IAEA-TECDOC-1344

Categorization of radioactive sources

Revision of IAEA-TECDOC-1191, Categorization of radiation sources

INTERNATIONAL ATOMIC ENERGY AGENCY

July 2003

The originating Section of this publication in the IAEA was:

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International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
A-1400 Vienna, Austria

CATEGORIZATION OF RADIOACTIVE SOURCES: REVISION OF IAEA-TECDOC-1191,
CATEGORIZATION OF RADIATION SOURCES
IAEA, VIENNA, 2003
IAEA-TECDOC-1344
ISBN 92–0–105903–5
ISSN 1011–4289

Printed by the IAEA in Austria
July 2003

FOREWORD

Radiation sources, utilizing either radioactive materials or radiation generators, are used throughout the world for a wide variety of peaceful purposes, in industry, medicine, research and education; they are also used for various military purposes. Many are in the form of sealed sources with the radioactive materials firmly contained or bound within a suitable capsule or housing. The risks posed by these sources and materials vary widely, depending on such factors as the radionuclide, the physical and chemical form, and the activity. Unless breached or leaking, sealed sources present a risk from external radiation exposure only. However, breached or leaking sealed sources, as well as unsealed radioactive materials, may lead to contamination of the environment and the intake of radioactive materials into the human body.

Until the 1950s, only radionuclides of natural origin, particularly ^{226}Ra, were generally available. Since then, radionuclides produced artificially in nuclear facilities and accelerators have become widely available, including ^{60}Co, ^{90}Sr, ^{137}Cs and ^{192}Ir. The risks associated with the use of radioactive materials must be restricted and protected against by the application of appropriate radiation safety standards.

Recognizing the need for a graded approach to the regulatory control of radiation sources, the IAEA's 'Action Plan on the Safety of Radiation Sources and Security of Radioactive Material' called for the development of a categorization. The resulting categorization system (IAEA-TECDOC-1191) assigned a limited range of practices to one of three categories.

Under the 'Revised Action Plan on the Safety and Security of Radiation Sources', the IAEA Secretariat reviewed how the categorization system was being used. It was found that the categorization system had a number of limitations, and therefore, a revised categorization system has been developed. This revised categorization of radioactive sources provides a numerical relative ranking of radioactive sources and practices, and assigns them into one of five categories. The system is based on a logical and transparent methodology that provides the flexibility for it to be applied to a wider range of uses than the original categorization. The present revised categorization of radioactive sources replaces IAEA-TECDOC-1191 and provides an internationally harmonized fundamental basis for decision makers.

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CONTENTS

1. INTRODUCTION

1.1. Background

Radioactive sources are used throughout the world for a wide variety of peaceful purposes in industry, medicine, agriculture, research and education; and they are also used in military applications. The International Basic Safety Standards [1] provide an internationally harmonized basis for ensuring the safe and secure use of sources of ionizing radiation. Because of the wide variety of uses and activities of radiation sources, a categorization system is necessary so that the controls that are applied to the sources are commensurate with the radiological risks.

In September 1998, following an assessment of the major findings of the first *International Conference on the Safety of Radiation Sources and the Security of Radioactive Materials*, held in Dijon, France, from 14 to 18 September 1998 (the Dijon Conference), the IAEA's General Conference (in resolution GC(42)/RES/12), inter alia, encouraged all governments "*to take steps to ensure the existence within their territories of effective national systems of control for ensuring the safety of radiation sources and the security of radioactive materials*" and requested the Secretariat "*to prepare for the consideration of the Board of Governors a report on: (i) how national systems for ensuring the safety of radiation sources and the security of radioactive materials can be operated at a high level of effectiveness; and, (ii) whether international undertakings concerned with the effective operation of such systems and attracting broad adherence could be formulated*".

In February 1999, the Secretariat submitted to the IAEA Board of Governors a report prepared in response to the request made of it by the General Conference. The Board took up the report at its March 1999 session and, inter alia, requested the Secretariat to prepare an action plan that took into account the conclusions and recommendations in the report, and the Board's discussion of the report.

In August 1999, the Secretariat circulated a proposed *Action Plan for the Safety of Radiation Sources and the Security of Radioactive Materials* (the Action Plan) in Attachment 2 to publication GOV/1999/46-GC(43)/10. In September 1999, the Board approved the *Action Plan* and requested the Secretariat to implement it. The subsequent General Conference endorsed the Board's decision and urged the Secretariat to implement the *Action Plan*.

The Action Plan covered seven major work areas, one of which identified the need for a system of source categorization. The resulting IAEA-TECDOC-1191 Categorization of Radiation Sources [2], was published in December 2000. Whilst IAEA-TECDOC-1191 provided a useful system for categorizing radioactive sources, according to radiological and other risks, it was limited in its scope of application.

Under the auspices of the Action Plan, the IAEA also organized an *International Conference of National Regulatory Authorities with Competence in the Safety of Radiation Sources and the Security of Radioactive Material*, which was held in Buenos Aires, Argentina, from 11 to 15 December 2000 (the Buenos Aires Conference). At its meetings in March 2001 the Board considered the report on the major findings of the Buenos Aires Conference (GOV/2001/3, 12 February 2001). It noted these major findings and requested the Secretariat to assess the implications of the major findings of the Buenos Aires Conference for the Action Plan for the Safety of Radiation Sources and the Security of Radioactive Materials, and to implement any adjustments to the *Action Plan* that may be necessary. The subsequent revised Action Plan on the Safety and Security of Radiation Sources (GOV/2001/29-GC(45)/12) noted the need to review how the categorization system was being used, and to consider revising it. The Secretariat also recognized that the new categorization system was crucial to other high-priority work initiatives being carried out by IAEA, such as the revised Code of Conduct on the Safety and Security of Radioactive Sources (in preparation) and guidance on the Security of Radioactive Sources [3]. The categorization system has, therefore been revised taking these factors into consideration and, in particular to extend both its scope and applicability.

1.2. Objective

The objective of this TECDOC is to provide a simple, logical system for ranking radioactive sources based on their potential to cause harm to human health and for grouping the practices in which these sources are used into discrete categories.

1.3. Purpose

The purpose of categorizing radioactive sources is to provide a fundamental and internationally harmonized basis for risk-informed decision making. It is envisaged that the categorization system will be used as an input to many activities relating to the safety and security of radioactive sources, including:

- Developing or refining (inter)national safety standards;
- Developing or refining national regulatory infrastructures to meet the circumstances of a State;
- Optimizing decisions about priorities for regulation within resource constraints;
- Optimizing security measures for radioactive sources, including potential malicious use;
- Emergency planning and response;
- Developing national strategies for improving control over radioactive sources;
- Other decision making.

This report replaces IAEA-TECDOC-1191, Categorization of Radiation Sources [2].

1.4. Scope

The present publication provides a categorization for radioactive sources, particularly those used in industry, medicine, agriculture, research and education. The principles of the categorization can be equally applied to radioactive sources, such as radioisotope thermoelectric generators (RTGs), that may be under military control.

This categorization is not relevant to radiation-generating devices such as X ray machines and particle accelerators, although it may be applied to radioactive sources produced by, or used as target material, in such devices. Nuclear materials, as defined in the Convention on the Physical Protection of Nuclear Materials [4], are excluded from the scope of the present report. In addition, in applications where factors other than those considered here are a dominant component, this categorization may not be appropriate. One example of this is in waste management and disposal options for disused sources, where such things as specific activity, chemical properties and half-life become important considerations [5].

While the categorization focuses on sealed sources, the methodology can also be used to categorize unsealed radioactive sources.

2. RATIONALE FOR THE CATEGORIZATION OF RADIOACTIVE SOURCES

2.1. Introduction and uses of the categorization

Radioactive sources are used in a wide range of practices in industry, medicine, agriculture, research and education, and they are also used in military and defense applications. Within this variety of practices there is a range of radionuclides, forms and quantities of radioactive material that need to be considered in the categorization system. High activity sources, if not managed safely or securely, can cause severe deterministic effects to individuals in a short period of time [6–11], whereas low activity sources are unlikely to cause such effects. The categorization system, therefore, provides a relative ranking and grouping of sources and practices, on which decisions can be based.

In developing the categorization system, the variety of ways in which it will be applied need to be considered, whilst recognizing that the system should not be dependent on, or tied to, any one of these applications. In general terms the categorization system will be relevant to decisions both in a retrospective sense to ensure that existing sources are brought, or are maintained under control, and in a prospective sense to ensure that future sources are appropriately regulated.

While the new categorization system was developed with the end purposes in mind, it is not dependent on them, nor tied to any one — thus enabling it to be applied[1] to many situations, including:

- *Regulatory measures*: To provide a logical and transparent basis for a graded system of notification, registration, licensing and inspections. The categorization also provides a basis for ensuring that the allocation of human and financial resources is commensurate with the category of source.

- *Security measures:* To provide a graded basis for assisting in the determination of security measures, recognizing that other factors are important (e.g. threats against specific facilities/sources).

- *National registry of sources:* To optimize decisions regarding which sources, and the level of detail, that could be included in a national registry of sources.

- *Import/export controls:* To optimize decisions regarding which sources may be subject to import and export controls.

