IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Radioactive Sources:
Applications and Alternative Technologies
Meeting #3 Virtual Meeting
The National Academies of Sciences-Engineering- Medicine

Categorization of Radioactive Sources and Safety Considerations

Ronald Pacheco ,
Unit Head, Control of Radiation Sources Unit
Regulatory Infrastructure & Transport Safety Section,
Division of Radiation Transport and Waste Safety

Department of Nuclear Safety and Security

June 2019

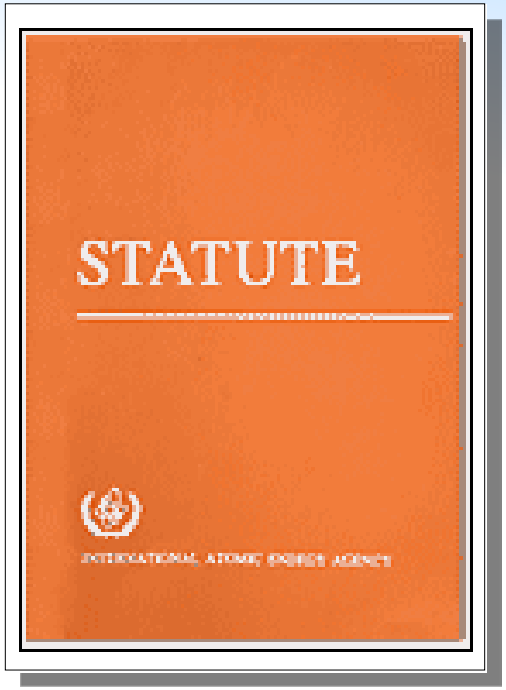
Content

- IAEA Role on the Safety and Control of Radioactive Sources;
- Questions from Academies committee about Categorization of Sources

Content

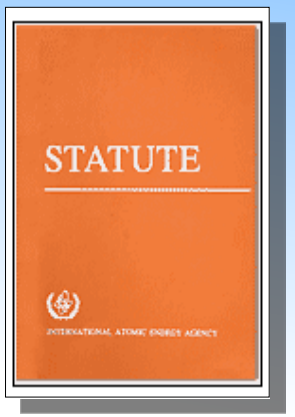
- IAEA Role on the Safety and Control of Radioactive Sources;
- Questions from Academies committee about Categorization of Sources

International Atomic Energy Agency



Use of Nuclear Technology should not take place if a Regulatory System has not been established and to ensure that Radiation Safety Programs are established to **Protect the Workers- Patients- Public and Environment**

IAEA Safety functions



INTERNATIONAL MECHANISMS FOR APPLYING STANDARDS

Rendering RADIATION SAFETY SERVICES

Providing TECHNICAL COOPERATION

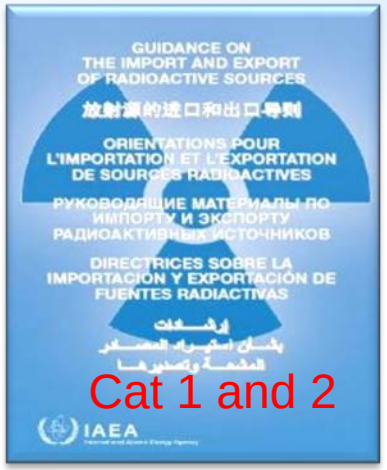
safety

Code of conduct on the safety and security of radioactive sources and Supplementary Guidance

States should have effective national legislation, regulations and a regulatory body and

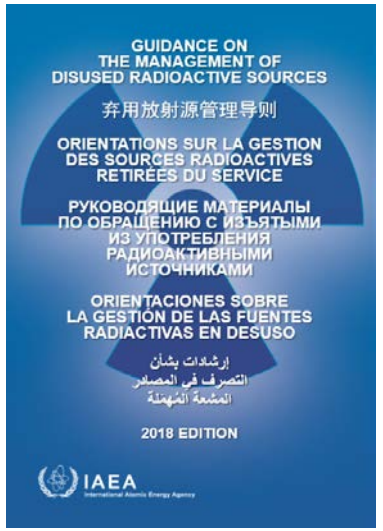
Cat 1, 2 and 3

Effective import/export controls: ***supplementary Guidance on the Import and Export of Radioactive Sources,*** 2004



