

GUIDANCE ON CALCULATING SOURCE CATEGORY FOR SEALED RADIOACTIVE SOURCES

INTRODUCTION

This guidance is to help you calculate the source categories of your sealed radioactive sources. It has been written for those who need to be authorised under the *Environmental Authorisations (Scotland) Regulations 2018* (EASR) and for those who have a sealed source permit with a standard condition limiting source holdings by source category. This guidance does not cover calculations on security group of sealed sources.

DEFINITIONS

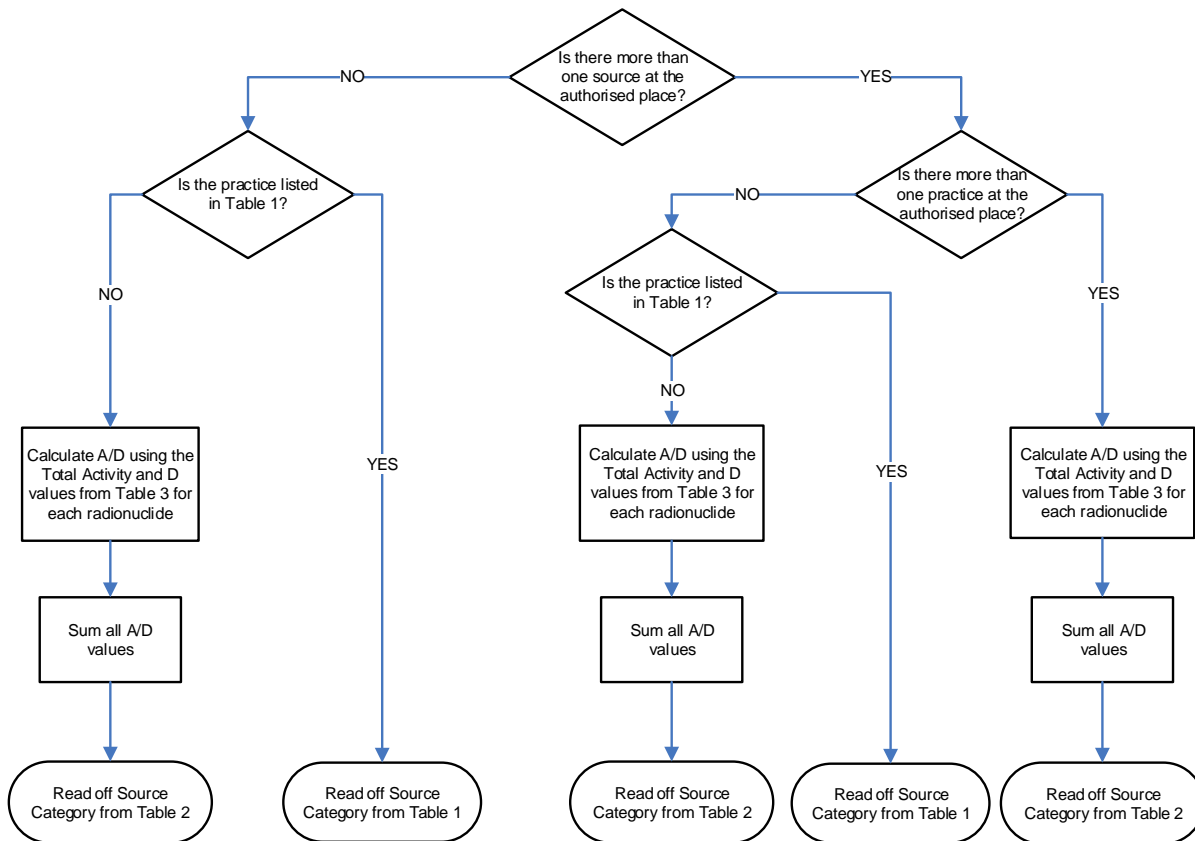
A “sealed source” means a radioactive source in which the radioactive substance is permanently sealed in a capsule or incorporated in a solid form with the objective of preventing, under normal conditions of use, any dispersion of radioactive substances.

The “source category” is based on the International Atomic Energy Agency (IAEA) category system. The IAEA has published a safety guide (Safety Guide RS-G-1.9) detailing a risk based ranking of sealed radioactive sources and practices. The category system is divided into five categories with category 1 carrying the highest risk and category 5 carrying the lowest risk.

The “authorised place” means the place you may carry on the authorised activity as specified in your authorisation.

HOW TO DETERMINE SOURCE CATEGORY

Step 1 is to read off from a list of practices that specify the source category. If your practice is not listed or if you have more than 1 practice at your authorised place then you must continue to step 2 to calculate the A/D value. You must carry out step 1 before going to step 2. You may use this flow chart to assist you.



Step 1

This step uses categories listed in the International Atomic Energy Agency (IAEA) safety guide RS-G-1.9 Categorization of Radioactive Sources. It should be used only if you have one practice at your authorised place, which is listed in Table 1. If you have more than one practice or if your practice is not listed then you must go to step 2.