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[1] Recognizing that the categorization may be used either as the fundamental basis for decision making, or as an input to the process if other factors need to be considered.

- *Labeling of high activity sources:* To optimize decisions regarding which sources may be marked with an appropriate label (additional to the trefoil) to warn persons of the radiation hazard.

- *Emergency preparedness and response:* To ensure that emergency preparedness plans and response to accidents are commensurate with the category of the source.

- *Prioritization for regaining control over orphan sources:* To optimize decisions relating to where efforts should be focused to regain control over orphan sources.

- *Communication with the public:* To provide a basis for explaining the relative hazard of events involving radioactive sources.

The categorization system will also act as a basis for decisions within the IAEA, relating to its internal work programmes and the provision of assistance to its Member States.

In summary, this categorization system is:

- Useful for a variety of purposes;

- Developed with its end uses in mind, but not dependent on them;

- Compatible with the previous categorization system [2];

- Logical, transparent and simple.

2.2. Basis for the categorization system

When radioactive sources are managed according to Standards in a safe and secure manner, the radiation risks to workers and the public are minimized. However, if sources are not managed appropriately, as in the case of accidents, malicious use, or orphan sources, they can cause a range of deterministic health effects resulting in acute radiation sickness, erythema, amputation of limbs, or death.

Recognizing that human health and safety is of paramount importance, the categorization system is, therefore, based on the potential for radioactive sources to cause deterministic health effects. This potential is comprised partly by the physical properties of the source and partly by the way in which the source is used. The actual practice in which the source is used, the provision of any inherent shielding provided by the device containing the source, portability, level of supervision and other judgmental criteria are taken into consideration, as described in Section 2.3.6.

Certain factors are specifically excluded from the categorization criteria:

- Socio-economic consequences resulting from radiological accidents or malicious acts are excluded, as the methodology to quantify and compare these effects, especially on an international basis, is not yet fully developed.

- The stochastic effects of radiation (e.g. increased risk of cancer) are excluded, as the deterministic effects resulting from an accident or malicious act are likely to overshadow any increased stochastic risk in the short term.

- The deliberate exposure of persons for medical reasons is excluded from the categorization criteria, although the radioactive sources used for these purposes are included in the categorization system as there are reports of accidents involving such sources [12–14].

2.3. Methodology and development of the categorization system

2.3.1. Collection of data

Data on radionuclides and activities used in a variety of practices were reviewed and updated [2] [15], [16], [17] [Appendix II]. For each practice (e.g. level gauge) and each radionuclide used within the practice, three activity levels are given — the maximum, minimum and typical (recognizing that there may be exceptions that are not included). These data are given in Columns I to V of Appendix II. In order to numerically rank the sources and practices, each activity (Column V) was divided by a normalizing factor.

2.3.2. Normalizing factor

Initial consideration was given to using the A_1 and A_2 values from the Transport Regulations [18] as normalizing factors to numerically rank the sources and practices in Appendix II. However, although the A_1 and A_2 are established values and could be used as a means of comparing risks from radionuclides during transport, there are certain factors (e.g. the artificial cut-off values for beta emitting radionuclides) that limit their application to other uses. As the categorization system is needed for a variety of purposes it was, therefore, considered inappropriate to use A_1 and A_2 values as the normalizing factors.

The IAEA has developed radionuclide-specific activity levels for the purposes of emergency planning and response [19]. These levels, hereafter referred to in this publication as the 'D' values, are given in terms of an activity above which a radioactive source is considered to be 'a dangerous source' [20] as it has a significant potential to cause severe deterministic effects if not managed safely and securely. Since the new categorization of sources is also based upon the potential for sources to cause deterministic health effects, the 'D' values were considered to be compatible normalizing factors for the purpose of generating a numerical relative ranking of sources and practices. A comprehensive list of radionuclide-specific 'D' values for both internal and external exposure is given in reference [19]. For the purposes of developing the categorization, the more restrictive of these values was used as the normalizing factor. These values, for the radionuclides specified in Appendix II, are given in Table I.2, Appendix I. (Note: Because Table I.2 does not show which dose criteria were used, these D-values should not be used in reverse to derive doses from sources of known activity.)

2.3.3. Relative ranking of sources and practices

For each practice and radionuclide used within the practice (Appendix II), the activity in TBq (Column V) was divided by the corresponding radionuclide-specific 'D' value in TBq (Column VI), to give the dimensionless normalized ratio of A/D (Column VII). The A/D ratios were plotted on a logarithmic graph, using the A/D ratio for the 'typical' activity as the main data points, and the A/D ratio for the maximum and minimum activities plotted as 'range bars'. This gives a normalized relative ranking of sources and practices, as shown in Appendix III.

2.3.4. Optimum number of categories

In order to fulfill the various needs of the categorization system, the relative ranking of sources/practices given in Appendix III needs to be divided into a number of discrete categories. The optimum number of categories and the A/D dividing lines between them required a certain degree of judgment based on professional expertise. The following factors were taken into consideration:

- Too few categories could lead to categories being split at a later date to meet national or other needs. This could lead to a loss of transparency of the categorization system, and a lack of international harmonization resulting in the potential for inconsistent approaches to the similar issues.

- Too many categories could imply a degree of precision that is not warranted and could be difficult to justify. Too many categories could, furthermore, lead to difficulties in its application and may discourage its use.

2.3.5. Category boundaries based on radionuclide and activity

As discussed in Section 2.3.2, the categorization system is based on the potential for sources to cause deterministic effects and uses the ‘D’ values as normalizing factors. This means that, in practice, sources with an activity greater than ‘D’ have the potential to cause severe deterministic effects (Appendix I). The activity ratio of A/D = 1 was, therefore, considered to be a logical category-dividing line, resulting in two categories. However, in order for the categorization system to meet the many and various uses described in Section 2.1, there clearly needs to be more than two categories. Furthermore, the large number and the diversity of applications above and below this line confirmed that further categories were needed.

In the development of the ‘D’ values it was recognized that a source activity ten times greater could give rise to a life threatening exposure in a relatively short period of time [20]. Hence a category dividing line was drawn at A/D=10. This, however, left some of the very high activity sources (e.g. RTGs) in the same category as sources with significantly lower activities (e.g. high dose rate brachytherapy (HDR)). It was therefore decided to use operational experience, professional judgement and lessons learned from accidents to separate these practices, which resulted in a further dividing line at A/D = 1000.

As there were a large range of practices and source activities below A/D = 1 a further category dividing line was needed. Operational experience, professional judgement and lessons learned from accidents were, therefore, used to draw dividing line at A/D = 0.01, with a lower cut-off for this category set at the activity of a radionuclide that is considered to be ‘exempt’ from regulatory control divided by the relevant ‘D’ value[a]. Radionuclide-specific exemption levels are given in Schedule 1 of the BSS [1].

Taking the above factors into consideration resulted in a five-category system, as shown by the boxes in Appendix III. The categorization was then refined, recognizing that factors other than activity may need to be considered.

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[a] Although low activity sources will not lead to severe deterministic effects, the ‘D’ values were used as normalizing factors for all sources to ensure consistency across all categories.

2.3.6. Refinement of the categorization system

Experience and judgment was further used to review the category allocated to each practice/radionuclide. The results indicated that, although the A/D ratios provide a robust and logical basis for the categorization, there are other risk factors that formed part of the approach used in IAEA-TECDOC-1191, which drew upon the consensus views of experienced practitioners in the field of radiation protection. Furthermore, where practicable, it was considered undesirable to have a particular practice spanning two categories, although in some cases it was necessary to split a generic practice (e.g. brachytherapy was split into high dose rate (HDR), low dose rate (LDR) and permanent implants). In other cases, such as calibration sources, it was not possible to assign them to a single category since their activity can range from low activity to over 100 TBq. Thus, in such situations, allocation of a category can be considered on a case-by-case basis by calculating the A/D ratio and then considering other factors if appropriate.

The category assigned to each practice/radionuclide was, therefore, reviewed taking into consideration factors such as the nature of the work, the mobility of the source, experience from reported accidents, and typical vs. unique activities within an application. For example, some low-activity RTGs could fall into Category 2 if only the activity were to be considered. However, since RTGs are likely to be in remote, unsupervised, locations and may contain large amounts of plutonium or strontium, all RTGs were allocated to Category 1. Likewise, all fixed level gauges were placed into Category 3, although the activity of a few ^{60}Co level gauges may range into Category 2 by virtue of activity alone. Because the typical range of activities for level gauges falls into Category 3 and access to the higher activity fixed gauges is generally low, the practice of ‘fixed level gauges’ was, therefore, allocated to Category 3. The final categorization of specific applications is given in Table 1, and a comparison of categories based solely on A/D to those assigned to practices can be seen in columns VIII and IX in Appendix II.

3. CATEGORIES

3.1. Categories assigned to practices

The categorization methodology described above was used to assign the practices given in Appendix II. to one of five categories. Category 1 sources are considered to pose a high risk to human health if not managed safely and securely, and Category 5 sources a low risk. A ‘plain language’ definition of the categories is given in Annex II.

Examples of categories assigned to some common practices are given in Table 1, and Appendices II and III show these in more detail.