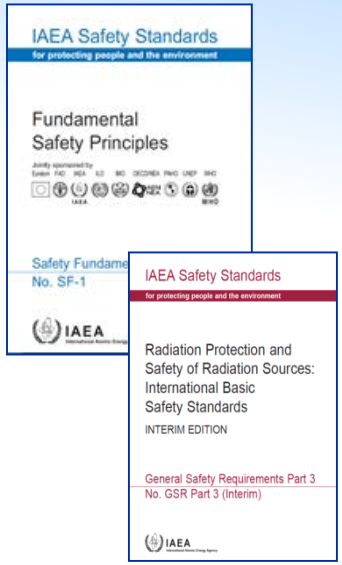
Cat 1 and 2

Safe and secure management of disused RS: ***supplementary Guidance on the Management of Disused Radioactive Sources,*** 2017



IAEA'S RADIATION SAFETY STANDARDS

- IAEA Safety Standards are not legally binding on Member States but may be adopted by them, at their own discretion



however...

- IAEA Safety Standards are binding on IAEA in relation to its own operations and to operations assisted by the IAEA; and

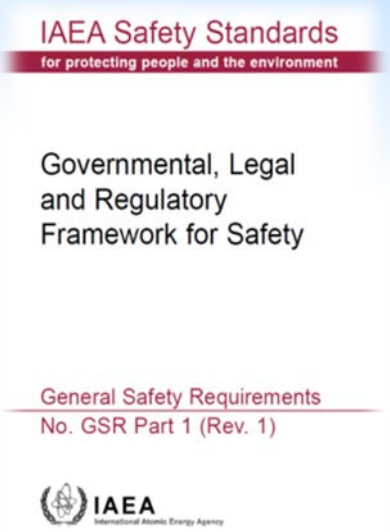
- Member States receiving IAEA assistance are obliged to apply IAEA Safety Standards

Certain minimum level of radiation safety ?
Complying with the (Board resolutions)

Regulatory Control in Place.

Radiation safety programme in place for the workers, Patients and Public and Environment .

GSR part 1 Governmental. Legal and Regulatory Framework for Safety



1. Responsibilities and Functions of the Government

- Legislative framework for safety
- Establishment of a regulatory body
- Funding of the regulatory body
- National Coordination

2. Global Safety Regime

- International Obligations for International Cooperation
- Sharing of regulatory experience

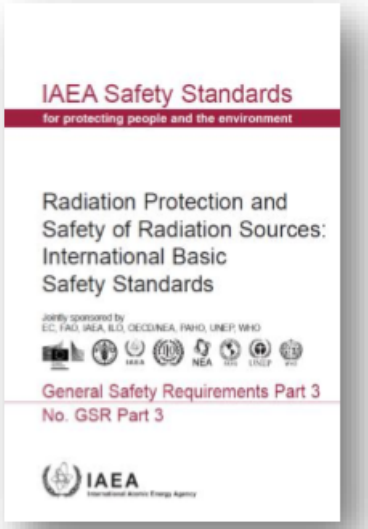
3. Responsibilities, Organization and Functions of the Regulatory Body.

- Regulations and guidance
- National inventory of radiation sources
- Staffing and competence of the regulatory boc
- Authorization and review and assessment
- Inspection
- Enforcement
- Management system of the regulatory body

International Basic Safety Standards

GSR part 3 BSS

- An integrated and consistent set of Safety Requirements that establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future.



