Clearance of radioactive waste from regulatory control

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International Atomic Energy Agency

Overview

- Concept of controlling radioactive material in the BSS
  - exclusion
  - exemption
  - clearance
- Approaches to derive exemption and clearance levels
- Practical application of clearance
- Familiarization with the BSS tables
- Waste hierarchy
- Summary

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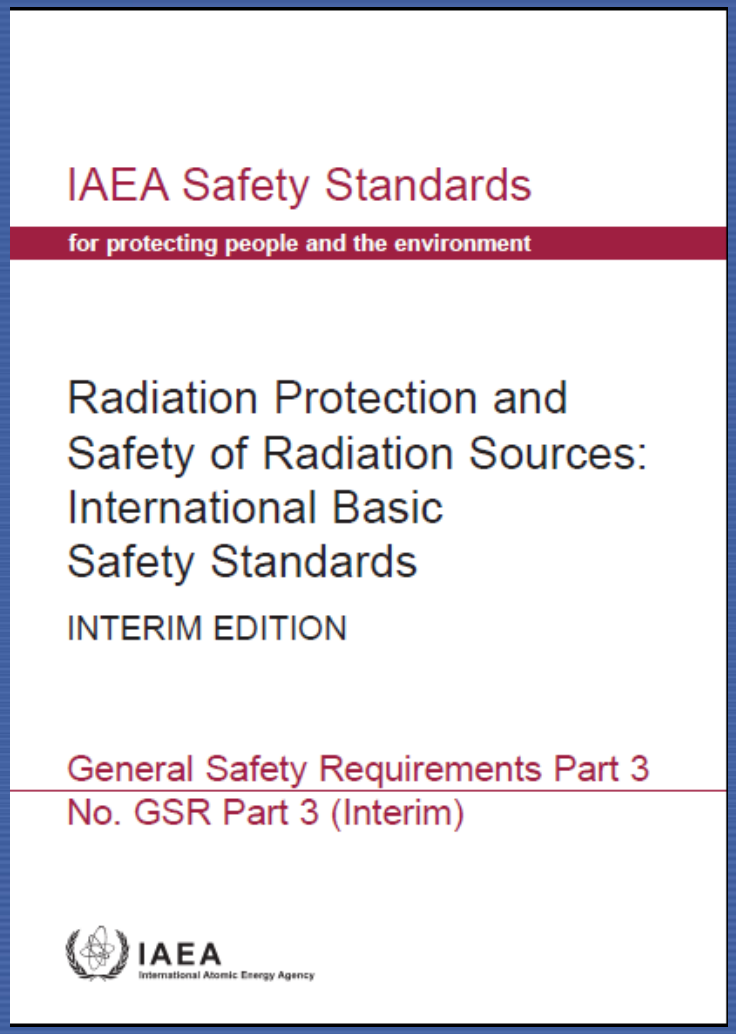
Basis IAEA Publications

- Safety Standards : Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards INTERIM EDITION, GSR Part 3 (2011)
- IAEA Safety Guide RS-G-1.7, Application of the concepts of exclusion, exemption and clearance (2004)
- IAEA Safety Report 44, Derivation of activity concentration values for exclusion, exemption and clearance (2005)

