶
At-211	1x10 ³	1x10 ⁷	U -240	1x10 ³	1x10 ⁷
Rn-220 ^a	1x10 ⁴	1x10 ⁷	U -240 ^a	1x10 ¹	1x10 ⁶
Np237a	1x10 ⁰	1x10 ³	Cm-244	1x10 ¹	1x10 ⁴
Np- 239	1x10 ²	1x10 ⁷	Cm-245	1x10 ⁰	1x10 ³
Np-240	1x10 ¹	1x10 ⁶	Cm-246	1x10 ⁰	1x10 ³
Pu-234	1x10 ²	1x10 ⁷	Cm-247	1x10 ⁰	1x10 ⁴

Pu- 235	1x10 ²	1x10 ⁷	Cm-248	1x10 ⁰	1x10 ³
Pu- 236	1x10 ¹	1x10 ⁴	Bk-249	1x10 ³	1x10 ⁶
Pu- 237	1x10 ³	1x10 ⁷	Cf-246	1x10 ³	1x10 ⁶
Pu-238	1x10 ⁰	1x10 ⁴	Cf-248	1x10 ¹	1x10 ⁴
Pu-239	1x10 ⁰	1x10 ⁴	Cf- 249	1x10 ⁰	1x10 ³
Pu-240	1x10 ⁰	1x10 ³	Cf- 250	1x10 ¹	1x10 ⁴
Pu- 241	1x10 ²	1x10 ⁵	Cf- 251	1x10 ⁰	1x10 ³
Pu- 242	1x10 ⁵	1x10 ⁴	Cf- 252	1x10 ¹	1x10 ⁴
Pu- 243	1x10 ³	1x10 ⁷	Cf- 253	1x10 ²	1x10 ⁵
Pu- 244	1x10 ⁰	1x10 ⁴	Cf- 254	1x10 ⁰	1x10 ³
Am- 241	1x10 ⁰	1x10 ⁴	Es- 253	1x10 ²	1x10 ⁵
Am-242	1x10 ³	1x10 ⁶	Es- 254	1x10 ¹	1x10 ⁴
Am- 242m ^a	1x10 ⁰	1x10 ⁴	Es- 254m	1x10 ²	1x10 ⁶
Am -243 ^a	1x10 ⁰	1x10 ³	Fm-254	1x10 ⁴	1x10 ⁷
Cm-242	1x10 ²	1x10 ⁵	Fm-255	1x10 ³	1x10 ⁶
Cm-243	1x10 ⁰	1x10 ⁴			1x10 ⁷

^a parent nuclides and their progeny included in secular equilibrium are listed in the following:

Sr- 90 Y- 90
Zr- 937 Nb- 93m
Zr- 97 Nb- 97
Ru- 106Rh- 106
Cs- 137Ba- 137m
Ce-134 La- 134
Ce- 144Pr- 144
Ba- 140La- 140
Bi- 212 Tl- 208 (0.36), Po- 212 (0.64)
Pb- 210Bi- 210, Po- 210
Pb- 212Bi-212, Tl- 208(0.36), Po- 212(0.64)
Rn- 220Po- 216
Rn- 222Po- 218, Pb- 214, Bi- 214, Po- 214
Ra- 223Rn- 219, Po- 215, Pb- 211, Bi-211, Tl- 207
Ra- 224Rn- 220, Po- 216, Pb- 212, Bi- 212, Tl- (20 (0.36), Po- 212(0.64)
Ra- 226Rn- 222, Po-218, Pb- 214, Bi- 214, Po- 214, Pb- 210, Bi- 210, Po- 210
Ra- 228Ac-228
Th-226 Ra-222, Rn- 218, Po-214
Th- 228Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl- 208 (0.36), Po-212(0.64)
Th-229 Ra- 225, Ac-225, F-221, At- 217, Bi- 213, Po- 213, Pb- 209
Th- nat Ra- 228, Ac- 228, Th-228, Ra- 224, Rn- 220, Po-216, Pb-212, Bi- 212, Tl-
208(0.36), PO- 212(0.64), Pa-234m
Th- 234 Pa-234m
U- 230 Th- 226, Ra-222, Rn-218, Po-214
U- 232 Th-228, Ra-224, Rn-220, Po- 212, Bi- 212, Tl- 208 (0.36, Po-212(0.64)
U- 235 Th-231,
U- 238 Th- 234, Pa- 234m,
U- nat Th-234, Pa- 234m, U- 234, Th- 230, Ra- 226, Rn-222, Po-218, Pb-214, Bi-
214, Pb-210, Bi-210, Po-210
U- 240 Np- 240m
Np- 237 Pa- 233
Am- 242m Am- 242
Am- 243 Np- 239

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