3.2. Combining categories

The five-category system described above should fulfill all the expected uses of the categorization system described in Section 2.1 — recognizing that in some cases it may be beneficial to combine two or more categories. Subdividing the categories is, however, not recommended as this would lead to loss of international harmonization and an unwarranted impression of precision.

TABLE 1. Categorization table

Category	Categorization of common practices[a]	Activity ratio[b] (A/D)
1	Radioisotope thermoelectric generators (RTGs) Irradiators Teletherapy Fixed, multi-beam teletherapy (gamma knife)	$A/D \geq 1000$
2	Industrial gamma radiography High/medium dose rate brachytherapy	$1000>A/D \geq 10$
3	Fixed industrial gauges -level gauges -dredger gauges -conveyor gauges containing high activity sources -spinning pipe gauges Well logging gauges	$10>A/D \geq 1$
4	Low dose rate brachytherapy (except eye plaques and permanent implant sources) Thickness/fill-level gauges Portable gauges (e.g. moisture/density gauges) Bone densitometers Static eliminators	$1>A/D \geq 0.01$
5	Low dose rate brachytherapy eye plaques and permanent implant sources X ray fluorescence devices Electron capture devices Mossbauer spectrometry Positron Emission Tomography (PET) checking	$0.01>A/D \geq$ Exempt[c]/D

[a] Recognizing that factors other than A/D have been taken into consideration (Section 2.3.6).

[b] This column can be used to determine the category of a source, based purely on A/D. This may be appropriate if, for example: the practice is not known or is not listed; sources have a short half-life and/or are unsealed; or sources are aggregated (See Section 3.3).

[c] Exempt quantities are given in Schedule I of the BSS [1].

3.3. Categories based on A/D

3.3.1. Practice not known or not listed

For practices not known or listed in Table 1, the category of a source can be determined by dividing the activity of the radionuclide by the appropriate ‘D’ value given in Appendix I, Table I.2 This gives a normalized A/D ratio that can be compared to the A/D ratios in the right-hand column of Table 1 and a category assigned based on activity (recognizing that other factors may need to be taken into consideration).

This ability to apply the categorization system to non-listed practices/sources will be especially useful for emerging technologies.

3.3.2. Short half-life and unsealed sources

In developing the categorization system it was recognized that some practices, such as nuclear medicine, use radionuclides with a short half-life that may also be unsealed. Examples of such applications include ^{99m}Tc in diagnosis and ^{131}I in therapy. In these situations, the principles of the categorization system can still be applied to determine a category for the source, but a judgmental decision will be needed in choosing the activity on which to calculate the A/D ratio. It is, therefore, suggested that these situations are considered on a case-by-case basis.

3.3.3. Aggregation of sources

If a practice involves the aggregation of sources into a single storage or use location where sources are in close proximity, such as in storage facilities, manufacturing processes, or transport conveyance, the total activity can be treated as one source for the purposes of assigning a category. Therefore, the summed activity of the radionuclide can be divided by the appropriate D value, and the calculated A/D ratio compared to the A/D ratios given in the right-hand column of Table 1, thus allowing a category, based on activity, to be allocated to the practice. If sources with several radionuclides are aggregated, then the sum of the A/D ratios can be used to determine the category in accordance with the formula:

$$\text{Aggregate A/D} = \sum_n \frac{\sum_i A_{i,n}}{D_n}$$

where:

$A_{i,n}$ = activity of each individual source *i* of radionuclide *n*.
D_n = D value for radionuclide *n*.

In each case it should be recognized that other factors may need to be taken into consideration in assigning a category. Furthermore, when considering the accumulation of sources it is important to recognize that the practice may change, e.g. the ‘manufacture’ of a level gauge is a different practice from the ‘use’ of such a gauge.

4. CONCLUSIONS

The new categorization system provides a fundamental and internationally harmonized basis for risk-informed decision making, by providing a relative ranking and grouping of sources and practices, which is based on a logical and transparent methodology.

Taking the expected uses of the categorization into consideration, a system composed of five categories is considered to provide the optimum grouping, giving the flexibility to use the categories as they stand or to combine them if needed.

Appendix I

THE D-VALUE

This appendix outlines the 'dangerous' source concept and the origins of the 'D' value that was used in the development of the categorization system. It is a brief summary only, and Refs. [19] and [20] should be consulted for a more detailed explanation.

A dangerous source is defined [20] as: "A source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects."

A deterministic effect is defined [20] as: A health effect of radiation for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose. Such an effect is described as a 'severe deterministic effect' if it is fatal or life threatening or results in a permanent injury that decreases the quality of life.

The concept of a 'dangerous' source has been converted into operational parameters by calculating the quantity of radioactive material that could lead to severe deterministic effects for given exposure scenarios and for given dose criteria [19].

In addition to typical accident situations, these scenarios included dispersion situations that may be applicable to malevolent acts. The following exposure scenarios (pathways) were considered:

- an unshielded source being carried in the hand for one hour, in a pocket for 10 hours, or by being in a room for days to weeks.
- dispersal of a source, for example by fire, explosion or human action, resulting in a dose from inhalation, ingestion and/or skin contamination.

The derivation of the dangerous source values refers to the following dose criteria:

(1) **1 Gy to the bone marrow or 6 Gy to the lung from low LET radiation, received by the organ in 2 days**. These are the dose levels from Table IV-I of the BSS [1] at which intervention is always justified in order to prevent early deaths [21], [22]. It should be noted that these are limiting criteria associated with the lowest dose rates that are considered as life threatening [19].

(2) **25 Gy to the lung from inhaled high LET radiation in 1 year.** This is the dose level which induces fatalities to beagle dogs due to radiation pneumonitis and pulmonary fibrosis within 1.5 years [23].

(3) **5 Gy to the thyroid received by the organ in 2 days.** This is the dose level from Table IV-I of Schedule IV of the BSS [1] at which intervention is always justified to prevent hypothyroidism. Hypothyroidism is assumed to decrease the quality of life.

(4) **For a source in contact with tissue, a dose of more than 25 Gy at a depth of: (a) 2 cm for most parts of the body (e.g., from a source in a pocket) or (b) 1 cm for the hand.** Twenty five (25) Gy is the threshold for necrosis (death of tissue) [22], [24]. Experience [25] indicates that tissue death in many parts of the body (e.g. in the thigh) from carrying a source in a pocket can be successfully treated without resulting in a

decrease in quality of life if the absorbed dose to tissue within about 2 cm of a source is kept below 25 Gy. However, for a source carried in the hand, the absorbed dose to within about 1 cm must be kept below 25 Gy in order to prevent an injury that decreases the quality of life.

(5) **For a source that is considered to be too big to be carried, 1 Gy to the bone marrow in 100 hours from a source in a room at a distance of 1 meter.**

Table I.1. Reference doses for D-values

Tissue	Dose criteria
Bone marrow	1 Gy in 2 days
Lung	6 Gy in 2 days from low LET radiation 25 Gy in 1 year from high LET radiation
Thyroid	5 Gy in 2 days
Skin/tissue (contact)	25 Gy at depth of 2 cm for most parts of the body (e.g., from a source in a pocket) or 1 cm for the hand for a period of 10 hours
Bone marrow	1 Gy in 100 hours for a source that is too big to be carried

Table I.2. Activity[a] corresponding to a 'dangerous' source (D-value[b]) for selected radionuclides and useful multiples thereof

Radionuclide	1000 x D		10 x D		D		0.01 x D	
	(TBq)	(Ci)[c]	(TBq)	(Ci)[c]	(TBq)	(Ci)[c]	(TBq)	(Ci)[c]
Am-241	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Am-241/Be	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Au-198	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
Cd-109	2.E+04	5.E+05	2.E+02	5.E+03	2.E+01	5.E+02	2.E-01	5.E+00
Cf-252	2.E+01	5.E+02	2.E-01	5.E-00	2.E-02	5.E-01	2.E-04	5.E-03
Cm-244	5.E+01	1.E+03	5.E-01	1.E+01	5.E-02	1.E+00	5.E-04	1.E-02
Co-57	7.E+02	2.E+04	7.E+00	2.E+02	7.E-01	2.E+01	7.E-03	2.E-01
Co-60	3.E+01	8.E+02	3.E-01	8.E+00	3.E-02	8.E-01	3.E-04	8.E-03
Cs-137	1.E+02	3.E+03	1.E+00	3.E+01	1.E-01	3.E+00	1.E-03	3.E-02
Fe-55	8.E+05	2.E+07	8.E+03	2.E+05	8.E+02	2.E+04	8.E+00	2.E+02
Gd-153	1.E+03	3.E+04	1.E+01	3.E+02	1.E+00	3.E+01	1.E-02	3.E-01
Ge-68	7.E+02	2.E+04	7.E+00	2.E+02	7.E-01	2.E+01	7.E-03	2.E-01
H-3	2.E+06	5.E+07	2.E+04	5.E+05	2.E+03	5.E+04	2.E+01	5.E+02
I-125	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
I-131	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
Ir-192	8.E+01	2.E+03	8.E-01	2.E+01	8.E-02	2.E+00	8.E-04	2.E-02
Kr-85	3.E+04	8.E+05	3.E+02	8.E+03	3.E+01	8.E+02	3.E-01	8.E+00

