



IAEA

International Atomic Energy Agency
Atoms for Peace and Development

**NKS-B Workshop on Radioanalytical Chemistry in Nuclear Decommissioning
and Waste Management (RadWorkshop 2018)**

8-12 October 2018, Roskilde, Denmark

IAEA Safety Standards on Decommissioning, Clearance of Materials and Release of Sites from Regulatory Control

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Division of Radiation, Transport and Waste Safety

Radiological surveys during facility lifetime



- Radiological surveys of different kind and for different purposes are almost **continuous activity during all phases** of lifecycle of a facility that produces, uses, possesses, stores radioactive material
- Some of those surveys are **needed for decommissioning**
- Facility siting – **radiological “baseline” survey**, existing background prior to construction of a facility
- Construction – presence of **natural radioactivity in construction materials, trace elements** that could get activated

Radiological surveys during facility lifetime



- Operation – surveys for operational purposes, process control, working place monitoring, effluents control, cleanup of **spills and consequences of incidents**, radioactive waste management
- Transition from operation to decommissioning – **characterization campaign to support final decommissioning planning, detailed inventory of radioactive materials in the facility's premises and SSCs**
- Decommissioning conduct – radiation **safety of workers during dismantling**, effectiveness of **decontamination**, **management of material and waste** including clearance, effluents control
- Decommissioning termination – **final radiological survey**, release of site

Radiological surveys during facility lifetime

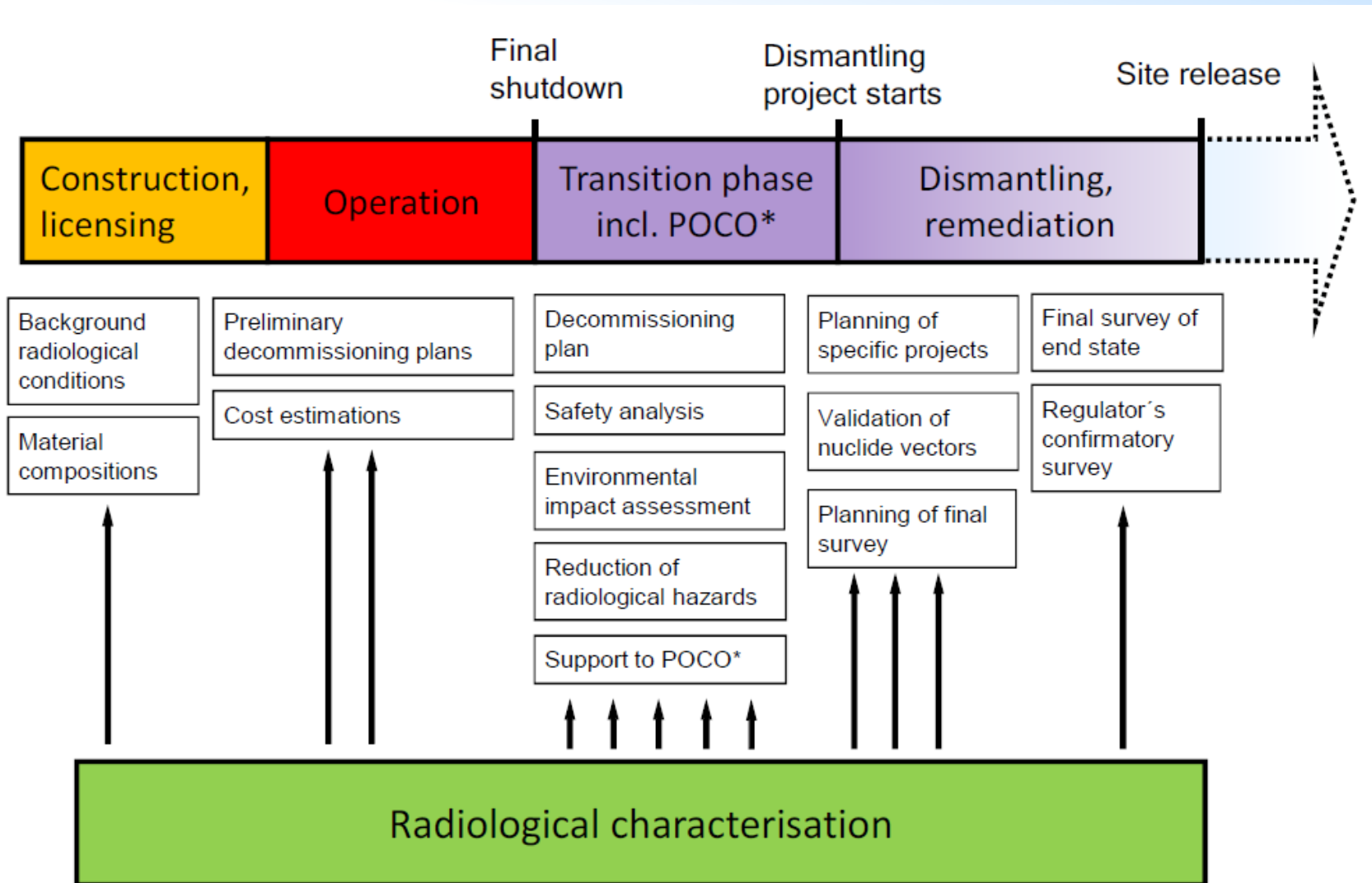
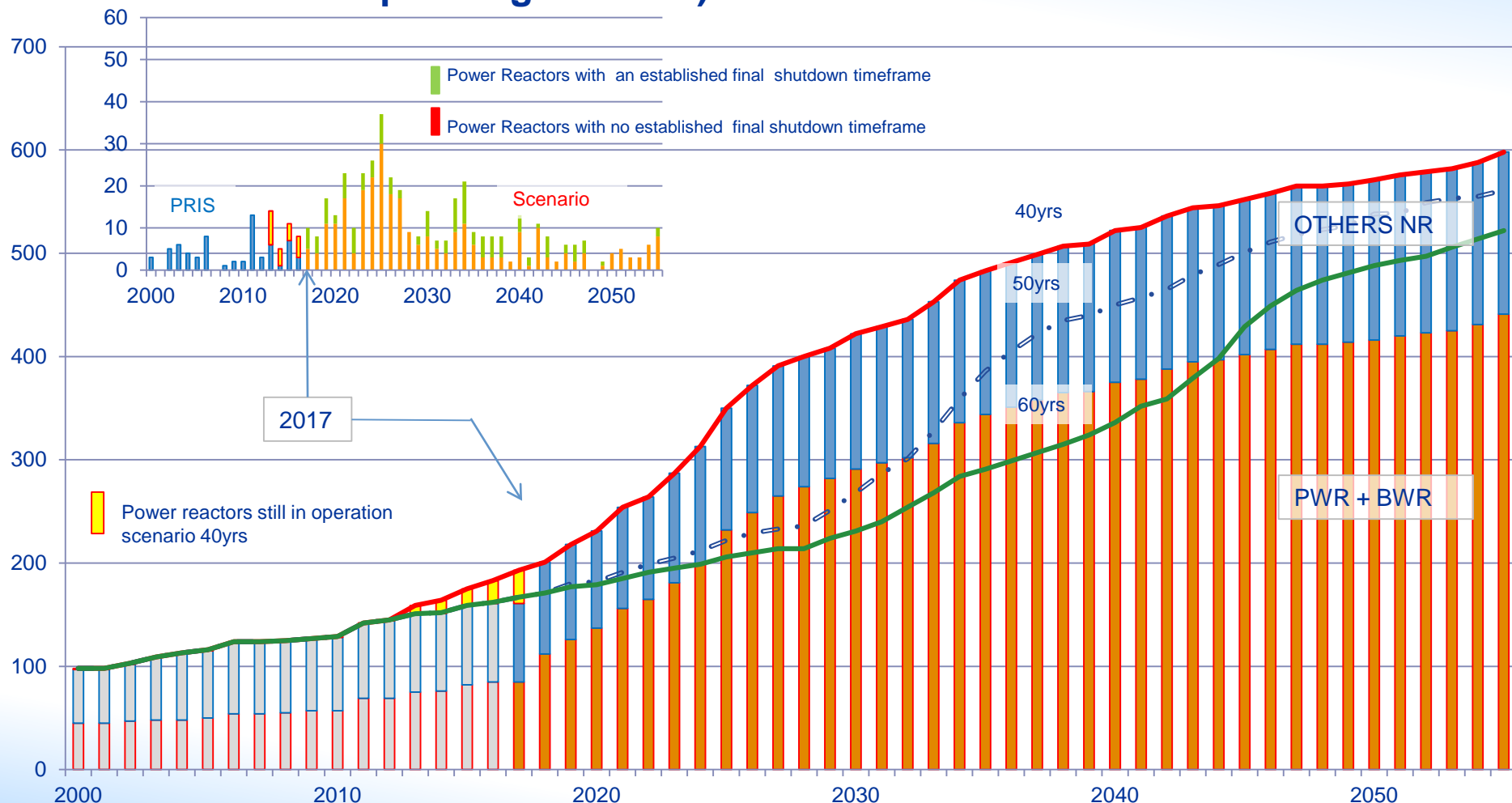