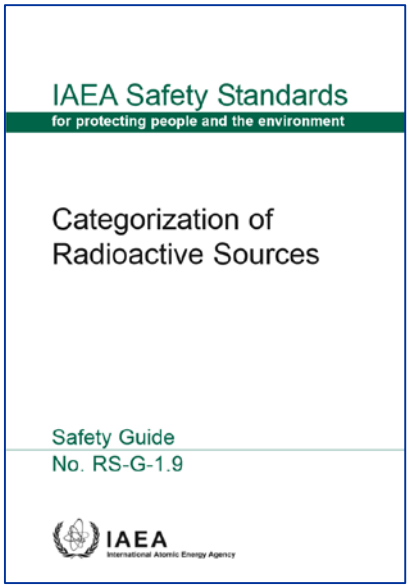
- GSR Part 3 (BSS) follows ICRP 103 recommendations
- Protection and Safety requirements of the BSS apply to all facilities and activities
- **Planned, emergency and existing exposure situations**
- **Occupational,** public and medical exposure categories
- 52 overarching requirements – for **governments, regulatory bodies, industry, health and safety professionals, workers**, public and **service providers** such as technical support organizations
- **12 requirements for ORP**; Control, monitoring and recording
- **Regulator, TSO** (authorization or approval of service providers for individual monitoring and calibration services) & **End-users**

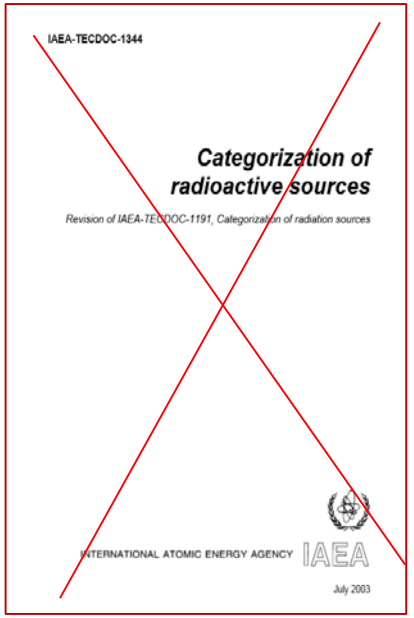
Content

- IAEA Role on the Safety and Control of Radioactive Sources;
- Questions from Academies committee about Categorization of Sources

Please provide an overview of the 2003 document Categorization of Radioactive Sources, IAEA-TECDOC-1344.

Superseded





The safety guide provides a Risk based Ranking of radioactive sources and practices in FIVE categories

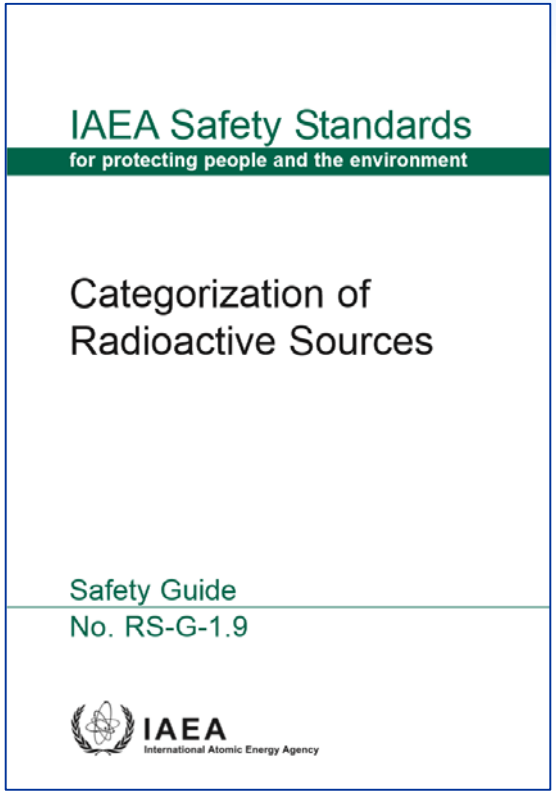
RS-G-1.9

Scope: All radioactive sources used in industry, medicine, agriculture research and education