Ch5 Exemption and clearance Audio file D1_2 Ch5a



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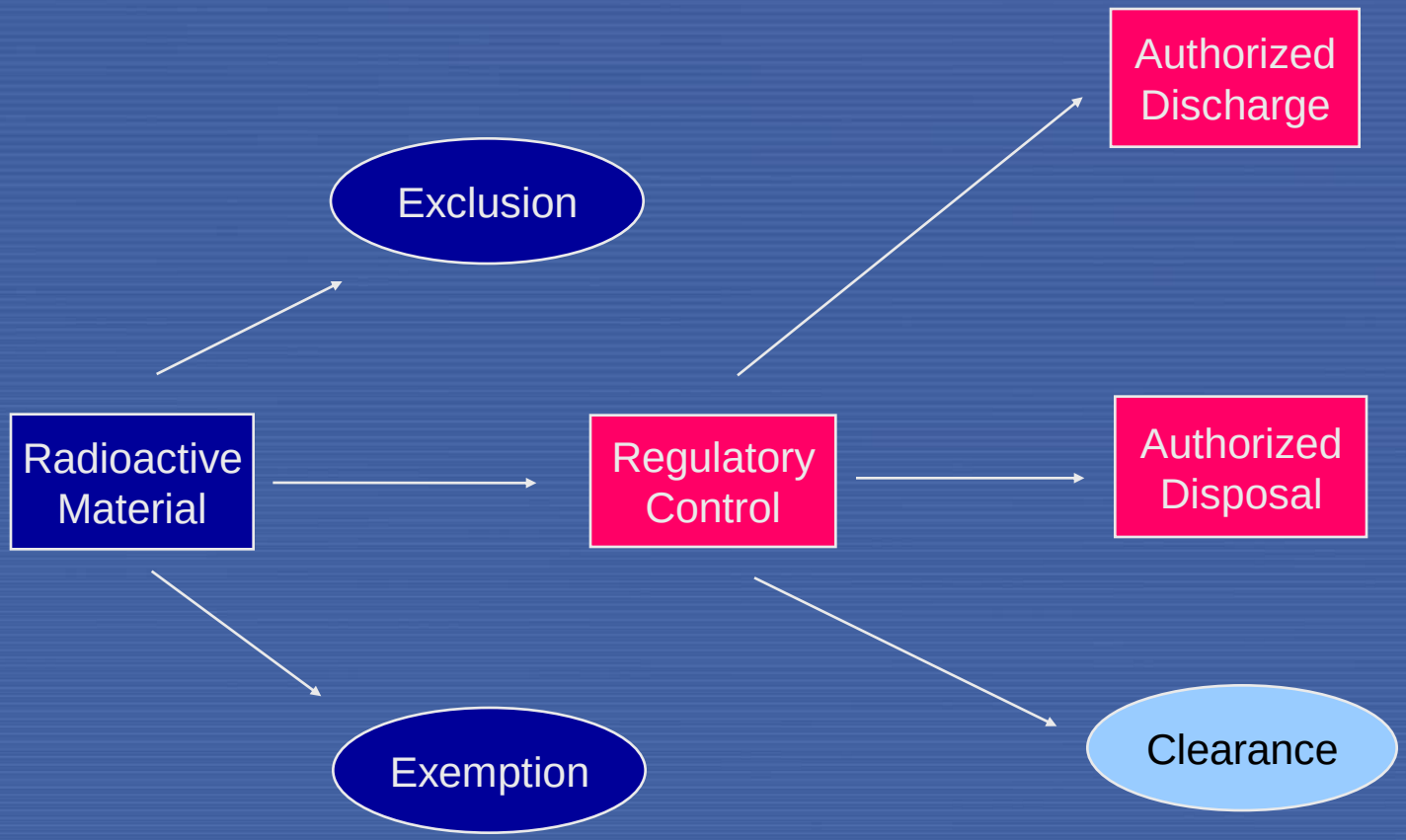
Options for Radioactive Material Control



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Exclusion

- An exposure that is essentially unamenable to control may be EXCLUDED from regulation
- Examples are exposures from:
  - ^{40}K in a (human) body
  - Cosmic radiation on the surface of the earth
  - Unmodified concentrations of radionuclides in most raw materials
  - Gaseous discharge, through a building ventilation system, of radon and associated daughters arising from the ground or construction materials
- All represent entire categories of exposure regardless of exposure, quantity or concentration

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Exemption

- **Practices and sources within practices can be EXEMPTED from regulatory control (notification, registration or licensing) if the sources meet EXEMPTION CRITERIA ie if:**

  total activity of a given nuclide present on the premises at any one time

  or

  the activity concentration used in the practice

  does not exceed the exemption levels

- **Examples: Smoke detectors, use of uranium for colouring glass, thoria for crucibles**
- **Note: The practice must still be justified**