Fig. 2.1 from

*POCO = post-operational clean-out
removal of operational waste etc.

Decommissioning – growing industry

IAEA study 2017: Shutdown scenario (assumption of 40 years life time for operating reactors)



Decommissioning and clearance

- **Decommissioning** - administrative and technical actions taken to allow the **removal of** some or all of the **regulatory controls** from a facility (IAEA GSR Part 6)
- Objective – make the **site safe for reuse** for other purposes (often release of site from regulatory control) and properly **manage generated materials and waste**
- Decommissioning typically generates **large amounts of material** (potential to be recycled and reused) and **waste** (no intention for reuse)
- Those amounts are **larger than during operation** and are generated in a relatively **short period of time** (several years)
- Most of that material and waste is expected to be **radiologically clean or just slightly contaminated**

Decommissioning and clearance

- It could be **practical and economically viable to separate** the part that has to be managed as **radioactive waste** or reused within the nuclear applications (under continual regulatory control), and the **part that can be taken out of the regulatory control** (through clearance) immediately, after decontamination or after a decay
- With no clearance provisions in place, alternatives are:
 - to **keep** all the decommissioning waste **under regulatory control** (store locally) for a long period of time, or
 - to **dispose** it as **radioactive waste**
- Increasing number of **Member States requests** for assistance in **establishing provisions** for clearance and in **implementing clearance**
- **Existing guidance** in the IAEA Safety Standards (RS-G-1.7) and in supporting publications **does not satisfy needs** of Member States

Concepts of Exclusion, Exemption and Clearance



Exclusion, exemption and clearance define the **scope of regulatory control** as it applies to **planned exposure situations**.

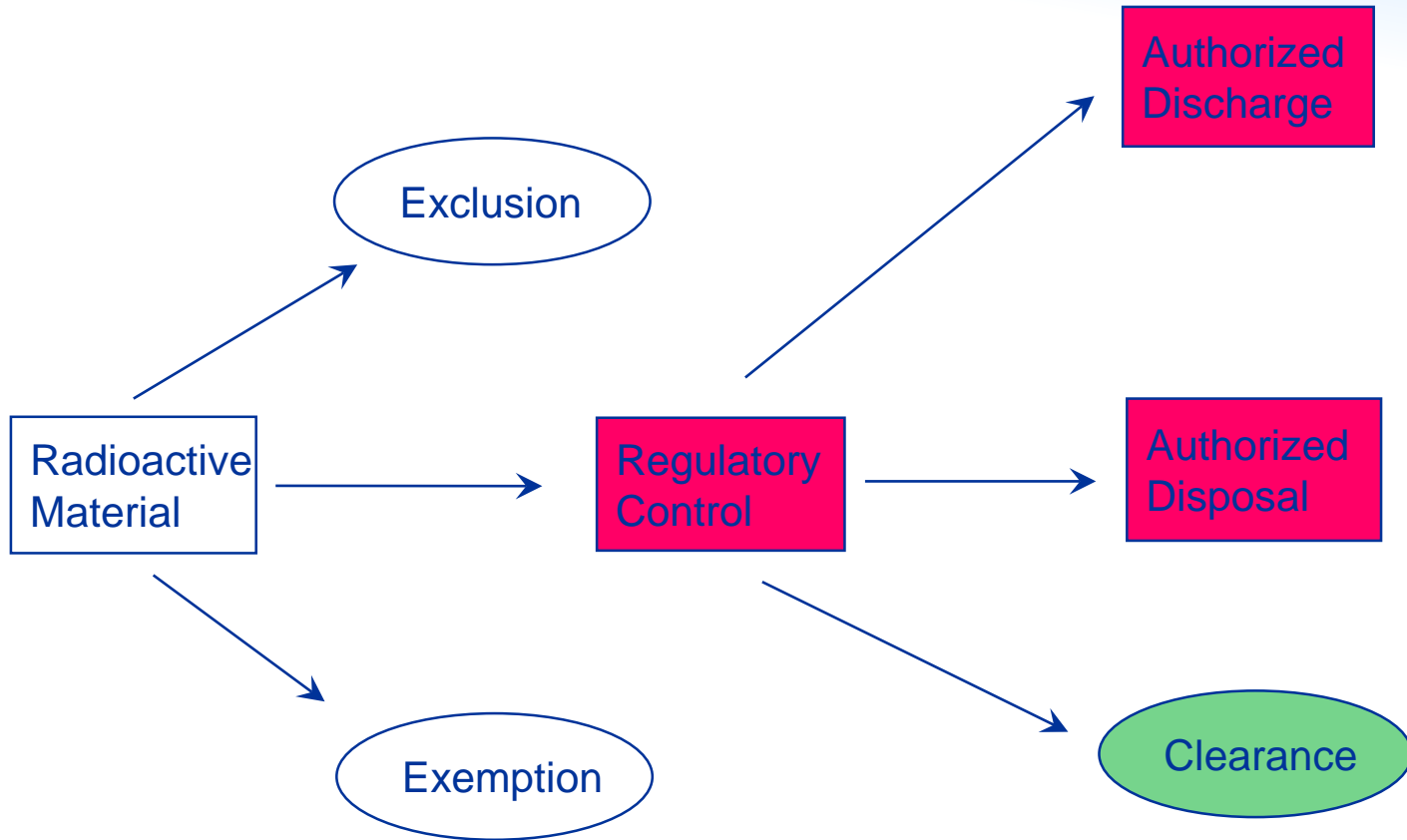
Exclusion applies to those planned exposures that are **not deemed amenable to control**, regardless of the magnitude of the exposures in question.