The categorization is not applied to X-ray machines and particle accelerators, although may be applied to radioactive sources produced by, or used as a target

The categorization is not applied to Nuclear Material as defined in the convention of Physical protection of Nuclear Material;

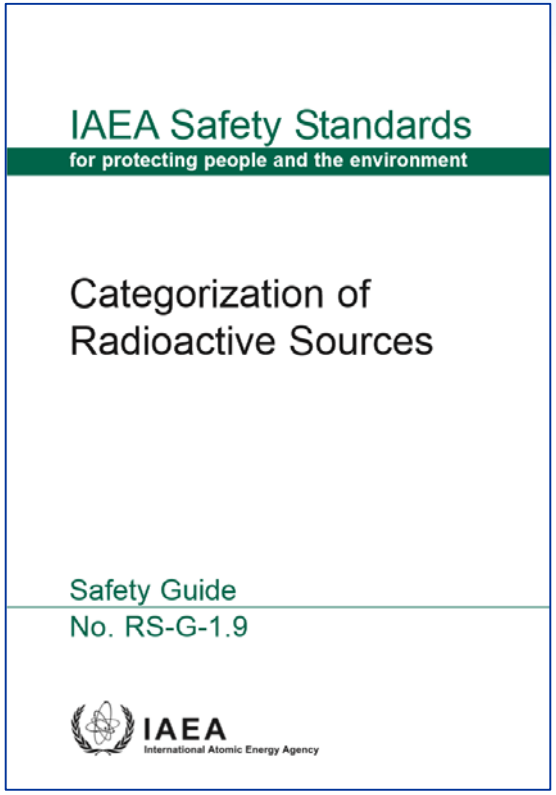
Article 1 : plutonium except that with isotopic concentration exceeding 80% in plutonium-238; uranium-233; uranium enriched in the isotope 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore-residue; any material containing one or more of the foregoing;



Categorization System: Is based primarily on the potential for radioactive sources to cause a deterministic Health effects .
These effects depend on time of exposure, doses, type of Radiation.it has a threshold of doses below which the effect does not occur the threshold may be vary from person to person.
The severity of an effect increases with dose.

Examples of deterministic effects (doses are given as absorbed doses and expressed in grays (Gy)):

- skin erythema: 2-5 Gy
- irreversible skin damage: 20-40 Gy
- hair loss: 2-5 Gy
- sterility: 2-3 Gy
- cataracts: 0.5 Gy (NB: a significantly lowered threshold of 5Gy to 0.5Gy lethality (whole body): 3-5 Gy
- fetal abnormality: 0.1-0.5 Gy



RS-G-1.9

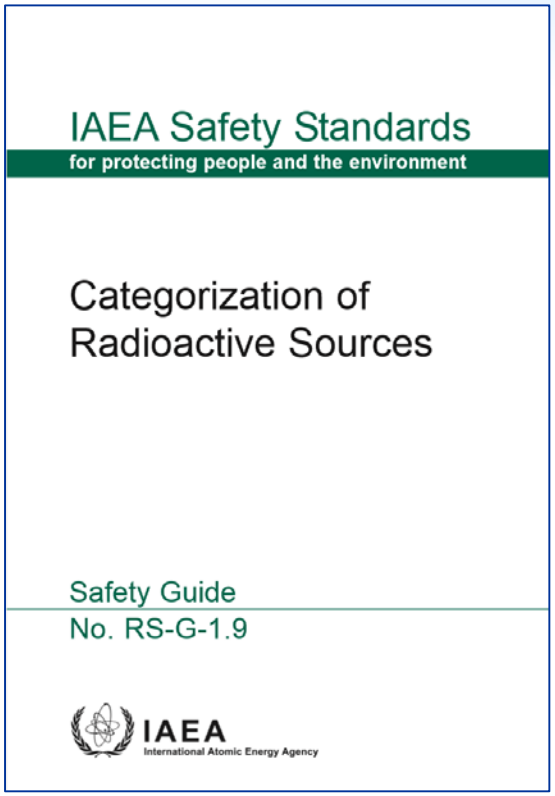
Categorization System: Is based primarily on the potential for radioactive sources to cause a deterministic Health effects .