Exemption - Principles

- Radiation risks to individuals are sufficiently low as to be of no regulatory concern
- Collective radiological impact is sufficiently low as not to warrant regulatory control under prevailing circumstances, trivial radiation risk
- The practice or scenario is inherently safe, with no likelihood of scenarios that could lead to a failure to meet the above two principles
- Applies to moderate quantities of material (at most on the order of a tonne)

Trivial Dose

- Corresponds to a dose and a risk level that which have no significant effect as regards to individuals:
  - Annual risks of death below to 10^{-6} p.a. are of no concern
  - Corresponds to annual dose level of 20 μSv
- Annual exposure to natural background, which is normal and unavoidable, provides a relevant reference level. This is typically a few thousand μSv
- An individual may be exposed to radiation from several exempted practices; it must be ensured that the total dose does not exceed the trivial level
- Therefore, the IAEA recommends 10 μSv in a year

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Exemption Criteria

- Exemption must meet the following criteria:
  - Effective dose to any member of the public is of the order of 10 μSv or less in a year
  - Collective effective dose committed by one year of performance of the practice is no more than about 1 man-Sv

  Or
  - An assessment for the optimization of protection shows that exemption is the optimum option

Exemption Levels

- Dose criteria apply to both workers and public
- Exemption Levels given in BSS
  - Based on scenarios using limited amount of material (less than 1 tonne)
  - Expressed in activity concentrations (Bq/g) and total activity (Bq)
- Exempt practices involve small-scale use of radionuclides

Typical levels

Some typical levels for exemption without further consideration (BSS 2011)

	Bq/g	Bq
Co-60	10	100,000 (2uCi)
Cs-137	10	10,000
U-238	10	10,000
Th-232	10	10,000
Am-241	1	10,000

Exemption is intended for small amounts of radioactive material and the practices that use them; invariably, the quantity of radioactive material is less than one tonne

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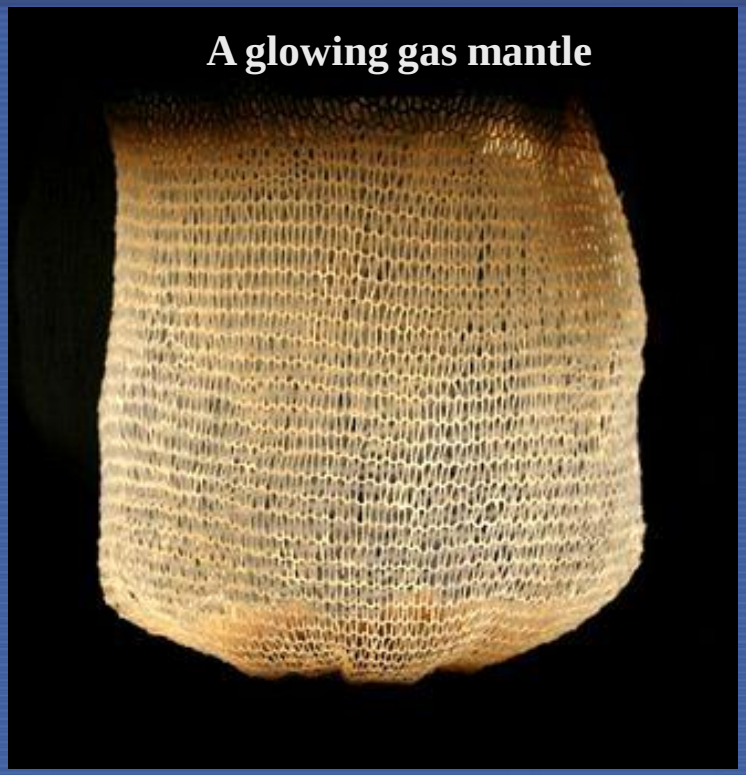
Exemption examples



Uranium glass

Photos – Wikipedia

UK allows 5kg of U or Th without registration
(about 20 MBq cf 10,000 Bq in BSS)

Clearance

- Clearance: removal of radioactive material or objects from any further regulatory control
- BSS: *Sources, including substances, materials and objects, within notified authorized practice may be released from further requirements … subject to complying with clearance levels approved by the Regulatory Authority*
- Can be used for recycling and reuse of materials or for disposal to conventional landfill sites (thus avoiding disposal as radioactive waste)