Exemption refers to the **determination by a regulatory body** that a **source or practice need not be subject to some or all aspects of regulatory control**.

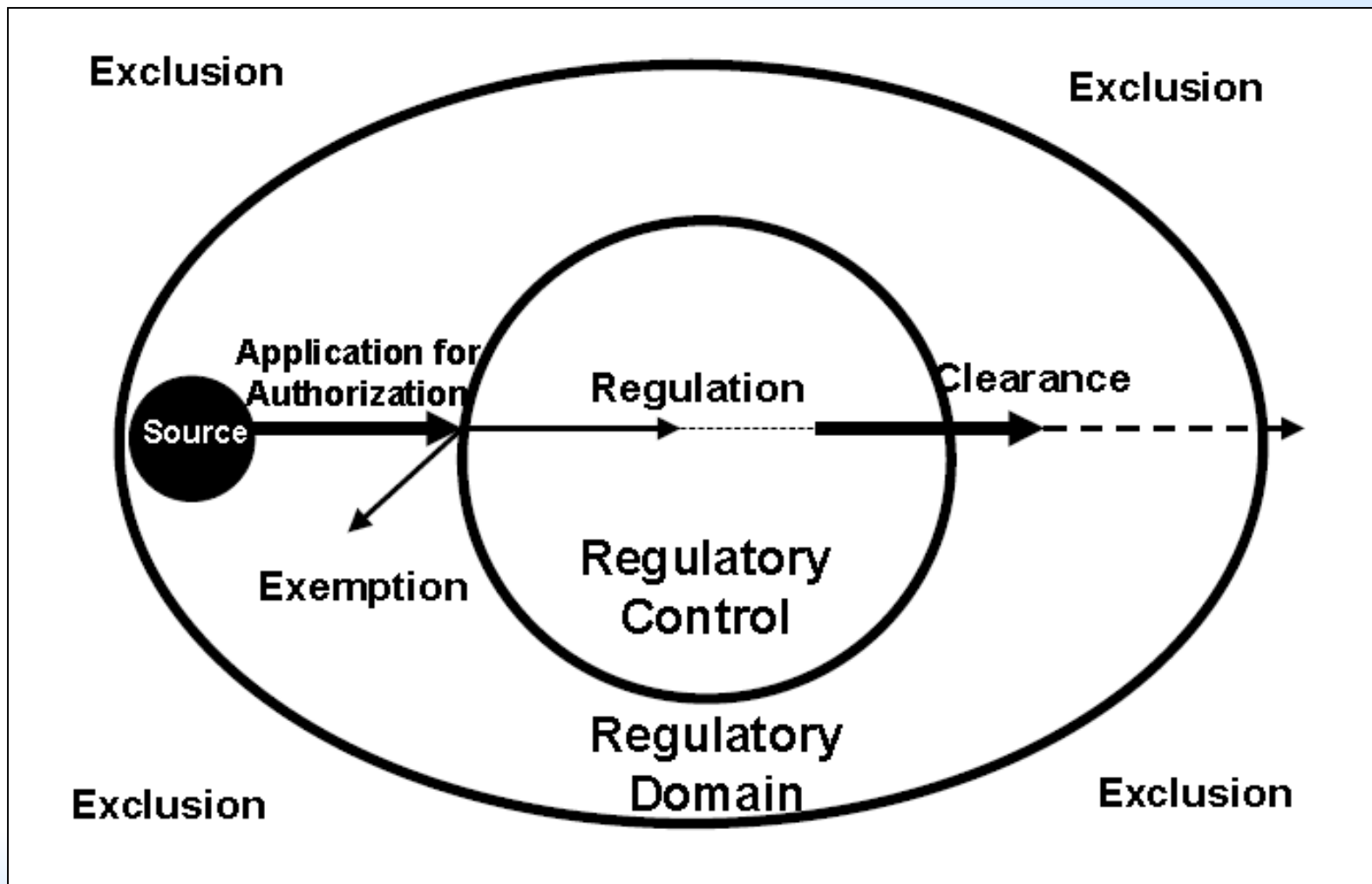
Clearance is the **removal of radiological regulatory control** from radioactive material or radioactive objects within notified or authorized practices.

The process of clearance is a **regulated activity** and the clearance process is carried out in accordance with the **regulatory regime for the practice**.