The categorization system is based in a “dangerous source” which are quantified in terms of **D values,** which is the radionuclide specific activity (amount of radioactivity or the decay rate of a particular radionuclide per unit mass of radionuclide) , which if not under control, **could cause deterministic effects** for a range of scenarios with external exposures but also with internal exposures.

Another important value is the A activity of the Source which could varies over many orders of magnitude

D values are therefore utilized to normalize the risk .

The A/D value are used to provide an initial ranking related to risk



RS-G-1.9

Category of sources by common Practices

IAEA Safety Standards
for protecting people and the environment

Categorization of Radioactive Sources

Safety Guide
No. RS-G-1.9

IAEA
International Atomic Energy Agency

RECOMMENDED CATEGORIES FOR SOURCES USED IN COMMON PRACTICES

2.4. The categorization method outlined here and described in more detail in Annex I has been used to assign sources used in common practices to one of five categories, as shown in Appendix I. Examples of commonly used sources are shown in Table 1.

TABLE 1. RECOMMENDED CATEGORIES FOR SOURCES USED IN COMMON PRACTICES

Category	Source[a] and practice	Activity ratio[b] (A/D)
1	Radioisotope thermoelectric generators (RTGs) Irradiators Teletherapy sources Fixed, multi-beam teletherapy (gamma knife) sources	$A/D \geq 1000$
2	Industrial gamma radiography sources High/medium dose rate brachytherapy sources	$1000 > A/D \geq 10$
3	Fixed industrial gauges that incorporate high activity sources[c] Well logging gauges	$10 > A/D \geq 1$
4	Low dose rate brachytherapy sources (except eye plaques and permanent implants) Industrial gauges that do not incorporate high activity sources[c] Bone densitometers Static eliminators	$1 > A/D \geq 0.01$
5	Low dose rate brachytherapy eye plaques and permanent implant sources X ray fluorescence (XRF) devices Electron capture devices Mossbauer spectrometry sources Positron emission tomography (PET) check sources	$0.01 > A/D$ and $A >$ exempt[d]