Radionuclide	1000 x D		10 x D		D		0.01 x D	
	(TBq)	(Ci)[c]	(TBq)	(Ci)[c]	(TBq)	(Ci)[c]	(TBq)	(Ci)[c]
Mo-99	3.E+02	8.E+03	3.E+00	8.E+01	3.E-01	8.E+00	3.E-03	8.E-02
Ni-63	6.E+04	2.E+06	6.E+02	2.E+04	6.E+01	2.E+03	6.E-01	2.E+01
P-32	1.E+04	3.E+05	1.E+02	3.E+03	1.E+01	3.E+02	1.E-01	3.E+00
Pd-103	9.E+04	2.E+06	9.E+02	2.E+04	9.E+01	2.E+03	9.E-01	2.E+01
Pm-147	4.E+04	1.E+06	4.E+02	1.E+04	4.E+01	1.E+03	4.E-01	1.E+01
Po-210	6.E+02	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Pu-238	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Pu-239[d]/Be	6.E+01	2.E+03	6.E-01	2.E+01	6.E-02	2.E+00	6.E-04	2.E-02
Ra-226	4.E+01	1.E+03	4.E-01	1.E+01	4.E-02	1.E+00	4.E-04	1.E-02
Ru-106(Rh-106)	3.E+02	8.E+03	3.E+00	8.E+01	3.E-01	8.E+00	3.E-03	8.E-02
Se-75	2.E+02	5.E+03	2.E+00	5.E+01	2.E-01	5.E+00	2.E-03	5.E-02
Sr-90(Y-90)	1.E+03	3.E+04	1.E+01	3.E+02	1.E+00	3.E+01	1.E-02	3.E-01
Tc-99^m	7.E+02	2.E+04	7.E+00	2.E+02	7.E-01	2.E+01	7.E-03	2.E-01
Tl-204	2.E+04	5.E+05	2.E+01	5.E+03	2.E+01	5.E+02	2.E-01	5.E+00
Tm-170	2.E+04	5.E+05	2.E+02	5.E+03	2.E+01	5.E+02	2.E-01	5.E+00
Yb-169	3.E+02	8.E+03	3.E+00	8.E+01	3.E-01	8.E+00	3.E-03	8.E-02

[a] Because Table I.2 does not show which dose criteria were used, these D-values should not be used in reverse to derive doses from sources of known activity.

[b] Full details of the derivation of the D-values, and D-values for additional radionuclides are given in reference [19].

[c] The primary values to be used are given in TBq. Curie values are provided for practical usefulness and are rounded after conversion.

[d] Criticality and safeguard issues will need to be considered for multiples of D.