Options for control of radioactive material



Exemption vs. Clearance



Relevant IAEA publications

IAEA Safety Standards

for protecting people and the environment

Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards

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General Safety Requirements Part 3
No. GSR Part 3



IAEA SAFETY STANDARDS SERIES

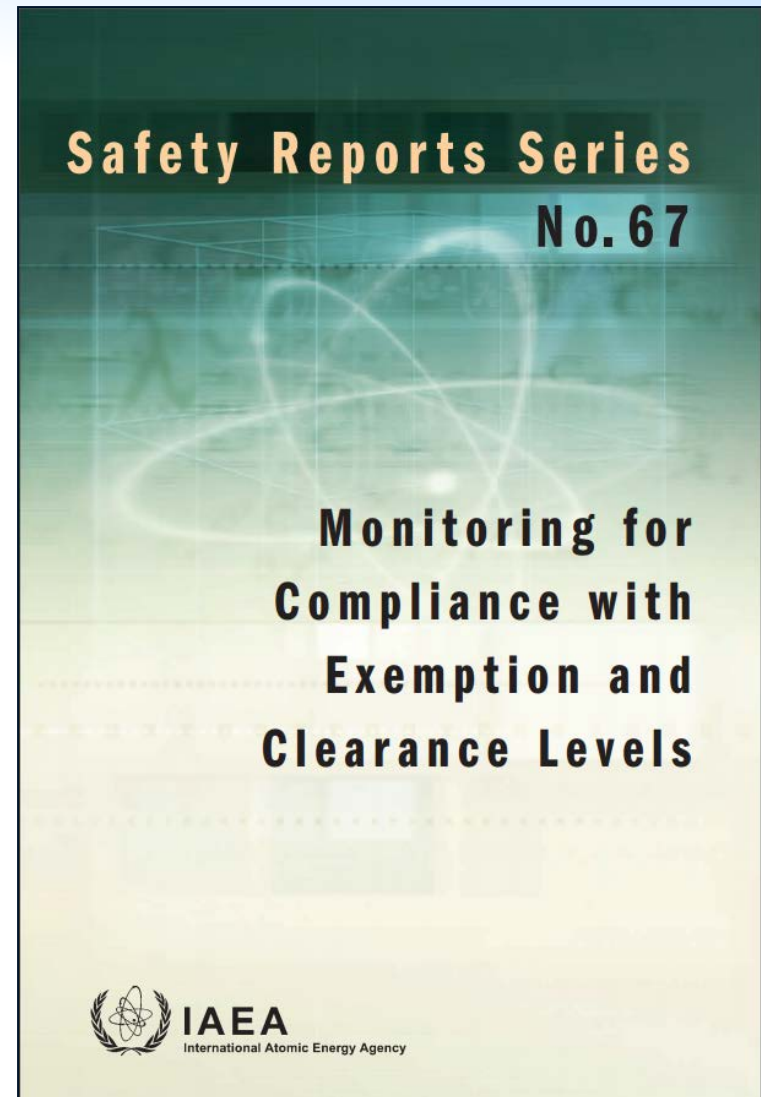
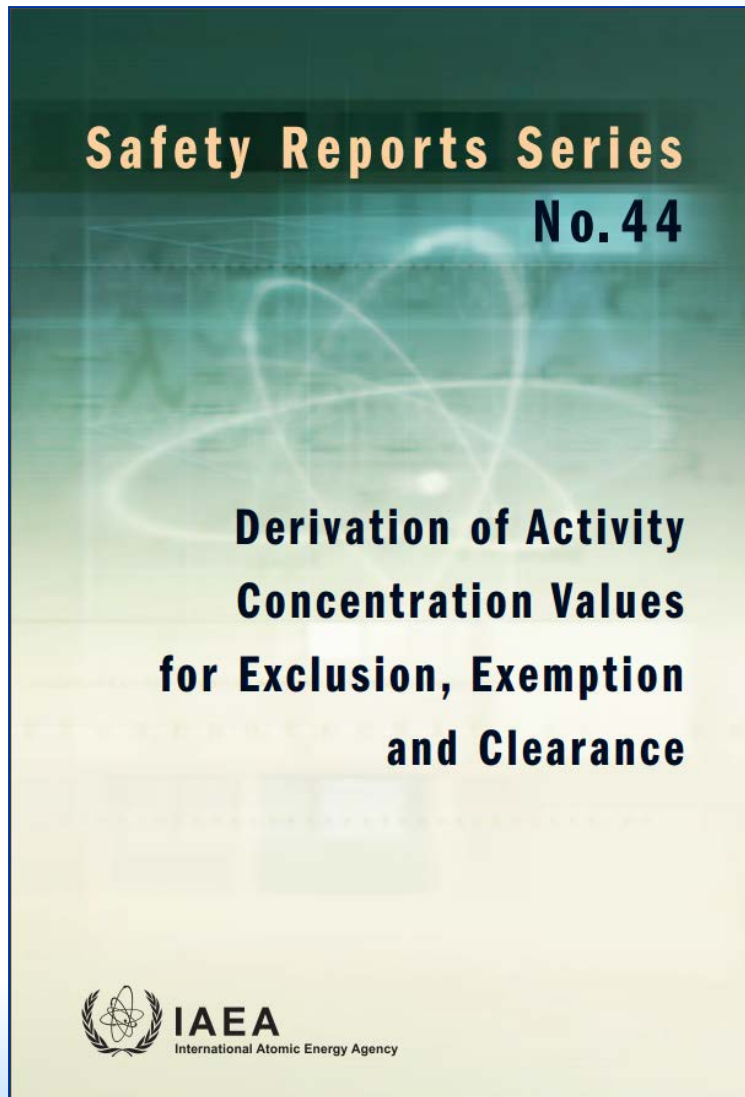
Application of the
Concepts of Exclusion,
Exemption and
Clearance