Importance of Clearance Levels

- Reduce the amount of material disposed as waste, thereby reducing cost - consistent with fundamental principles. If criteria are not established - resources will be wasted
- In decommissioning, need clearance criteria to determine when decommissioning is finished (decommissioning endpoint)otherwise a site might never be released from regulatory control

Impacts on National Policy

- Impacts on the amount of material to be disposed of have national repercussions as well as affecting operators
- Absence of clearance criteria can affect the ability to complete decommissioning & perform cleanups
- Inappropriate criteria can result in previously-cleared material becoming the focus for further remediation

Examples for Clearance

- Release of steel from nuclear installation to general scrap metal pool – but not always acceptable to recycling companies
- Release of waste oil from nuclear power plant:
  - Separation of water and oil
  - Filtering
  - Send for recycling
- Release solid hospital waste contaminated by ^{131}I
  - Allowing the ^{131}I decay
  - Disposal with other hospital wastes

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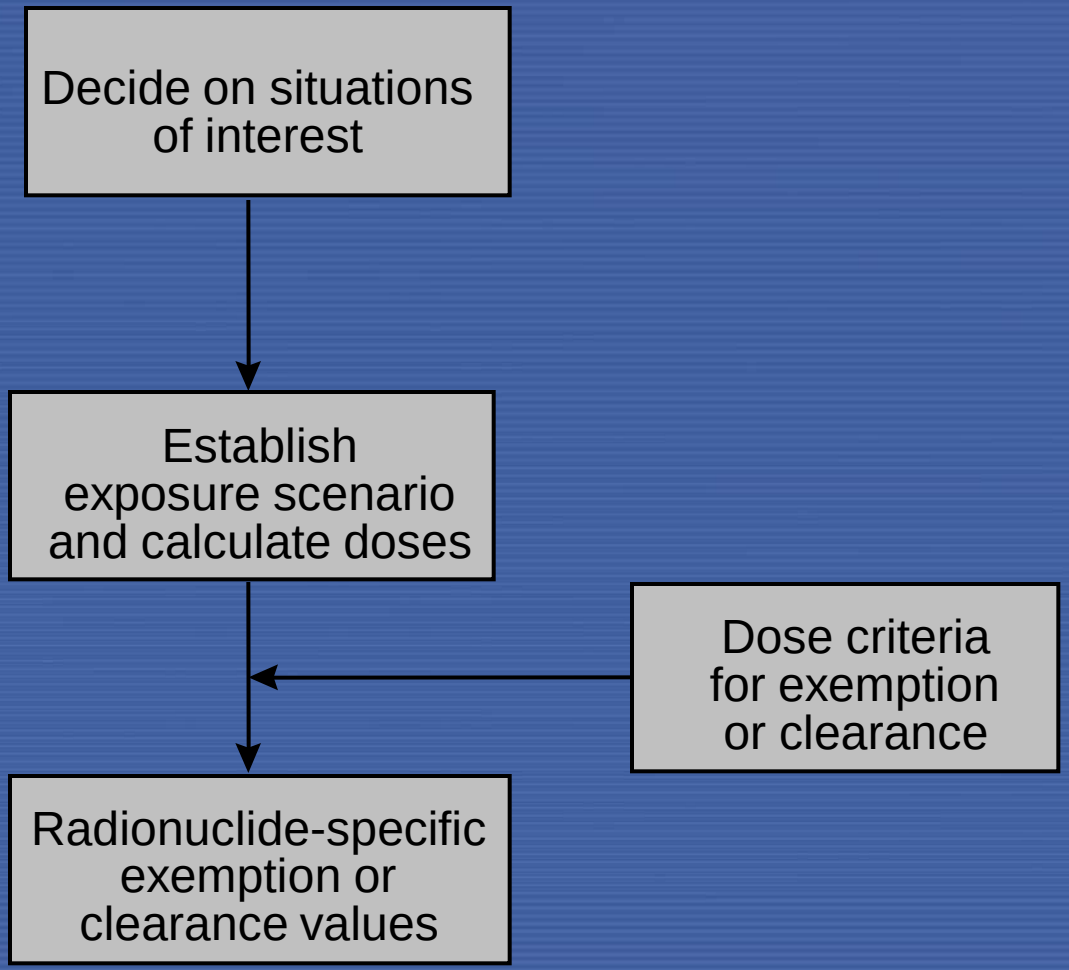
Nuclide-Specific Clearance Levels