Categories in some practices

Based on Operational Experience, professional Judgement and lessons learned

IAEA Safety Standards
for protecting people and the environment

Categorization of Radioactive Sources

Safety Guide
No. RS-G-1.9

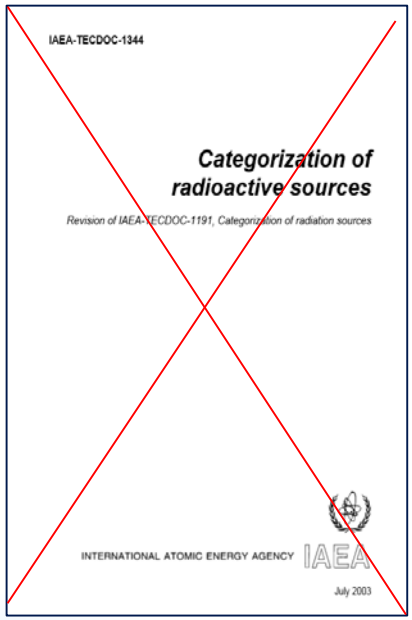
IAEA International Atomic Energy Agency

TABLE 2. CATEGORIES FOR SOURCES USED IN SOME COMMON PRACTICES

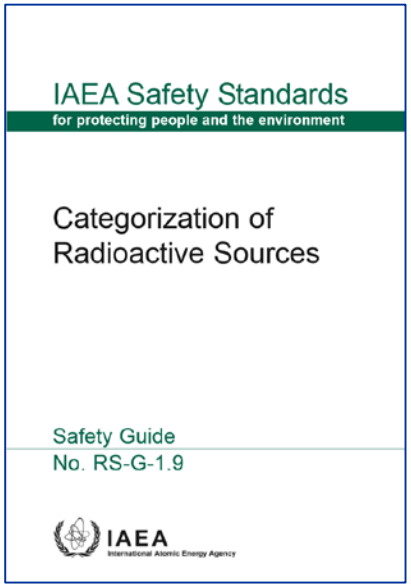
I	II	III	IV	V	VI	VII	VIII	IX
Source	Radionuclide		Quantity in use (A)		D value (TBq)	Ratio of A/D	Category	
			Ci	TBq			A/D based	Recommended
RTGs					**Category 1**			
	Sr-90	Max	6.8E+05	2.5E+04	1.0E+00	2.5E+04	1	
	Sr-90	Min	9.0E+03	3.3E+02	1.0E+00	3.3E+02	2	1
	Sr-90	Typ	2.0E+04	7.4E+02	1.0E+00	7.4E+02	2	
	Pu-238	Max	2.8E+02	1.0E+01	6.E-02	1.7E+02	2	
	Pu-238	Min	2.8E+01	1.0E+00	6.E-02	1.7E+01	2	1
	Pu-238	Typ	2.8E+02	1.0E+01	6.E-02	1.7E+02	2	
Irradiators used in sterilization and food preservation	Co-60	Max	1.5E+07	5.6E+05	3.E-02	1.9E+07	1	
	Co-60	Min	5.0E+03	1.9E+02	3.E-02	6.2E+03	1	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	
	Cs-137	Min	5.0E+03	1.9E+02	1.E-01	1.9E+03	1	1
	Cs-137	Typ	3.0E+06	1.1E+05	1.E-01	1.1E+06	1	
Self-shielded irradiators	Cs-137	Max	4.2E+04	1.6E+03	1.E-01	1.6E+04	1	
	Cs-137	Min	2.5E+03	9.3E+01	1.E-01	9.3E+02	2	1
	Cs-137	Typ	1.5E+04	5.6E+02	1.E-01	5.6E+03	1	

- **Does the IAEA have plans to re-evaluate the proposed categorization system? If yes, what are some factors the agency is reevaluating and what are the timelines for publication?**

- Please provide information on the feedback the IAEA receives from Member States on the document and its usefulness in setting regulatory guidance for radiation sources



No reevaluation is expected



The document is Highly used and very useful by all Member States

Cat of sources is used as basis for implementing requirements in different areas

Regulatory Safety Measures : Is the key factor in developing a graded system for notification, registration, authorization, inspection and enforcement and development of regulations.

Security Measures : Is the key factor in developing a graded basis for establishing security measures in facilities and activities.

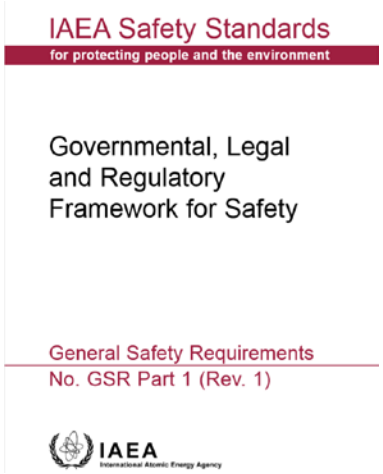
National Register of Sources : To decide what sources should be included and what level of detail should be used.

Import and Export controls : To optimize decisions regarding the import and export and the notification system established in the Code of Conduct

Emergencies preparedness and response , regaining control over orphan sources , communication with public, the categorization has been shown to be useful.

What are the IAEA's views on the adequacy of regulatory control of category 3 sources in the United States and worldwide?

What level of regulatory involvement does the IAEA feel is appropriate for category 3 sources?