SAFETY GUIDE

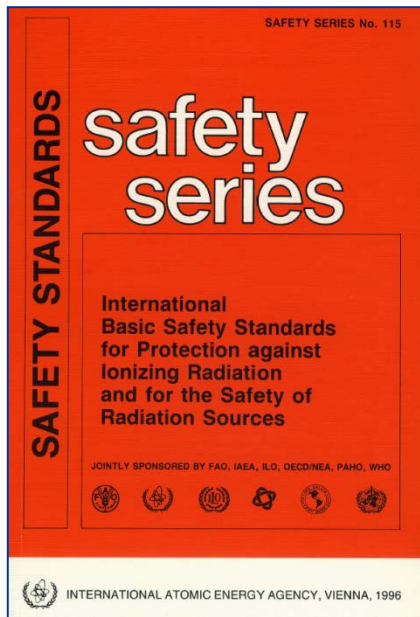
No. RS-G-1.7



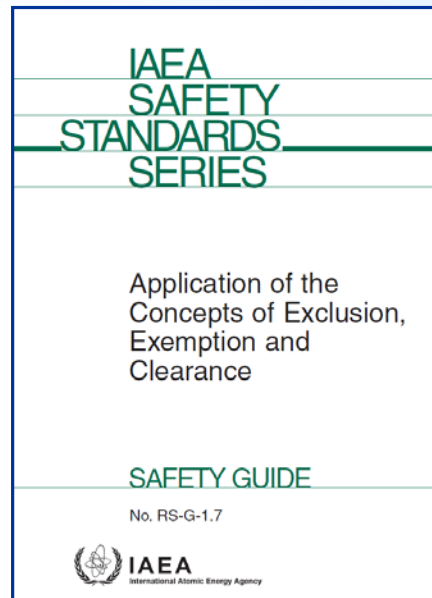
Relevant IAEA publications



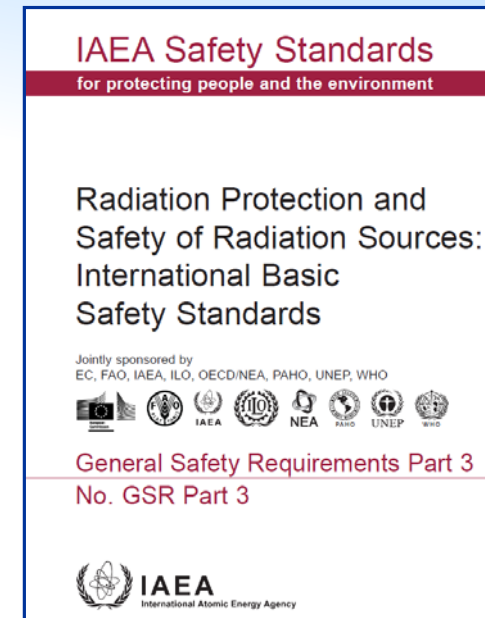
Relevant IAEA publications



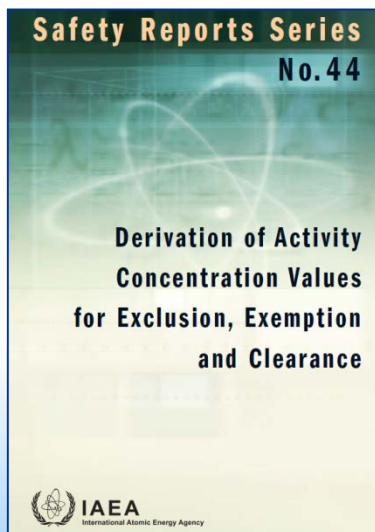
1996



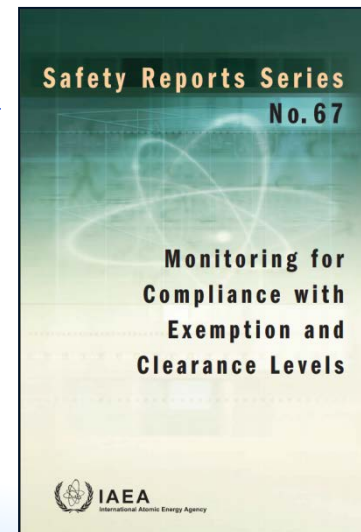
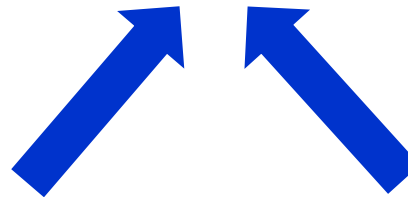
2004



2014



2005



2012

Clearance / Exemption

GSR Part 3 (BSS)

Requirement 8: Exemption and clearance

- The **government or the regulatory body** shall determine which **practices or sources** within practices are to be **exempted** from some or all of the requirements of these Standards. The **regulatory body** shall approve which **sources, including materials and objects**, within notified practices or authorized practices may be **cleared** from regulatory control.
- *Similar **dose and risk criteria** applied for both exemption and clearance.*

Criteria for clearance (BSS Schedule I)

I.10. The general criteria for clearance are that:

- a) **Radiation risks** arising from the cleared material are **sufficiently low** as not to warrant regulatory control, and there is no appreciable likelihood of occurrence for scenarios that could lead to a failure to meet the general criterion for clearance; or

- b) **Continued regulatory control** of the material would yield **no net benefit**, in that no reasonable control measures would achieve a worthwhile return in terms of reduction of individual doses or reduction of health risks.

Criteria for clearance (BSS Schedule I)

Clearance of material without further consideration if

- in reasonably foreseeable circumstances, effective dose for any individual from this material on the order of **10 μ Sv or less in a year**
- and for low probability scenarios **1 mSv in a year**

Clearance levels (CL) in the BSS:

- Table 1.2 – for **any quantity** of solid material
- identical to exemption values for bulk amounts of solid material

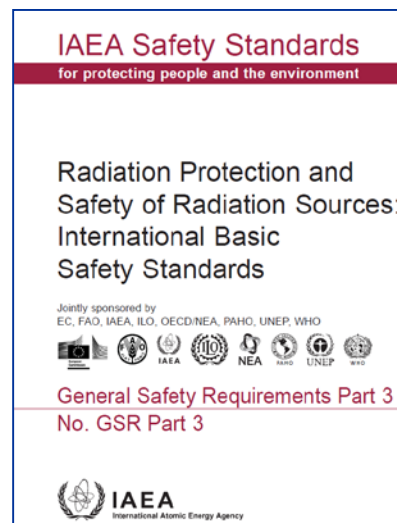
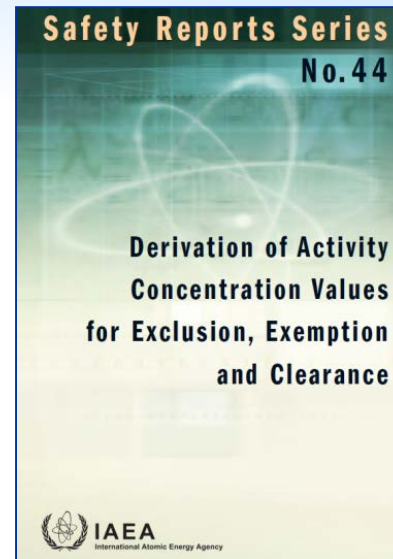
Derivation of clearance and exemption levels

Clearance levels in the IAEA-BSS

- Determined that the **cleared material** may be **used without any further restrictions**
- Based on IAEA SRS-44