- Dose criteria are the same as for exemption but for derivation of clearance levels different scenarios are used because greater (potentially much greater) amounts of material are involved (>1 tonne)
- Regulatory body either directly gives or approves clearance levels
- Clearance levels can be generic or defined case-by-case – could depend on the amount and the nature of the material concerned

Establishing Radionuclide-Specific Clearance Levels



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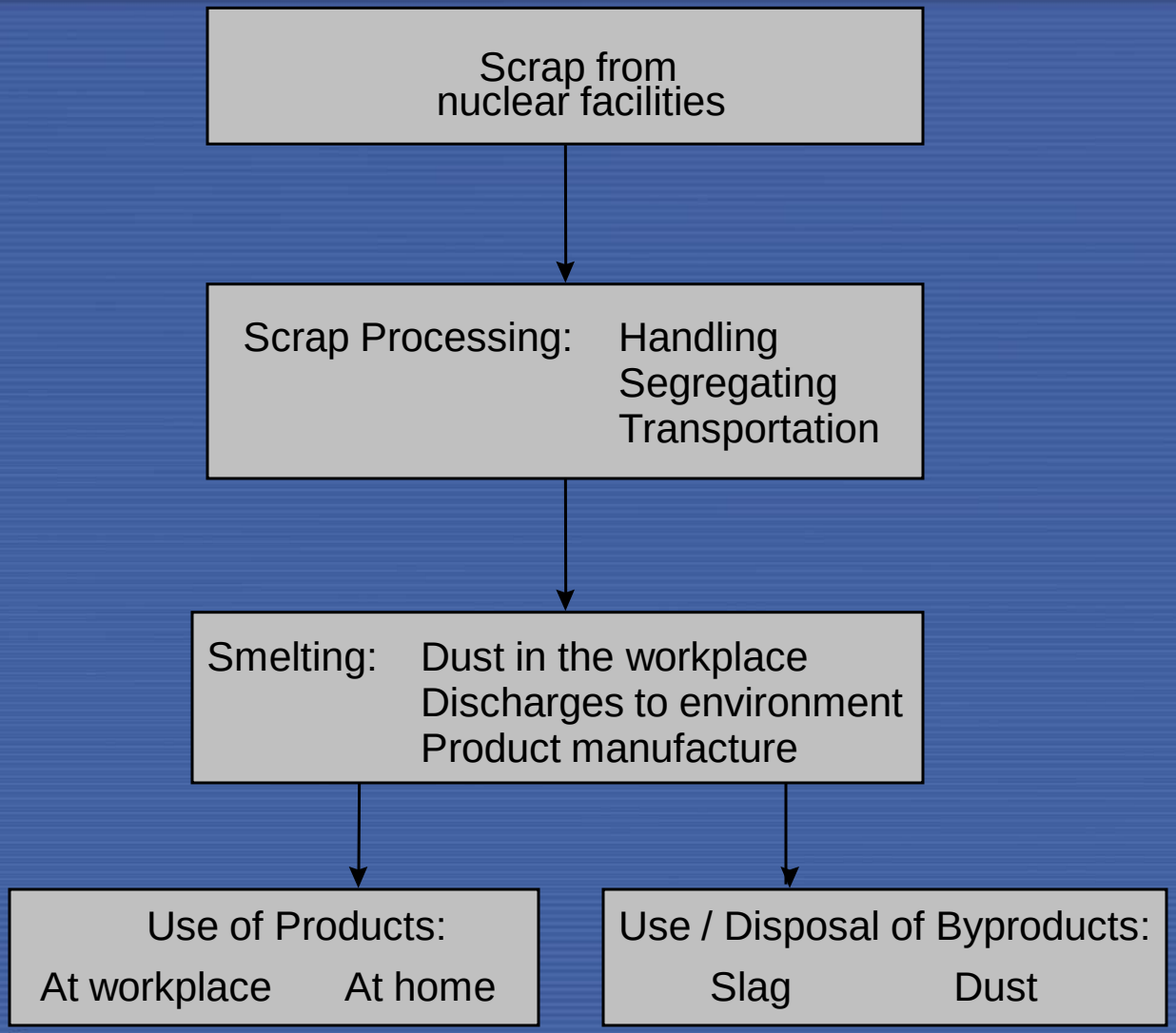
Calculating Clearance Levels for Scrap Metal