Table 1: Radioactive Source Categories by practice

Source Category	Practice
1	Medical Teletherapy, including multi-beam (Gamma knife) but excluding Strontium-90 eye plaques (which should be categorised using A/D)
	Irradiators, including sterilisation, preservation of materials and products, blood/tissue and self-shielded
2	Industrial Radiography
	Brachytherapy – high/medium dose rate using:
	Cobalt-60 > 110 GBq
	Caesium-137 > 190 GBq Iridium-192 > 110 GBq
3 and 4	Gauges: level, density, thickness, moisture, spinning pipe. This does NOT include the following (which should be categorised using A/D): <ul style="list-style-type: none"> • Any sources used in calibration or well logging • Crop yield meters on combine harvesters containing Americium-241 • Level gauges for fire extinguishers containing Caesium-137 • Fisher Betascopes containing Promethium-147 or Strontium-90 • Krypton-85 sources of any description
	Bone densitometry
	Brachytherapy – Low dose rate Cobalt-60 ≤ 110 GBq Caesium-137 ≤ 190 GBq Iridium-192 ≤ 110 GBq
5	Any practice with A/D < 0.01 (excluding the above)

Step 2

You must use this step if your practice is not listed in table 1 or if you have more than 1 practice at the authorised place. Using the total activity of the radionuclide (A) in Giga Becquerels (GBq) and the D value in GBq (from table 3 in Appendix 1) calculate A/D and then read off the source category from table 2 below. If you have more than one radionuclide you must calculate the A/D for each radionuclide and then sum together before reading off the source category.

Table 2 – Radioactive Source category by A/D calculation

A/D	Source Category
$A/D \geq 1000$	1
$10 \leq A/D < 1000$	2
$1 \leq A/D < 10$	3
$0.01 \leq A/D < 1$	4
$A/D < 0.01$	5

Example 1

A farmer has a crop yield meter on a combine harvester with Am-241 35 MBq source. The source category is determined as follows:

- 1) There is 1 source at the authorised place.
- 2) The practice is not listed in table 1 therefore you need to use the A/D calculation.
- 3) The total activity (A) of the source is 35 MBq and from table 3 the D value of Am-241 is 60 GBq. Therefore A/D (GBq) is $0.035/60 = 0.00058$.
- 4) From table 2 the source category is category 5.

Example 2

A hospital has 2 x Ir-192 sources used for brachytherapy. The sources are 90 GBq. The source category is determined as follows:

- 1) There are 2 source and 1 practice at the authorised place.
- 2) The practice is listed in table 1 where Ir-192 sources are less than 110 GBq.
- 3) Therefore from table 1 the source category is 3 and 4.

Example 3

A person manages 30 Am-241 sources and 5 Cs-137 sources for oil well logging. The activity of each of the Am-241 source is 55.5 GBq and the activity of each of the Cs-137 sources is 65 GBq. The source category is determined as follows:

- 1) There is more than 1 source at the authorised place.

- 2) Well logging is not included as a practice in table 1 therefore you need to use the A/D calculation.
- 3) The total activity (A) of the Am-241 sources is $30 \times 55.5 = 1665$ GBq and the total activity (A) of the Cs-137 sources is $5 \times 65 = 325$ GBq.
- 4) The D value of Am-241 is 60 GBq and the D value of Cs-137 is 100 GBq taken from Table 3.
- 5) A/D for Am-241 is $1665 / 60 = 27.75$ and the A/D for Cs-137 is $325 / 100 = 3.25$
- 6) Sum the A/D values $27.75 + 3.25 = 31$.
- 7) From table 2 the source category is category 2.

Example 4

A hospital uses a blood irradiator. The source category is determined as follows:

- 1) There is only 1 source at the authorised place.
- 2) The practice is listed in table 1.
- 3) From table 1 the source category is category 1.

APPENDIX 1 – D VALUES

Table 3 - IAEA safety guide RS-G-1.9 Categorization of Radioactive Sources

Radionuclide	Symbol	'D' Value GBq	Radionuclide	Symbol	'D' Value GBq
Americium 241	Am-241	60	Americium 243	Am-243	200
Antimony 124	Sb-124	40	Antimony 125	Sb-125	200
Argon 41	Ar-41	50	Arsenic 76	As-76	200
Astatine 211	At-211	500	Barium 133	Ba-133	200
Barium 137m	Ba-137m	10 000	Beryllium 7	Be-7	1 000
Bismuth 210	Bi-210	8 000	Bromine 76	Br-76	30
Bromine 77	Br-77	200	Bromine 82	Br-82	30
Cadmium 109	Cd-109	20 000	Caesium 134	Cs-134	40
Caesium 135	Cs-135	Unlimited	Caesium 137	Cs-137	100
Calcium 41	Ca-41	Unlimited	Calcium 45	Ca-45	100 000
Californium 252	Cf-252	20	Carbon 11	C-11	60
Carbon 14	C-14	50 000	Cerium 141	Ce-141	1 000
Cerium 144	Ce-144	900	Chlorine 36	Cl-36	20 000
Chromium 51	Cr-51	2 000	Cobalt 55	Co-55	30
Cobalt 56	Co-56	20	Cobalt 57	Co-57	700
Cobalt 58	Co-58	70	Cobalt 60	Co-60	30
Copper 61	Cu-61	10 000	Copper 64	Cu-64	300
Copper 67	Cu-67	700	Curium 242	Cm-242	40
Curium 243	Cm-243	200	Curium 244	Cm-244	50
Erbium 171	Er-171	200	Europium 152	Eu-152	60
Europium 154	Eu-154	60	Fluorine 18	F-18	60
Gadolinium 148	Gd-148	400	Gadolinium 153	Gd-153	1 000
Gallium 67	Ga-67	500	Gallium 68	Ga-68	70
Germanium 68	Ge-68	70	Gold 198	Au-198	200
Holmium 166	Ho-166	2 000	Indium 111	In-111	200