IAEA-BSS – Footnote 65

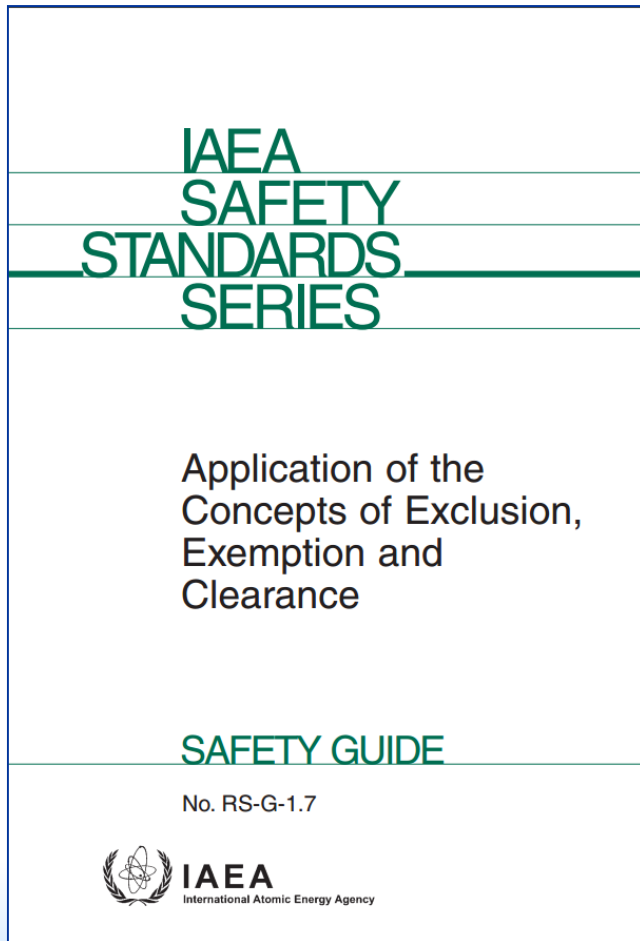
... **specific clearance levels** may be developed for metals, rubble from buildings and waste **for disposal in landfill sites:**
“Conditional clearance levels”



Interdependence of clearance and exemption levels

- The concepts of clearance and exemption are **different** in nature
- Clearance levels are derived based on **different assumptions / different purpose** than exemption levels
- Using only **one set of values** for both concepts is **not necessary** in principle, but there are also **advantages** of having a single set of values
- If values are different, take the **lower one**
 - in some cases **unnecessary conservatism**
- **Clearance levels shall not be higher than exemption levels**

Current guidance in RS-G-1.7



- Provides **mass specific** values for exemption or clearance (**unconditional**) of bulk quantities of **solid** material.
- Values are provided for both **natural** and **artificial** radionuclides.
- The **models** used in the calculations of individual dose are described in SRS-44 (scenarios primarily **relevant for clearance**, more restrictive)
- These values now appear in GSR Part 3, together with the values for **exemption of moderate amounts** of material from SS-115
- Regarding natural radionuclides, the values were selected on the basis of consideration of the **upper end of the worldwide distribution** of activity concentrations in soil provided by UNSCEAR

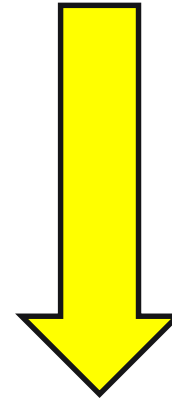
IAEA Safety Guides for decommissioning

DS452

DS403

<p>IAEA SAFETY STANDARDS SERIES</p> <p>Decommissioning of Nuclear Power Plants and Research Reactors</p> <p>SAFETY GUIDE</p> <p>No. WS-G-2.1</p> 	<p>IAEA SAFETY STANDARDS SERIES</p> <p>Decommissioning of Nuclear Fuel Cycle Facilities</p> <p>SAFETY GUIDE</p> <p>No. WS-G-2.4</p> 	<p>IAEA SAFETY STANDARDS SERIES</p> <p>Decommissioning of Medical, Industrial and Research Facilities</p> <p>SAFETY GUIDE</p> <p>No. WS-G-2.2</p> 
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In publication



IAEA Safety Standards
for protecting people and the environment

Decommissioning of
Facilities

General Safety Requirements Part 6
No. GSR Part 6



Revision of RS-G-1.7 has just started.


DS499 and DS500

IAEA
SAFETY
STANDARDS
SERIES

Application of the
Concepts of Exclusion,
Exemption and
Clearance

SAFETY GUIDE


No. RS-G-1.7



IAEA Safety Standards
for protecting people and the environment

Release of Sites from
Regulatory Control on
Termination of Practices


Safety Guide
No. WS-G-5.1

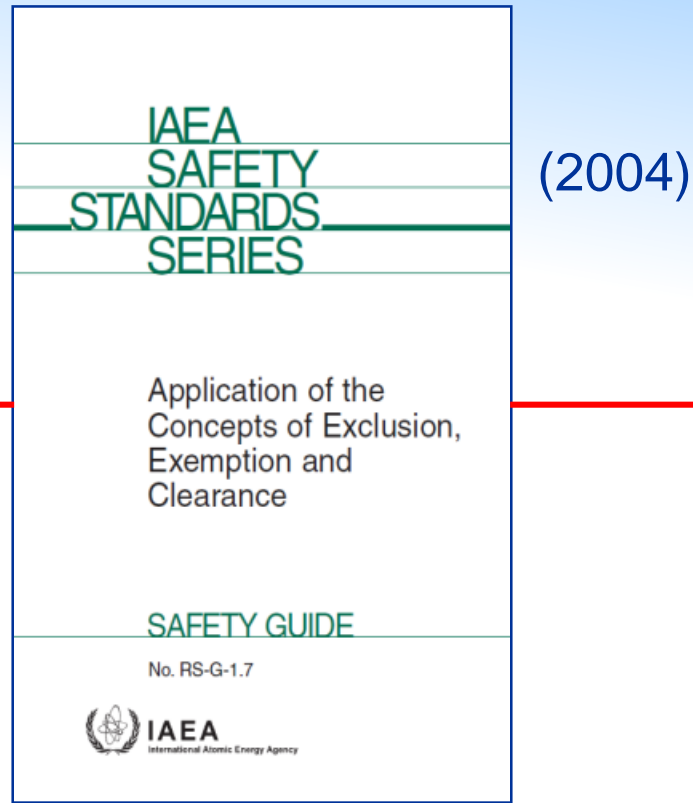


IAEA Safety Standards
for protecting people and the environment

Safety Assessment for the
Decommissioning of
Facilities Using
Radioactive Material