Appendix II

SOME PRACTICES AND RADIONUCLIDES OF INTEREST AND THEIR RANGE OF ACTIVITIES AND CATEGORIES

I	II	III	IV	V	VI	VII	VIII	IX
Practice	**Radionuclide**		**Quantity in use (A)**		**D-value**	**Ratio of A/D**	**Category**	
			Ci	**TBq**	**TBq**		**A/D based**	**Assigned**
			Category 1					
Radioisotopic thermoelectric generators (RTGs)	Sr-90	Max	6.8E+05	2.5E+04	1.0E+00	2.5E+04	1	1
	Sr-90	Min	9.0E+03	3.3E+02	1.0E+00	3.3E+02	2	
	Sr-90	Typ	2.0E+04	7.4E+02	1.0E+00	7.4E+02	2	
	Pu-238	Max	2.8E+02	1.0E+01	6.E-02	1.7E+02	2	1
	Pu-238	Min	2.8E+01	1.0E+00	6.E-02	1.7E+01	2	
	Pu-238	Typ	2.8E+02	1.0E+01	6.E-02	1.7E+02	2	
Irradiators: sterilization and food preservation	Co-60	Max	1.5E+07	5.6E+05	3.E-02	1.9E+07	1	1
	Co-60	Min	5.0E+03	1.9E+02	3.E-02	6.2E+03	1	
	Co-60	Typ	4.0E+06	1.5E+05	3.E-02	4.9E+06	1	
	Cs-137	Max	5.0E+06	1.9E+05	1.E-01	1.9E+06	1	1
	Cs-137	Min	5.0E+03	1.9E+02	1.E-01	1.9E+03	1	
	Cs-137	Typ	3.0E+06	1.1E+05	1.E-01	1.1E+06	1	
Irradiators: self-shielded	Cs-137	Max	4.2E+04	1.6E+03	1.E-01	1.6E+04	1	1
	Cs-137	Min	2.5E+03	9.3E+01	1.E-01	9.3E+02	2	
	Cs-137	Typ	1.5E+04	5.6E+02	1.E-01	5.6E+03	1	
	Co-60	Max	5.0E+04	1.9E+03	3.E-02	6.2E+04	1	1
	Co-60	Min	1.5E+03	5.6E+01	3.E-02	1.9E+03	1	
	Co-60	Typ	2.5E+04	9.3E+02	3.E-02	3.1E+04	1	
Irradiators: blood/tissue	Cs-137	Max	1.2E+04	4.4E+02	1.E-01	4.4E+03	1	1
	Cs-137	Min	1.0E+03	3.7E+01	1.E-01	3.7E+02	2	
	Cs-137	Typ	7.0E+03	2.6E+02	1.E-01	2.6E+03	1	
	Co-60	Max	3.0E+03	1.1E+02	3.E-02	3.7E+03	1	1
	Co-60	Min	1.5E+03	5.6E+01	3.E-02	1.9E+03	1	
	Co-60	Typ	2.4E+03	8.9E+01	3.E-02	3.0E+03	1	
Multi-beam teletherapy (gamma knife)	Co-60	Max	1.0E+04	3.7E+02	3.E-02	1.2E+04	1	1
	Co-60	Min	4.0E+03	1.5E+02	3.E-02	4.9E+03	1	
	Co-60	Typ	7.0E+03	2.6E+02	3.E-02	8.6E+03	1	
Teletherapy	Co-60	Max	1.5E+04	5.6E+02	3.E-02	1.9E+04	1	1
	Co-60	Min	1.0E+03	3.7E+01	3.E-02	1.2E+03	1	
	Co-60	Typ	4.0E+03	1.5E+02	3.E-02	4.9E+03	1	
	Cs-137	Max	1.5E+03	5.6E+01	1.E-01	5.6E+02	2	1
	Cs-137	Min	5.0E+02	1.9E+01	1.E-01	1.9E+02	2	
	Cs-137	Typ	5.0E+02	1.9E+01	1.E-01	1.9E+02	2	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	**Radionuclide**		**Quantity in use (A)**		**D-value**	**Ratio of A/D**	**Category**	
			Ci	**TBq**	**TBq**		**A/D based**	**Assigned**
				Category 2				
Industrial radiography	Co-60	Max	2.0E+02	7.4E+00	3.E-02	2.5E+02	2	2
	Co-60	Min	1.1E+01	4.1E-01	3.E-02	1.4E+01	2	
	Co-60	Typ	6.0E+01	2.2E+00	3.E-02	7.4E+01	2	
	Ir-192	Max	2.0E+02	7.4E+00	8.E-02	9.3E+01	2	2
	Ir-192	Min	5.0E+00	1.9E-01	8.E-02	2.3E+00	3	
	Ir-192	Typ	1.0E+02	3.7E+00	8.E-02	4.6E+01	2	
	Se-75	Max	8.0E+01	3.0E+00	2.E-01	1.5E+01	2	2
	Se-75	Min	8.0E+01	3.0E+00	2.E-01	1.5E+01	2	
	Se-75	Typ	8.0E+01	3.0E+00	2.E-01	1.5E+01	2	
	Yb-169	Max	1.0E+01	3.7E-01	3.E-01	1.2E+00	3	2
	Yb-169	Min	2.5E+00	9.3E-02	3.E-01	3.1E-01	4	
	Yb-169	Typ	5.0E+00	1.9E-01	3.E-01	6.2E-01	4	
	Tm-170	Max	2.0E+02	7.4E+00	2.E+01	3.7E-01	4	2
	Tm-170	Min	2.0E+01	7.4E-01	2.E+01	3.7E-02	4	
	Tm-170	Typ	1.5E+02	5.6E+00	2.E+01	2.8E-01	4	
Brachytherapy - high/medium dose rate	Co-60	Max	2.0E+01	7.4E-01	3.E-02	2.5E+01	2	2
	Co-60	Min	5.0E+00	1.9E-01	3.E-02	6.2E+00	3	
	Co-60	Typ	1.0E+01	3.7E-01	3.E-02	1.2E+01	2	
	Cs-137	Max	8.0E+00	3.0E-01	1.E-01	3.0E+00	3	2
	Cs-137	Min	3.0E+00	1.1E-01	1.E-01	1.1E+00	3	
	Cs-137	Typ	3.0E+00	1.1E-01	1.E-01	1.1E+00	3	
	Ir-192	Max	1.2E+01	4.4E-01	8.E-02	5.6E+00	3	2
	Ir-192	Min	3.0E+00	1.1E-01	8.E-02	1.4E+00	3	
	Ir-192	Typ	6.0E+00	2.2E-01	8.E-02	2.8E+00	3	
Calibration facilities	Co-60	Max	3.3E+01	1.2E+00	3.E-02	4.1E+01	2	Not assigned
	Co-60	Min	5.5E-01	2.0E-02	3.E-02	6.8E-01	4	
	Co-60	Typ	2.0E+01	7.4E-01	3.E-02	2.5E+01	2	
	Cs-137	Max	3.0E+03	1.1E+02	1.E-01	1.1E+03	1	Not assigned
	Cs-137	Min	1.5E+00	5.6E-02	1.E-01	5.6E-01	4	
	Cs-137	Typ	6.0E+01	2.2E+00	1.E-01	2.2E+01	2	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
Category 3								
Level gauges	Cs-137	Max	5.0E+00	1.9E-01	1.E-01	1.9E+00	3	3
	Cs-137	Min	1.0E+00	3.7E-02	1.E-01	3.7E-01	4	
	Cs-137	Typ	5.0E+00	1.9E-01	1.E-01	1.9E+00	3	
	Co-60	Max	1.0E+01	3.7E-01	3.E-02	1.2E+01	2	3
	Co-60	Min	1.0E-01	3.7E-03	3.E-02	1.2E-01	4	
	Co-60	Typ	5.0E+00	1.9E-01	3.E-02	6.2E+00	3	
Calibration facilities	Am-241	Max	2.0E+01	7.4E-01	6.E-02	1.2E+01	2	Not assigned
	Am-241	Min	5.0E+00	1.9E-01	6.E-02	3.1E+00	3	
	Am-241	Typ	1.0E+01	3.7E-01	6.E-02	6.2E+00	3	
Conveyor gauges	Cs-137	Max	4.0E+01	1.5E+00	1.E-01	1.5E+01	2	3
	Cs-137	Min	1.0E-01	3.7E-03	1.E-01	3.7E-02	4	
	Cs-137	Typ	3.0E+00	1.1E-01	1.E-01	1.1E+00	3	
	Cf-252	Max	3.7E-02	1.4E-03	2.E-02	6.8E-02	4	3
	Cf-252	Min	3.7E-02	1.4E-03	2.E-02	6.8E-02	4	
	Cf-252	Typ	3.7E-02	1.4E-03	2.E-02	6.8E-02	4	
Blast furnace gauges	Co-60	Max	2.0E+00	7.4E-02	3.E-02	2.5E+00	3	3
	Co-60	Min	1.0E+00	3.7E-02	3.E-02	1.2E+00	3	
	Co-60	Typ	1.0E+00	3.7E-02	3.E-02	1.2E+00	3	
Dredger gauges	Co-60	Max	2.6E+00	9.6E-02	3.E-02	3.2E+00	3	3
	Co-60	Min	2.5E-01	9.3E-03	3.E-02	3.1E-01	4	
	Co-60	Typ	7.5E-01	2.8E-02	3.E-02	9.3E-01	4	
	Cs-137	Max	1.0E+01	3.7E-01	1.E-01	3.7E+00	3	3
	Cs-137	Min	2.0E-01	7.4E-03	1.E-01	7.4E-02	4	
	Cs-137	Typ	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
Spinning pipe gauges	Cs-137	Max	5.0E+00	1.9E-01	1.E-01	1.9E+00	3	3
	Cs-137	Min	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
	Cs-137	Typ	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
Research reactor startup sources	Am-241/Be	Max	5.0E+00	1.9E-01	6.E-02	3.1E+00	3	Not assigned
	Am-241/Be	Min	2.0E+00	7.4E-02	6.E-02	1.2E+00	3	
	Am-241/Be	Typ	2.0E+00	7.4E-02	6.E-02	1.2E+00	3	
Well logging	Am-241/Be	Max	2.3E+01	8.5E-01	6.E-02	1.4E+01	2	3
	Am-241/Be	Min	5.0E-01	1.9E-02	6.E-02	3.1E-01	4	
	Am-241/Be	Typ	2.0E+01	7.4E-01	6.E-02	1.2E+01	2	
	Cs-137	Max	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	3
	Cs-137	Min	1.0E+00	3.7E-02	1.E-01	3.7E-01	4	
	Cs-137	Typ	2.0E+00	7.4E-02	1.E-01	7.4E-01	4	
	Cf-252	Max	1.1E-01	4.1E-03	2.E-02	2.0E-01	4	3
	Cf-252	Min	2.7E-02	1.0E-03	2.E-02	5.0E-02	4	
	Cf-252	Typ	3.0E-02	1.1E-03	2.E-02	5.6E-02	4	
Pacemakers	Pu-238	Max	8.0E+00	3.0E-01	6.E-02	4.9E+00	3	Not assigned
	Pu-238	Min	2.9E+00	1.1E-01	6.E-02	1.8E+00	3	
	Pu-238	Typ	3.0E+00	1.1E-01	6.E-02	1.9E+00	3	
Calibration sources	Pu-239/Be	Max	1.0E+01	3.7E-01	6.E-02	6.2E+00	3	Not assigned
	Pu-239/Be	Min	2.0E+00	7.4E-02	6.E-02	1.2E+00	3	
	Pu-239/Be	Typ	3.0E+00	1.1E-01	6.E-02	1.9E+00	3	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
				Category 4				
Brachytherapy - low dose rate	Cs-137	Max	7.0E-01	2.6E-02	1.E-01	2.6E-01	4	4
	Cs-137	Min	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	
	Cs-137	Typ	5.0E-01	1.9E-02	1.E-01	1.9E-01	4	
	Ra-226	Max	5.0E-02	1.9E-03	4.E-02	4.6E-02	4	4
	Ra-226	Min	5.0E-03	1.9E-04	4.E-02	4.6E-03	5	
	Ra-226	Typ	1.5E-02	5.6E-04	4.E-02	1.4E-02	4	
	I-125	Max	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	4
	I-125	Min	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	
	I-125	Typ	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	
	Ir-192	Max	7.5E-01	2.8E-02	8.E-02	3.5E-01	4	4
	Ir-192	Min	2.0E-02	7.4E-04	8.E-02	9.3E-03	5	
	Ir-192	Typ	5.0E-01	1.9E-02	8.E-02	2.3E-01	4	
	Au-198	Max	8.0E-02	3.0E-03	2.E-01	1.5E-02	4	4
	Au-198	Min	8.0E-02	3.0E-03	2.E-01	1.5E-02	4	
	Au-198	Typ	8.0E-02	3.0E-03	2.E-01	1.5E-02	4	
	Cf-252	Max	8.3E-02	3.1E-03	2.E-02	1.5E-01	4	4
	Cf-252	Min	8.3E-02	3.1E-03	2.E-02	1.5E-01	4	
	Cf-252	Typ	8.3E-02	3.1E-03	2.E-02	1.5E-01	4	
Thickness gauges	Kr-85	Max	1.0E+00	3.7E-02	3.E+01	1.2E-03	5	4
	Kr-85	Min	5.0E-02	1.9E-03	3.E+01	6.2E-05	5	
	Kr-85	Typ	1.0E+00	3.7E-02	3.E+01	1.2E-03	5	
	Sr-90	Max	2.0E-01	7.4E-03	1.E+00	7.4E-03	5	4
	Sr-90	Min	1.0E-02`	3.7E-04	1.E+00	3.7E-04	5	
	Sr-90	Typ	1.0E-01	3.7E-03	1.E+00	3.7E-03	5	
	Am-241	Max	6.0E-01	2.2E-02	6.E-02	3.7E-01	4	4
	Am-241	Min	3.0E-01	1.1E-02	6.E-02	1.9E-01	4	
	Am-241	Typ	6.0E-01	2.2E-02	6.E-02	3.7E-01	4	
	Pm-147	Max	5.0E-02	1.9E-03	4.E+01	4.6E-05	5	4
	Pm-147	Min	5.0E-02	1.9E-03	4.E+01	4.6E-05	5	
	Pm-147	Typ	5.0E-02	1.9E-03	4.E+01	4.6E-05	5	
	Cm-244	Max	1.0E+00	3.7E-02	5.E-02	7.4E-01	4	4
	Cm-244	Min	2.0E-01	7.4E-03	5.E-02	1.5E-01	4	
	Cm-244	Typ	4.0E-01	1.5E-02	5.E-02	3.0E-01	4	
Fill-level, thickness gauges	Am-241	Max	1.2E-01	4.4E-03	6.E-02	7.4E-02	4	4
	Am-241	Min	1.2E-02	4.4E-04	6.E-02	7.4E-03	5	
	Am-241	Typ	6.0E-02	2.2E-03	6.E-02	3.7E-02	4	
	Cs-137	Max	6.5E-02	2.4E-03	1.E-01	2.4E-02	4	4
	Cs-137	Min	5.0E-02	1.9E-03	1.E-01	1.9E-02	4	
	Cs-137	Typ	6.0E-02	2.2E-03	1.E-01	2.2E-02	4	
Calibration facilities	Sr-90	Max	2.0E+00	7.4E-02	1.E+00	7.4E-02	4	Not assigned
	Sr-90	Min	2.0E+00	7.4E-02	1.E+00	7.4E-02	4	
	Sr-90	Typ	2.0E+00	7.4E-02	1.E+00	7.4E-02	4	
Moisture detectors	Am-241/Be	Max	1.0E-01	3.7E-03	6.E-02	6.2E-02	4	4
	Am-241/Be	Min	5.0E-02	1.9E-03	6.E-02	3.1E-02	4	
	Am-241/Be	Typ	5.0E-02	1.9E-03	6.E-02	3.1E-02	4	