Requirement 3: Establishment of a regulatory body

The government, through the legal system, shall establish and maintain a regulatory body, and shall confer on it the legal authority and provide it with the competence and the resources necessary to fulfil its statutory obligation for the regulatory control of facilities and activities.

We relied on the National Regulatory Frameworks

IAEA's position on considering the socioeconomic risks posed by the sources in the categorization system.

Requirement 16 : Organizational structure of the regulatory body and allocation of resources

4.5. The regulatory body has the responsibility for structuring its organization and managing its available resources so as to fulfil its statutory obligations effectively. The regulatory body shall allocate resources commensurate with the radiation risks associated with facilities and activities, in accordance with **a graded approach.**

Description of the categories

TABLE 3. PLAIN LANGUAGE DESCRIPTIONS OF THE CATEGORIES

Category of source	Risk in being close to an individual source	Risk in the event that the radioactive material in the source is dispersed by fire or explosion
1	**Extremely dangerous to the person:** This source, if not safely managed or securely protected, would be likely to cause permanent injury to a person who handled it or who was otherwise in contact with it for more than a few minutes. It would probably be fatal to be close to this amount of unshielded radioactive material for a period in the range of a few minutes to an hour.	This amount of radioactive material, if dispersed, could possibly — although it would be unlikely — 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. For large sources the area to be cleaned up could be a square kilometre or more.[a]
2	**Very dangerous to the person:** This source, if not safely managed or securely protected, could cause permanent injury to a person who handled it or who was 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.	This amount of radioactive material, if dispersed, could possibly – although it would be very unlikely — 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 area to be cleaned up would probably not exceed a square kilometre.[a]
3	**Dangerous to the person:** This source, if not safely managed or securely protected, could cause permanent injury to a person who handled it or who was otherwise in contact with it for some hours. It could possibly — although it would be unlikely — be fatal to be close to this amount of unshielded radioactive material for a period of days to weeks.	This amount of radioactive material, if dispersed, could possibly – although it would be extremely unlikely — 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 area to be cleaned up would probably not exceed a small fraction of a square kilometre.[a]
4	**Unlikely to be dangerous to the person:** It is very unlikely that anyone would be permanently injured by this source. However, this amount of unshielded radioactive material, if not safely managed or securely protected, could possibly — although it would be unlikely — temporarily injure someone who handled it or who was otherwise in contact with it for many hours, or who was close to it for a period of many weeks.	This amount of radioactive material, if dispersed, could not permanently injure persons.[b]
5	**Most unlikely to be dangerous to the person:** No one could be permanently injured by this source.[b]	This amount of radioactive material, if dispersed, could not permanently injure anyone.[b]

Does the IAEA keep an inventory of radioactive sources worldwide? If not, does the agency have some idea of the number of sources, e.g., blood irradiators, sterilization sources available worldwide?

We don't have an inventory of radioactive sources worldwide. However, we do help MSs in establishing the National Register of Sources

The Regulatory Authority Information System (RAIS) is a software application developed by the IAEA to assist Member States in managing their regulatory control programmes in accordance with IAEA Safety Standards and guides. This includes the IAEA Code of Conduct on the Safety and Security of Radioactive Sources and its supplementary Guidance on the Import and Export of Radioactive Sources.

What are the IAEA's thoughts on large numbers of Category 3 or 4 sources in the same location whose cumulative activity exceeds Category 2 levels.

Aggregation of sources

3.5. There will be situations in which radioactive sources are in close proximity to each other, such as in manufacturing processes (e.g. in the same room or building) or in storage facilities (e.g. in the same enclosure). In such circumstances, the regulatory body may wish to aggregate the activity in the sources to determine a situation specific categorization for the purposes of implementing regulatory control measures. In such situations, the summed activity of the radionuclide should be divided by the appropriate D value and the calculated ratio A/D compared with the ratios A/D given in Table 1, thus allowing the set of sources to be categorized on the basis of activity. If sources with various radionuclides are aggregated, then the sum of the ratios A/D should be used in determining 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.

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Thank you