Safety Guide
No. WS-G-5.2





**New Safety Guide on
Application of the Concept
of Exemption (DS499)**

**New Safety Guide on
Application of the Concept of
Clearance (DS500)**

Being developed in parallel

New Safety Guide on Application of the Concept of Clearance – Objective and Scope

- The objective of the Safety Guide is to provide **detailed guidance** on the **application of the concept of clearance** for materials and buildings that are to be released from regulatory control.
- There is **no intention to revise numerical values** provided in GSR Part 3
- Clarification on the **use of terminology**, especially the use of terms clearance and release;
- **Responsibilities** of the licensee and the regulatory body;
- All relevant steps of the **clearance process** including characterization, **determination of the nuclide vector**, **measurement techniques**, sampling, management of the clearance process;
- **Mass specific** and **surface specific** clearance criteria for unconditional clearance;

New Safety Guide on Application of the Concept of Clearance – Objective and Scope

- Examples of derivation of mass specific and surface specific clearance **criteria for conditional clearance** (actual values would depend on specific conditions applied, so no universal set of values could be proposed);
- **Case by case approach**, which can be used for small quantities of material, or for other situations where the assumptions for the generic derivation of clearance levels do not apply;
- Provide explanations on **needs for control of conditionally cleared materials** (for example during **transport**), clarify **at which point clearance act happens** in case of conditional clearance;
- Clearance in an area affected by consequences of a **nuclear or radiological accident**;
- Considerations of **clearance of liquids**;
- Consideration of **clearance of gases**;

New Safety Guide on Application of the Concept of Clearance – Objective and Scope



- Additional considerations for building materials containing **naturally occurring radionuclides**;
- Considerations of **averaging masses** and **averaging areas**;
- Discussion of the degree of **homogeneity** that was assumed in the calculation of the clearance levels and the implications for application of the clearance levels to non-homogenous material;
- Involvement of **interested parties**.

IAEA Safety Standards

for protecting people and the environment

Release of Sites from Regulatory Control on Termination of Practices

2006

Safety Guide

No. WS-G-5.1



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Background

- WS-G-5.1 published in 2006 (the same year as the Safety Fundamentals SF-1, and **prior to most of the current Safety Requirements** in the waste safety and radiation safety areas)
- Covers aspects of relevance to **decommissioning**, protection of public and the environment, and **management of radioactive waste**
- **Both the key related Safety Requirements** documents, the BSS and the decommissioning requirements, have been **revised in the meantime** (GSR Part 3 and GSR Part 6 published in 2014)
 - **New concepts and definitions** introduced (such as exposure situations)
- Two new decommissioning Safety Guides **DS452 and DS403** have been finalized and will be published soon. **Consistency** with them needs to be ensured
- Significant decommissioning **experience and lessons learned** accumulated since 2006 – **revision of WS-G-5.1 is needed**

The Process for the Release of Sites from Regulatory Control



- Identification of the **site release criteria** (generic or site specific)
- **Site characterization**
- **Comparison** of the site characterization results with the site release criteria ←
- If the site does not meet the release criteria, cleanup actions will be needed
- Evaluation of the **cleanup options**, selection of an **optimal** cleanup option and **end-point**
- Development of a **Cleanup Plan** by the operator (preferably as part of the overall decommissioning plan, should define restrictions, if any)
- **Review/approval** by the regulatory body
- **Implementation** of the cleanup actions (radiological monitoring during cleanup)
- **Final radiological survey** to demonstrate compliance with the site release criteria for restricted or unrestricted release
- Preparation of the **Final Radiological Survey Report** and submission to the RB
- **Review** of the Final Radiological Survey Report by the RB
- Independent **confirmatory survey** by the RB (optional)
- **Decision by the regulator on release of site** (with or without restrictions)
- **Implementation of restrictions, institutional control and monitoring** (if any), record keeping