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Derivation of Generic Clearance Levels (RS-G-1.7)

- For artificial radionuclides: use scenarios representing typical exposure situations
  - Using realistic parameter values and a dose criteria of 10 μSv/a
  - Using low probability parameter values and a dose criteria of 1 mSv/a
  - Dose criteria to the skin of 50 mSv in a year
- Values developed for naturally occurring radionuclides based on worldwide distribution of activity concentrations by UNSCEAR (2000)
- Not applicable to food and drinking water (use Codex Alimentarius / WHO recommendations)

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Typical Clearance Levels

Nuclide	Bq/g
H-3	100
C-14	1
Mn-54	0.1
Fe-59	1
Co-60	0.1
Ni-59	100
Sr-90	1
Tc-99	1
I-131	10
Cs-137	0.1
Eu-154	0.1
Pu-238	0.1
Am-241	0.1

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Clearance Procedures

- Clearance using general clearance levels derived / approved by the regulatory body.
- Competent operator: activity measurements reliable, records kept, quality assurance in place, clearance plans given to the regulatory body.
- Reporting (e.g. annual information of amount and activity of cleared materials to the regulatory body)
- Case by case clearance:
  - No general clearance levels in place or
  - The general clearance levels are exceeded

  A case/site specific assessment has to be carried out

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Practical Application of Clearance

- Locate clearance instruments in low-background area
- Have process knowledge of the material (where did it come from, and its chain of custody)
- Non-porous materials are much easier to clear
- Clearance levels are set on a volumetric and surface contamination basis
- Material that is suspected to be alpha-contaminated is difficult to clear

Clearance examples

Metal re-melting
Photo courtesy Studsvik

Redundant steam generator arriving for decontamination and metal processing
Photo courtesy Studsvik