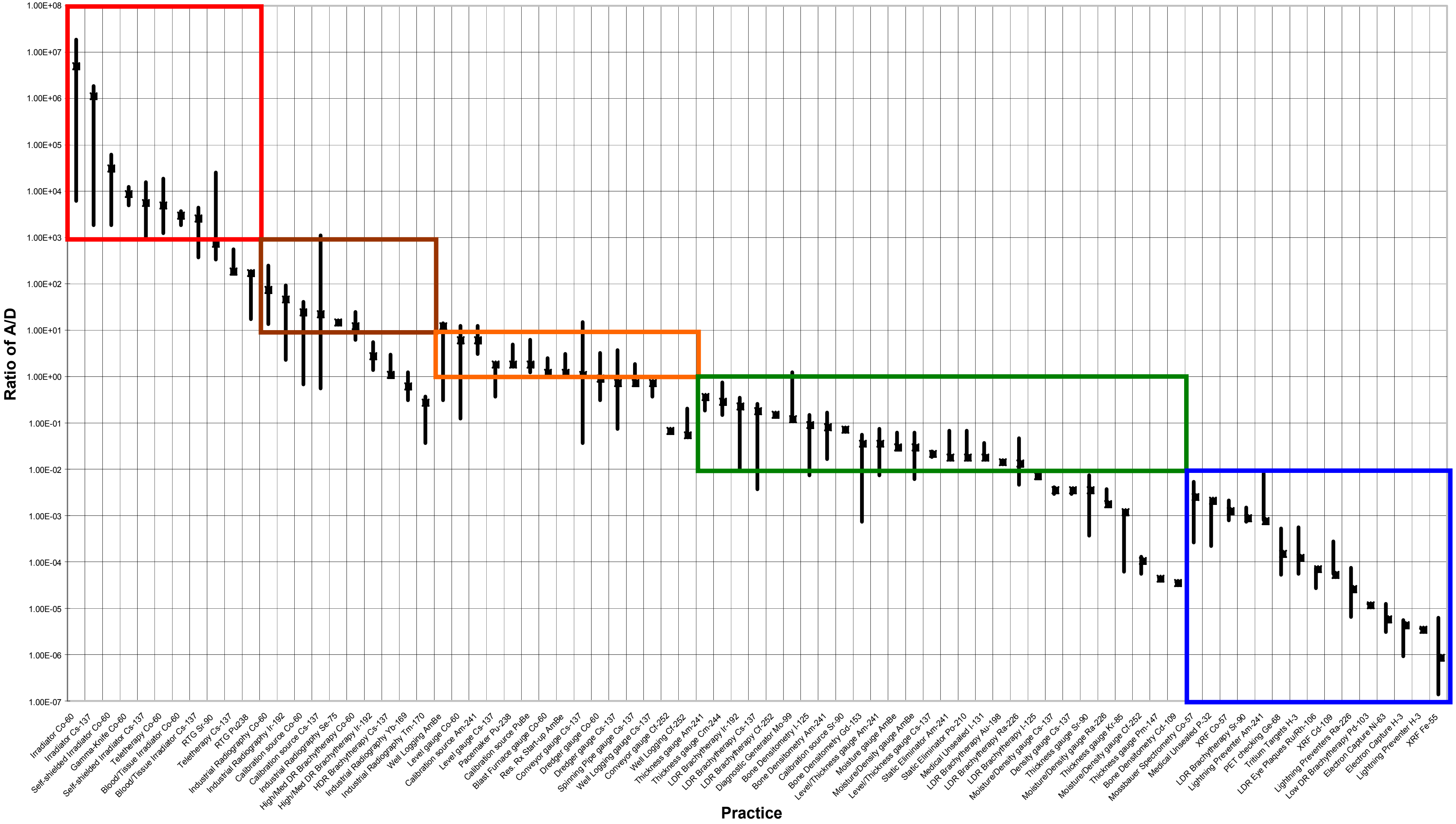
I	II	III	IV	V	VI	VII	VIII	IX
Practice	**Radionuclide**		**Quantity in use (A)**		**D-value**	**Ratio of A/D**	**Category**	
			Ci	**TBq**	**TBq**		**A/D based**	**Assigned**
Density gauges	Cs-137	Max	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	4
	Cs-137	Min	8.0E-03	3.0E-04	1.E-01	3.0E-03	5	
	Cs-137	Typ	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	
Moisture/density gauges	Am-241/Be	Max	1.0E-01	3.7E-03	6.E-02	6.2E-02	4	4
	Am-241/Be	Min	1.0E-02	3.7E-04	6.E-02	6.2E-03	5	
	Am-241/Be	Typ	5.0E-02	1.9E-03	6.E-02	3.1E-02	4	
	Cs-137	Max	1.1E-02	4.1E-04	1.E-01	4.1E-03	5	4
	Cs-137	Min	8.0E-03	3.0E-04	1.E-01	3.0E-03	5	
	Cs-137	Typ	1.0E-02	3.7E-04	1.E-01	3.7E-03	5	
	Ra-226	Max	4.0E-03	1.5E-04	4.E-02	3.7E-03	5	4
	Ra-226	Min	2.0E-03	7.4E-05	4.E-02	1.9E-03	5	
	Ra-226	Typ	2.0E-03	7.4E-05	4.E-02	1.9E-03	5	
	Cf-252	Max	7.0E-05	2.6E-06	2.E-02	1.3E-04	5	4
	Cf-252	Min	3.0E-05	1.1E-06	2.E-02	5.6E-05	5	
	Cf-252	Typ	6.0E-05	2.2E-06	2.E-02	1.1E-04	5	
Bone densitometry	Cd-109	Max	2.0E-02	7.4E-04	2.E+01	3.7E-05	5	4
	Cd-109	Min	2.0E-02	7.4E-04	2.E+01	3.7E-05	5	
	Cd-109	Typ	2.0E-02	7.4E-04	2.E+01	3.7E-05	5	
	Gd-153	Max	1.5E+00	5.6E-02	1.E+00	5.6E-02	4	4
	Gd-153	Min	2.0E-02	7.4E-04	1.E+00	7.4E-04	5	
	Gd-153	Typ	1.0E+00	3.7E-02	1.E+00	3.7E-02	4	
	I-125	Max	8.0E-01	3.0E-02	2.E-01	1.5E-01	4	4
	I-125	Min	4.0E-02	1.5E-03	2.E-01	7.4E-03	5	
	I-125	Typ	5.0E-01	1.9E-02	2.E-01	9.3E-02	4	
	Am-241	Max	2.7E-01	1.0E-02	6.E-02	1.7E-01	4	4
	Am-241	Min	2.7E-02	1.0E-03	6.E-02	1.7E-02	4	
	Am-241	Typ	1.4E-01	5.0E-03	6.E-02	8.3E-02	4	
Static eliminators	Am-241	Max	1.1E-01	4.1E-03	6.E-02	6.8E-02	4	4
	Am-241	Min	3.0E-02	1.1E-03	6.E-02	1.9E-02	4	
	Am-241	Typ	3.0E-02	1.1E-03	6.E-02	1.9E-02	4	
	Po-210	Max	1.1E-01	4.1E-03	6.E-02	6.8E-02	4	4
	Po-210	Min	3.0E-02	1.1E-03	6.E-02	1.9E-02	4	
	Po-210	Typ	3.0E-02	1.1E-03	6.E-02	1.9E-02	4	
Diagnostic isotope generators	Mo-99	Max	1.0E+01	3.7E-01	3.E-01	1.2E+00	3	Not assigned
	Mo-99	Min	1.0E+00	3.7E-02	3.E-01	1.2E-01	4	
	Mo-99	Typ	1.0E+00	3.7E-02	3.E-01	1.2E-01	4	
Medical unsealed	I-131	Max	2.0E-01	7.4E-03	2.E-01	3.7E-02	4	Not assigned
	I-131	Min	1.0E-01	3.7E-03	2.E-01	1.9E-02	4	
	I-131	Typ	1.0E-01	3.7E-03	2.E-01	1.9E-02	4	