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Radionuclide	Symbol	'D' Value GBq	Radionuclide	Symbol	'D' Value GBq
Indium 113m	In-113m	300	Iodine 120	I-120	10 000
Iodine 123	I-123	500	Iodine 124	I-124	60
Iodine 125	I-125	200	Iodine 129	I-129	Unlimited
Iodine 131	I-131	200	Iridium 192	Ir-192	80
Iron 52	Fe-52	20	Iron 55	Fe-55	800 000
Iron 59	Fe-59	60	Krypton 79	Kr-79	1 000
Krypton 81	Kr-81	30 000	Krypton 85	Kr-85	30 000
Lanthanum 140	La-140	30	Lead 210	Pb-210	300
Manganese 52	Mn-52	20	Manganese 54	Mn-54	80
Manganese 56	Mn-56	40	Mercury 203	Hg-203	300
Molybdenum 99	Mo-99	300	Neptunium 237	Np-237	70
Nickel 59	Ni-59	1 000 000	Nickel 63	Ni-63	60 000
Nitrogen 13	N-13	60	Oxygen 15	O-15	60
Palladium 103	Pd-103	90 000	Phosphorus 32	P-32	10 000
Phosphorus 33	P-33	200 000	Plutonium 238	Pu-238	60
Plutonium 239	Pu-239	60	Plutonium 240	Pu-240	60
Plutonium 241	Pu-241	3 000	Plutonium 242	Pu-242	70
Polonium 210	Po-210	60			
Potassium 40	K-40	Unlimited	Potassium 42	K-42	200
Protactinium 231	Pa-231	60	Promethium 147	Pm-147	40 000
Radium 224	Ra-224	50	Radium 226	Ra-226	40
Radium 228	Ra-228	30	Rhenium 186	Re-186	4 000
Rhenium 188	Re-188	1 000	Rubidium 81	Rb-81	100
Rubidium 81m	Rb-81m	10 000	Rubidium 82	Rb-82	10 000
Rubidium 82m	Rb-82m	10 000	Rubidium 84	Rb-84	70
Rubidium 86	Rb-86	700	Ruthenium 103	Ru-103	100
Ruthenium 106	Ru-106	300	Samarium 151	Sm-151	500 000

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Radionuclide	Symbol	'D' Value GBq	Radionuclide	Symbol	'D' Value GBq
Samarium 153	Sm-153	2 000	Scandium 46	Sc-46	30
Scandium 47	Sc-47	700	Selenium 75	Se-75	200
Silver 110m	Ag-110m	20	Sodium 22	Na-22	30
Sodium 24	Na-24	20	Strontium 83	Sr-83	1 000
Strontium 85	Sr-85	100	Strontium 89	Sr-89	20 000
Strontium 90	Sr-90	1 000	Sulphur 35	S-35	60 000
Tantalum 182	Ta-182	60	Technetium 94	Tc-94	1 000
Technetium 99m	Tc-99m	700	Thallium 201	Tl-201	1 000
Thallium 204	Tl-204	20 000	Thorium natural	Th-nat	Unlimited
Thorium 228	Th-228	40	Thorium 229	Th-229	10
Thorium 230	Th-230	70	Thorium 232	Th-232	Unlimited
Thulium 170	Tm-170	20 000	Tin 113	Sn-113	300
Tin 117m	Sn-117m	500	Tin 119	Sn-119	100
Tin 121	Sn-121	20 000	Tin 121m	Sn-121m	70 000
Tin 125	Sn-125	100	Tritium	H-3	2 000 000
Uranium depleted	U Dep DU	Unlimited	Uranium natural	U Nat	Unlimited
Vanadium 48	V-48	20	Xenon 133	Xe-133	3 000
Ytterbium 169	Yb-169	300	Ytterbium 175	Yb-175	2 000
Yttrium 86	Y-86	1 000	Yttrium 88	Y-88	30
Yttrium 90	Y-90	5 000	Zinc 62	Zn-62	1 000
Zinc 65	Zn-65	100	Zirconium 89	Zr-89	1 000
Zirconium 95	Zr-95	40			