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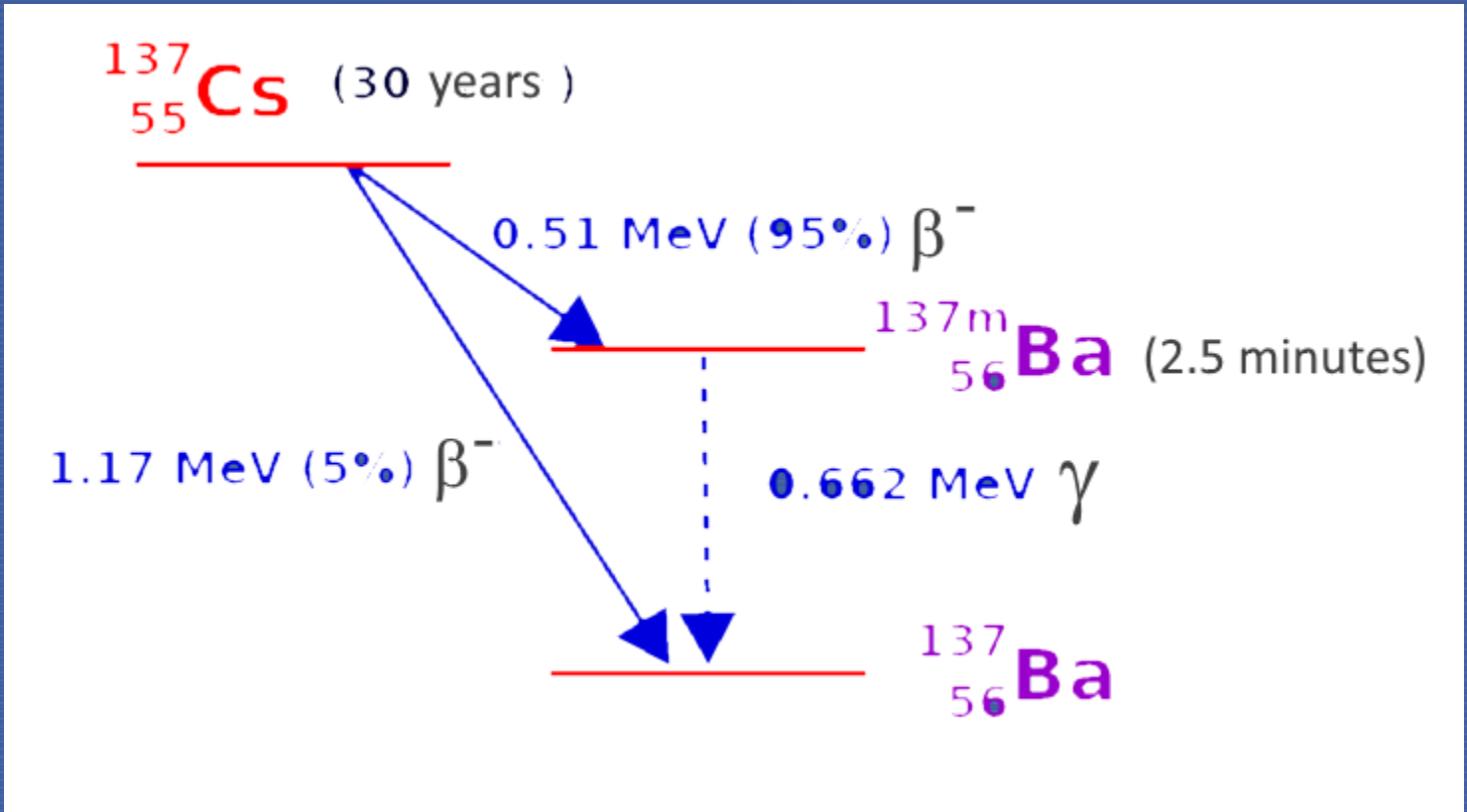
BSS Table 1-1

TABLE I-1: LEVELS FOR EXEMPTION OF MODERATE AMOUNTS OF MATERIAL WITHOUT FURTHER CONSIDERATION: EXEMPT ACTIVITY CONCENTRATIONS AND EXEMPT ACTIVITIES OF RADIONUCLIDES *(see footnotes 57 and 58)*

Radionuclide	Activity concentration (Bq/g)	Activity (Bq)
H-3	1×10^{6}	1×10^{9}
Cs-137[a]	1×10^{1}	1×10^{4}
U-238[a]	1×10^{1}	1×10^{4}

Cs-137 decay


137 55 Cs (30 years)
0.51 MeV (95%) β⁻
137m 56 Ba (2.5 minutes)
1.17 MeV (5%) β⁻
0.662 MeV γ
137 56 Ba

BSS Table 1-2

TABLE I-2. LEVELS FOR EXEMPTION OF BULK AMOUNTS OF SOLID MATERIAL WITHOUT FURTHER CONSIDERATION AND FOR CLEARANCE OF SOLID MATERIAL WITHOUT FURTHER CONSIDERATION: ACTIVITY CONCENTRATIONS OF RADIONUCLIDES OF ARTIFICIAL ORIGIN *(see footnote 58)*