I	II	III	IV	V	VI	VII	VIII	IX
Practice	Radionuclide		Quantity in use (A)		D-value	Ratio of A/D	Category	
			Ci	TBq	TBq		A/D based	Assigned
				Category 5				
X ray fluorescence analyzers	Fe-55	Max	1.4E-01	5.0E-03	8.E+02	6.2E-06	5	5
	Fe-55	Min	3.0E-03	1.1E-04	8.E+02	1.4E-07	5	
	Fe-55	Typ	2.0E-02	7.4E-04	8.E+02	9.3E-07	5	
	Cd-109	Max	1.5E-01	5.6E-03	2.E+01	2.8E-04	5	5
	Cd-109	Min	3.0E-02	1.1E-03	2.E+01	5.6E-05	5	
	Cd-109	Typ	3.0E-02	1.1E-03	2.E+01	5.6E-05	5	
	Co-57	Max	4.0E-02	1.5E-03	7.E-01	2.1E-03	5	5
	Co-57	Min	1.5E-02	5.6E-04	7.E-01	7.9E-04	5	
	Co-57	Typ	2.5E-02	9.3E-04	7.E-01	1.3E-03	5	
Electron capture detectors	Ni-63	Max	2.0E-02	7.4E-04	6.E+01	1.2E-05	5	5
	Ni-63	Min	5.0E-03	1.9E-04	6.E+01	3.1E-06	5	
	Ni-63	Typ	1.0E-02	3.7E-04	6.E+01	6.2E-06	5	
	H-3	Max	3.0E-01	1.1E-02	2.E+03	5.6E-06	5	5
	H-3	Min	5.0E-02	1.9E-03	2.E+03	9.3E-07	5	
	H-3	Typ	2.5E-01	9.3E-03	2.E+03	4.6E-06	5	
Lightning preventers	Am-241	Max	1.3E-02	4.8E-04	6.E-02	8.0E-03	5	5
	Am-241	Min	1.3E-03	4.8E-05	6.E-02	8.0E-04	5	
	Am-241	Typ	1.3E-03	4.8E-05	6.E-02	8.0E-04	5	
	Ra-226	Max	8.0E-05	3.0E-06	4.E-02	7.4E-05	5	5
	Ra-226	Min	7.0E-06	2.6E-07	4.E-02	6.5E-06	5	
	Ra-226	Typ	3.0E-05	1.1E-06	4.E-02	2.8E-05	5	
	H-3	Max	2.0E-01	7.4E-03	2.E+03	3.7E-06	5	5
	H-3	Min	2.0E-01	7.4E-03	2.E+03	3.7E-06	5	
	H-3	Typ	2.0E-01	7.4E-03	2.E+03	3.7E-06	5	
Brachytherapy: low dose-rate- eye plaques and permanent implants	Sr-90	Max	4.0E-02	1.5E-03	1.E+00	1.5E-03	5	5
	Sr-90	Min	2.0E-02	7.4E-04	1.E+00	7.4E-04	5	
	Sr-90	Typ	2.5E-02	9.3E-04	1.E+00	9.3E-04	5	
	Ru/Rh-106	Max	6.0E-04	2.2E-05	3.E-01	7.4E-05	5	5
	Ru/Rh-106	Min	2.2E-04	8.1E-06	3.E-01	2.7E-05	5	
	Ru/Rh-106	Typ	6.0E-04	2.2E-05	3.E-01	7.4E-05	5	
	Pd-103	Max	3.0E-02	1.1E-03	9.E+01	1.2E-05	5	5
	Pd-103	Min	3.0E-02	1.1E-03	9.E+01	1.2E-05	5	
	Pd-103	Typ	3.0E-02	1.1E-03	9.E+01	1.2E-05	5	
Poistron Emission Tomography (PET) checking	Ge-68	Max	1.0E-02	3.7E-04	7.E-01	5.3E-04	5	5
	Ge-68	Min	1.0E-03	3.7E-05	7.E-01	5.3E-05	5	5
	Ge-68	Typ	3.0E-03	1.1E-04	7.E-01	1.6E-04	5	5
Mossbauer Spectrometry	Co-57	Max	1.0E-01	3.7E-03	7.E-01	5.3E-03	5	5
	Co-57	Min	5.0E-03	1.9E-04	7.E-01	2.6E-04	5	5
	Co-57	Typ	5.0E-02	1.9E-03	7.E-01	2.6E-03	5	5
Tritium targets	H-3	Max	3.0E+01	1.1E+00	2.E+03	5.6E-04	5	Not assigned
	H-3	Min	3.0E+00	1.1E-01	2.E+03	5.6E-05	5	
	H-3	Typ	7.0E+00	2.6E-01	2.E+03	1.3E-04	5	
Medical unsealed	P-32	Max	6.0E-01	2.2E-02	1.E+01	2.2E-03	5	Not assigned
	P-32	Min	6.0E-02	2.2E-03	1.E+01	2.2E-04	5	
	P-32	Typ	6.0E-01	2.2E-02	1.E+01	2.2E-03	5	

Appendix III

RELATIVE RANKING OF PRACTICES BASED ON A/D

NOTE: Boxes show categories based purely on A/D. The final categories took other factors into consideration, as shown in Table 1 in the main text



REFERENCES

[1] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115, IAEA, Vienna (1996).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Categorization of Radiation Sources, IAEA-TECDOC-1191, Vienna (2000).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Security of Radioactive Sources, IAEA-TECDOC-1355, Vienna (2003).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on the Physical Protection of Nuclear Materials, Legal Series No. 12, IAEA, Vienna (1982).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Management of spent high activity radioactive sources (SHARS), IAEA-TECDOC-1301, Vienna (2002).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Goiânia, IAEA, Vienna (1988).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in San Salvador, IAEA, Vienna (1990).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Tammiku, IAEA, Vienna (1998).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Yanango, IAEA, Vienna (2000).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Gilan, IAEA, Vienna (2002).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Samut Prakarn, IAEA, Vienna (2002).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Lessons Learned from Accidental Exposures in Radiotherapy, Safety Reports Series No. 17, IAEA, Vienna (2000).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Investigation of the Accidental Exposure of Radiotherapy Patients in Panama, IAEA, Vienna (2001).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Accidental Overexposure of Radiotherapy Patients in San José, Costa Rica, IAEA, Vienna (1998).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Methods to Identify and Locate Spent Radiation Sources, IAEA-TECDOC-804, Vienna (1995).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Recommendations for the Safe Use and Regulation of Radiation Sources in Industry, Medicine, Research and Teaching, Safety Series No. 102, IAEA, Vienna (1990).

[17] UNITED STATES NUCLEAR REGULATORY COMMISSION, Sealed Source and Device Registry, http://www.hsrd.ornl.gov/nrc/sources/index.cfm.

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulations for the Safe Transport of Radioactive Material – 1996 Edition (Revised), IAEA Safety Standards Series No. TS-R-1 (ST-1 Revised), IAEA, Vienna (1996).

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency. (Updating IAEA-TECDOC-953), Emergency Preparedness and Response Series, Vienna (in preparation).

[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Preparedness and Response for a Nuclear or Radiological Emergency. IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Intervention Criteria in a Nuclear or Radiation Emergency, Safety Series No. 109, IAEA, Vienna (1994).

[22] UNITED STATES NUCLEAR REGULATORY COMMISSION, Health Effects Models for Nuclear Power Plant Accidents Consequence Analysis, NUREG/CR-4214, USNRC, Washington, DC (1989).

[23] INTERNATIONAL COMMISION ON RADIOLOGICAL PROTECTION, Publication 58, RBE for Deterministic Effects, Annals of the ICRP 20 (4) (1989).

[24] INTERNATIONAL ATOMIC ENERGY AGENCY, Diagnosis and Treatment of Radiation Injuries, Safety Reports Series No. 2, IAEA, Vienna (1998).

[25] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Lilo, IAEA, Vienna (2000).

[26] INTERNATIONAL ATOMIC ENERGY AGENCY, Draft Revised Code of Conduct on the Safety and Security of Radioactive Sources. GOV/2002/35/Add.1-GC(46)/11/Add.1 (2002).

Annex I

BRIEF DESCRIPTION OF SELECTED PRACTICES

Teletherapy units are commonly found in medical institutions, such as hospitals or clinics. The physical dimensions of the source are relatively small, with generally a cylindrical (few cm in diameter by several cm long) shape. The source is contained inside a large shielding device. Fixed multi-beam teletherapy units (Gamma Knife) focus gamma radiation from an array of over 200 ^{60} Co sources on brain lesions. The facilities within which the units are located are usually specifically designed and include thick shield walls and have other protective equipment, due to the high activity source strength.

Radioisotope thermoelectric generators (RTGs) are used to provide low amounts of electric power. Heat generated by radioactive decay of high activity sources is converted to electricity by thermoelectric converters. Typically the RTGs contain ^{238}Pu or ^{90}Sr. These devices are used primarily for military purposes and space exploration.

Irradiator facilities are relatively few in number, and contain very high activity sources to sterilize foodstuffs, medical products and supplies, and for other specialized applications. The sources used in performing the irradiation of the material vary in physical size, some being large or others being pencil-sized, and each facility will contain many such sources. The facilities that contain the irradiation sources are specially designed, often including thickly shielded walls, interlocks, and other protective equipment. Other irradiators are self-shielded and are used in research applications or for blood irradiation.

Industrial radiography sources and devices are generally small in terms of physical size, although the devices are usually heavy due to the shielding contained in them. The sources themselves are very small, less than 1 cm in diameter, and only a few cm long, and are attached to specially designed cables for their proper operation. The use of radiography sources and devices are very common, and their portability may make them susceptible to theft or loss. The small size of the source allows for unauthorized removal by an individual, and such a source may be placed into a pocket of a garment. Industrial radiography may also be performed in fixed installations, either using the same small portable devices, or using larger machines that may appear to be similar to teletherapy units.