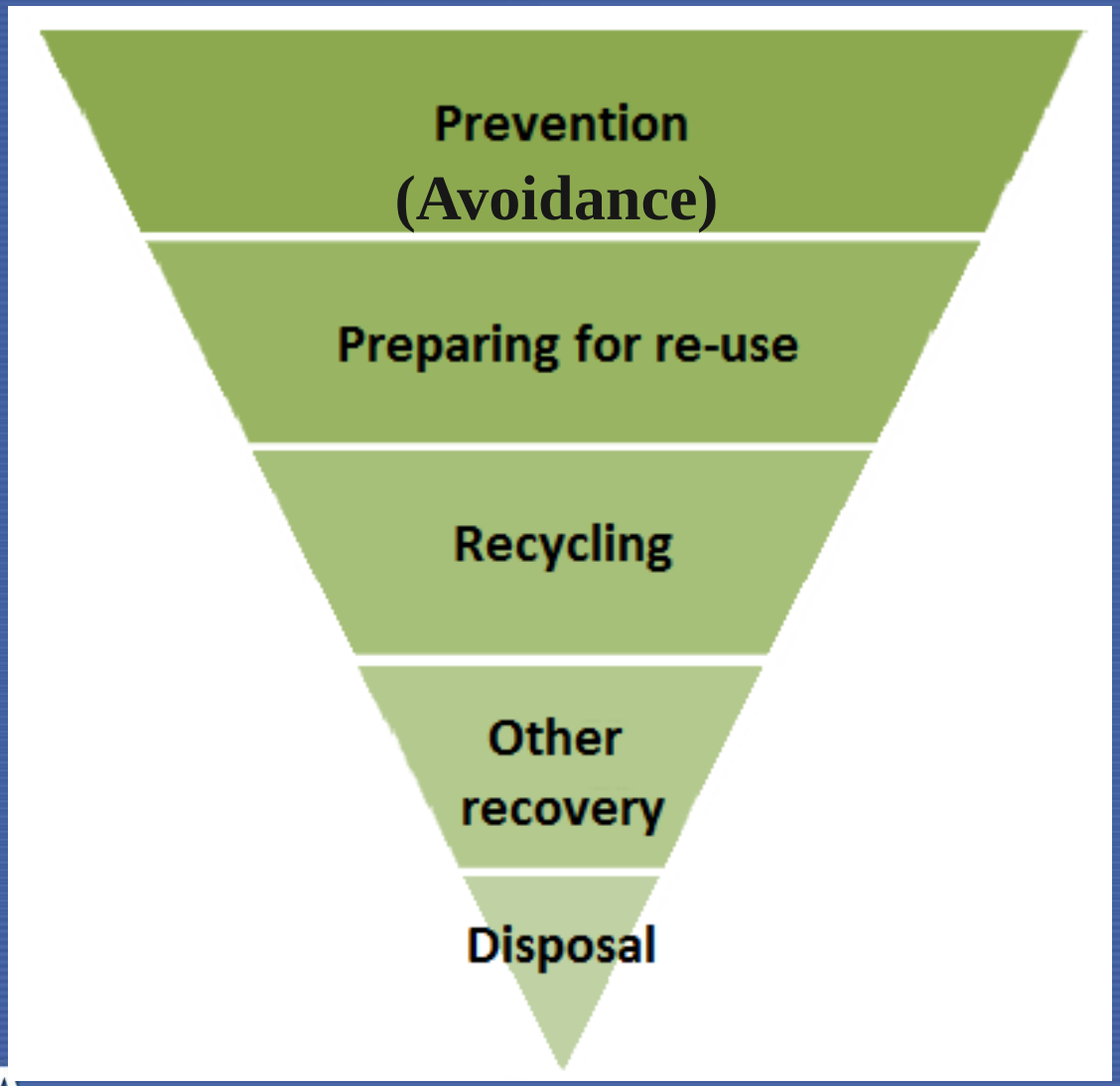
Radionuclide	Activity concentration (Bq/g)
H-3	100
Cs-137[a]	0.1
U-238	Not present

BSS Table 1-3

TABLE I-3: LEVELS FOR CLEARANCE OF MATERIAL: ACTIVITY CONCENTRATIONS OF RADIONUCLIDES OF NATURAL ORIGIN

Radionuclide	Activity concentration (Bq/g)
K-40	10
Each radionuclide in the uranium and thorium decay chains	1

Waste hierarchy



Increasing strategic preference

Increasing environmental impact

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Summary

- Exclusion is removal of entire types of materials from regulatory control (based on unamenability to control)
- Exemption / clearance of specific quantities of materials based on trivial risk (de-minimis)
- Levels for exemption and clearance without further consideration are listed in the BSS (downloadable)
- Exclusion, exemption and clearance provide a fundamental basis for waste segregation strategies
- Clearance levels are much lower than exemption