Brachytherapy applications are of three slightly different varieties. These are generally referred to as low dose rate (LDR) brachytherapy, medium dose rate (MDR) brachytherapy, and high dose rate (HDR) brachytherapy. These applications use sources that may be small physically (less than 1 cm in diameter, only a few cm long), and thus are susceptible to being lost or misplaced. HDR and MDR sources, and some LDR sources, may be in the form of a long wire attached to a device (a remote after-loading device). The after-loading device may be heavy, due to the shielding for the sources when not in use, and the device may be on wheels for transport within a facility. The remote after-loading device may also contain electrical and electronic components for its operation. Brachytherapy sources are located in hospitals, clinics and similar medical institutions, and such facilities may have a large number of sources.

Well logging sources and devices are generally found in areas where exploration for minerals is occurring, such as coal, oil, natural gas. The sources are usually contained in long (1–2 m, typically) but thin (<10 cm in diameter) devices that also contain detectors and various electronic components. The actual size of the sources inside the devices is generally small.

The devices are heavy, due to the ruggedness needed for the environments in which they are to be used.

Industrial gauges are of various shapes and sizes, and are either fixed or portable. These devices are generally designed for many years of operation with little or no special maintenance. Industrial gauges are used for process control; for measurement of flow, volume, density, or material presence; and may be placed in locations unsuitable for continuous human presence (e.g.: in a blast furnace). Consequently, they often accumulate layers of dirt, grime, grease, oil and other material that may cover any warning labels that may have been present. Depending upon the specific application, industrial gauges may contain relatively small quantities of radioactive material, or may contain sources with activities approaching 1 TBq. The devices generally are not large, but may be located some distance from the radiation detector, which may have electrical or electronic components located within the detector. A facility may have a large number of these gauges. The locations of such devices or sources within a facility may not be recognized, since the devices may be connected to process control equipment. This lack of recognition may result in a loss of control if the facility decides to modernize or terminate operations.

Moisture/density devices are a type of industrial gauges that are small and portable. These devices contain the sources, detectors and electronic equipment necessary for the measurement. The source is physically small in size, typically a few cm long by a few cm in diameter, and may be located either completely within the device or at the end of a rod/handle assembly. The small size of the device makes it susceptible to loss of control or theft.

Annex II

PLAIN LANGUAGE DESCRIPTION OF THE CATEGORIES

The following is a plain language description of the categories for the purposes of public information.

Radioactive sources are used throughout the world for a wide variety of beneficial purposes in industry, medicine, agriculture, research and education. When such sources are safely managed and securely protected, the risks to workers and the public will be minimized and the benefits will outweigh the associated hazards.

If, however, a radioactive source becomes out of control and unshielded or dispersed as the result of an accident or a malevolent act, for example — persons could be exposed to radiation at dangerous levels. A radioactive source is considered to be dangerous if it could be ‘life threatening’ or could cause a permanent injury that would reduce the quality of life of the person exposed. Permanent injuries include burns requiring surgery and debilitating injuries to the hands, for example. An exposure is considered to be dangerous if it results in an injury to tissue or an organ that could cause death within a few years (increased cancer risks are not considered). Temporary injuries such as reddening and irritation of the skin or temporary changes to the composition of the blood are not considered to be dangerous. The extent of any such injuries will depend on many factors, including: the size of the radioactive source; how close a person is to the source and for how long; whether the source is shielded; and whether or not its radioactive material has been dispersed and caused the contamination of skin or been inhaled or ingested.

This categorization provides a relative ranking of radioactive sources in terms of their potential to cause immediate harmful health effects if the source is not safely managed or securely protected.

The following is a plain language description of the relative radiation hazards for both individual sources and dispersed radioactive material. Sources are classified into five categories: Category 1 sources are potentially the most dangerous and Category 5 sources are not dangerous.

I-1. Category 1

I-1.1. Individual sources[2]

Personally extremely dangerous: This amount of radioactive material, if not safely managed or securely protected would be likely to cause permanent injury to a person who handled it, or were otherwise in contact with it, for more than a few minutes. It would probably be fatal to be close to this amount of unshielded material for a period of a few minutes to an hour.

I-1.2. Dispersed radioactive material

This amount of radioactive material, if dispersed by a fire or explosion, could possibly — but

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[2] An ‘individual source’ means a radioactive source that can be picked up or otherwise handled (e.g. solids such as metals, ceramics, encapsulated powder, or liquid or gas in a sealed container).

would be unlikely to — permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a few hundred metres away, but contaminated areas would need to be cleaned up in accordance with international standards. The size of the area to be cleaned up would depend on many factors (including the size and type of the source, whether and how it had been dispersed, and the weather). For large sources the area to be cleaned up could be a square kilometre or more.

It would be highly unlikely for a Category 1 source to contaminate a public water supply to dangerous levels, even if the radioactive material were highly soluble in water.

I-2. Category 2

I-2.1. Individual sources

Personally very dangerous: This amount of radioactive material, if not safely managed or securely protected, could cause permanent injury to a person who handled it, or were otherwise in contact with it, for a short time (minutes to hours). It could possibly be fatal to be close to this amount of unshielded radioactive material for a period of hours to days.

I-2.2. Dispersed radioactive material

This amount of radioactive material, if dispersed by a fire or explosion, could possibly — but would be very unlikely to — permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a hundred metres or so away, but contaminated areas would need to be cleaned up in accordance with international standards. The size of the area to be cleaned up would depend on many factors (including the size and type of the source, whether and how it had been dispersed, and the weather), but would probably not exceed a square kilometre.

It would be virtually impossible for a Category 2 source to contaminate a public water supply to dangerous levels, even if the radioactive material were highly soluble in water.

I-3. Category 3

I-3.1. Individual sources

Personally dangerous: This amount of radioactive material, if not safely managed or securely protected, could cause permanent injury to a person who handled it, or were otherwise in contact with it, for some hours. It could possibly — although it is unlikely — be fatal to be close to this amount of unshielded radioactive material for a period of days to weeks.

I-3.2. Dispersed radioactive material

This amount of radioactive material, if dispersed by a fire or explosion, could possibly — but is extremely unlikely to — permanently injure or be life threatening to persons in the immediate vicinity. There would be little or no risk of immediate health effects to persons beyond a few metres away, but contaminated areas would need to be cleaned up in accordance with international standards. The size of the area to be cleaned up would depend on many factors (including the size and type of source, whether and how it had been dispersed, and the weather), but would probably not exceed a small fraction of a square kilometre.

It would be virtually impossible for a Category 3 source to contaminate a public water supply to dangerous levels, even if the radioactive material were highly soluble in water.

I-4. Category 4

I-4.1. Individual sources

Unlikely to be dangerous: It is very unlikely that anyone would be permanently injured by this amount of radioactive material. However, this amount of unshielded radioactive material, if not safely managed or securely protected, could possibly — although it is unlikely — temporarily injure someone who handled it or were otherwise in contact with it, or who were close to it for a period of many weeks.

I-4.2. Dispersed radioactive material

This amount of radioactive material, if dispersed by a fire or explosion, could not permanently injure persons.

I-5. Category 5

I-5.1. Individual sources

Not dangerous: No one could be permanently injured by this amount of radioactive material.

I-5.2. Dispersed radioactive material

This amount of radioactive material, if dispersed by a fire or explosion, could not permanently injure persons.

DEFINITIONS

accident: Any unintended event, including operating errors, equipment failure, or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety [1].

dangerous source: A source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects [20].

deterministic effect: A health effect of radiation for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose. A **severe deterministic effect** is one that is fatal or life threatening or results in a permanent injury that decreases the quality of life [20].

license: An authorization granted by the Regulatory Authority on the basis of a safety assessment and accompanied by specific requirements and conditions to be completed by the licensee [1].

management: means all activities, administrative and operational, that are involved in the manufacture, supply, receipt, storage, use, transfer, import, export, transport, maintenance or disposal of radioactive sources [26].

notification: A document submitted to the Regulatory Authority by the legal person to notify an intention to carry out a practice or any other action described in the General Obligations of the BSS [1].

orphan source: A source which poses sufficient radiological hazard to warrant regulatory control, but which is not under regulatory control because it has never been so, or because it has been abandoned, lost, misplaced, stolen or otherwise transferred without proper authorization [26].

practice: Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed [1].

radiation generator: Device capable of generating radiation, such as X rays, neutrons, electrons or other charged particles, which may be for scientific, industrial or medical purposes [1].

registration: A form of authorization for practices of low or moderate risks whereby the legal person responsible for the practice has, as appropriate, prepared and submitted a safety assessment of the facility and equipment to the Regulatory Authority. The practice of use is authorized with conditions or limitations as appropriate. The requirements for safety assessment and the conditions or limitations applied to the practice should be less severe than those for licensing [1].

regulatory authority: An authority or authorities designated or otherwise recognized by a government for regulatory purposes in connection with protection and safety [1].

safety: Means measures intended to minimize the likelihood of accidents with radiation sources and, should such an accident occur, to mitigate its consequences [26].

sealed source: Radioactive material that is permanently sealed in a capsule or is closely bonded and in a solid form. The capsule or material of a sealed source shall be strong enough to maintain leak-tightness under the conditions of use and wear for which the source was designed, also under foreseeable mishaps [1].

security: Means measures to prevent unauthorized access to, and loss, theft and unauthorized transfer of, radioactive sources, and measures to protect facilities in which radioactive sources are managed [26].

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Technical Meeting

Vienna, Austria: 18–22 November 2002