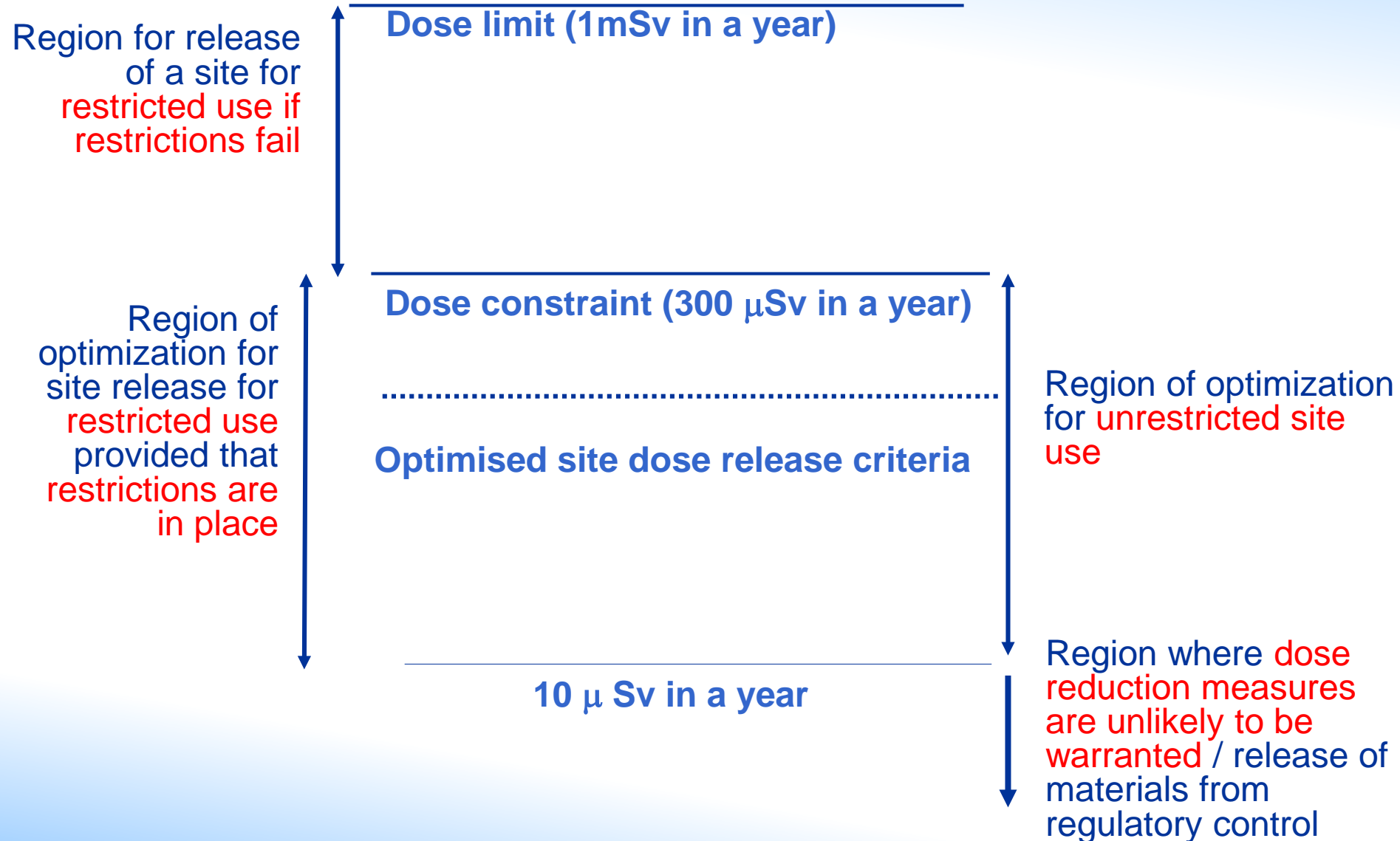
Protection and Safety Aspects

- Objective - to ensure **proper protection** of workers, the public and the environment **during the cleanup and after the release of the site**.
- The principles of **justification**, **dose limitation** and **optimization of protection** are applicable to cleanup and release of sites.
- Dose limit of **1 mSv** in a year for a member of the public is an **upper bound** for the sum of all exposures arising from authorized activities.
- Optimization of protection should include:
 - evaluation of the **exposure of workers during cleanup activities** (i.e. including material characterization and radioactive waste management);
 - evaluation of **long term exposure of the public** arising from the residual site contamination **after site release**.
- This evaluation need to ensure that the protection of workers and the public is optimized below the **dose constraints** defined by the RB.

Protection and Safety Aspects

- This dose constraint should take into account **multiple pathways** of exposure and should not exceed **300 μ Sv in a year above background**.
 - **Prospective effective doses** to members of the public above the background levels (before the commissioning of the facility) that would be received after the site has been released;
 - **Summed effective doses** arising from the site (considered as one source), **including land and buildings** and other structures;
 - The **uncertainties** associated with knowledge of the site and its potential uses after its release **should be taken into account** in the estimation of prospective doses.
- The applicable **dose constraint** for the public after the release of a site should be expected to be **no higher than that applied for the operational phase** of the facility lifetime.

Radiological Approach to the Release of Sites from Nuclear Regulatory Control (WS-G-5.1)



Definition of Release Criteria

- Generic or site specific criteria
 - Definition of the **scenarios** and identification of the **exposure pathways**;
 - **Compilation of the specific data** and information for the scenarios and pathways;
 - Definition of the **conceptual models** for the site;
 - Conduct of **dose assessments**;
 - Determination of the **release criteria**.
- The release criteria should be expressed in **measurable and verifiable units** (Bq/g or Bq/cm²).
- The IAEA does not provide radionuclide specific site release levels (as it does for the release of materials)
- Background
- Uncertainties (level of contamination, hidden buried structures and waste, uncertainties associated with the future use of the site)

Final Survey

- **Direct measurements and/or sampling**
- **Determination of sampling locations**
 - Sampling equipment
 - Sampling technique / Sample size
 - Analysis / Measurement
- **In case of contamination: increase density of grid / additional samples**
- **Measurement Uncertainty**
 - The **radionuclide vector** will inevitably differ slightly from the initial radionuclide vector
 - **Monitoring techniques** (e.g. emission probabilities in complex spectra, self-absorption, scan speed and detector size in case of field measurements)
 - Sampling variation
 - **Analytical process** imprecision
 - **Background** variability
- **Comparison to the derived site release criteria**
- **Prepare a final survey report** (part of the final decommissioning report)

Materials and radionuclides

- Materials of primary interest
 - steel, aluminium, concrete, graphite, resins, soil, water
- Radionuclides – will depend on type of facility and decommissioning strategy
 - Activation products: ^3H , ^{14}C , ^{22}Na , ^{36}Cl , ^{39}Ar , ^{41}Ca , ^{54}Mn , ^{55}Fe , ^{59}Ni , ^{60}Co , ^{63}Ni , ^{65}Zn , ^{79}Se , ^{93}Mo , ^{93}Zr , ^{94}Nb , $^{108\text{m}}\text{Ag}$, $^{110\text{m}}\text{Ag}$, ^{125}Sb , ^{126}Sn , ^{133}Ba , ^{134}Cs , ^{152}Eu , ^{154}Eu , ^{155}Eu , $^{166\text{m}}\text{Ho}$
 - Fission products: ^{90}Sr , ^{99}Tc , ^{106}Ru , ^{129}I , ^{135}Cs , ^{137}Cs , ^{144}Ce
 - Transuranics: isotopes of Pu, Np, Am and Cm
- Levels of activities
 - From different categories of radioactive waste for processing, storage and disposal to materials for clearance and environmental samples

International Project on Completion of Decommissioning (2018-2021)



- Increasing number of ongoing decommissioning projects worldwide (for different types of facilities), some nearing completion
- Aspects that need to be discussed include:
 - end state definition
 - site release criteria
 - final cleanup, final survey
 - regulatory process for release of sites
 - release with restrictions / institutional controls
- New IAEA international project COMDEC - platform for exchange of information, cooperation, “community of practice”
- 3 years, TM and CS meetings, working groups
- First TM held in Vienna 24-28 September 2018

Summary

- Concepts of exemption and clearance are related to **graded approach to regulation** of sources, practices and materials
- **Clearance** is an important **option for management of material and waste** from operation and from decommissioning of facilities, it enables for **significant reduction** of amounts to be managed as **radioactive waste**
- **Increased interest** in Member States and more frequent **demands for assistance** related to clearance, including conditional clearance
- The IAEA initiated **revision of existing guidance** on exemption and clearance - **two Safety Guides** and **several supporting publications** will be developed
- General intention with the revision is to **bring successful concepts, practices and experiences** from some Member States **into the IAEA Safety Standards**, providing **point of reference** for other Member States who want to follow such approaches

Summary

- With progress of decommissioning projects, the aspects related to release of sites attract more attention
- The IAEA will start soon revision of the Safety Guide on release of sites (WS-G-5.1)
- Both clearance of materials and release of sites deal with **low effective doses to members of public**, which can't be measured, so use of **complex radiological models** is needed
- Good knowledge of **concentrations of DTM radionuclides** and **nuclide vectors** is essential for application of radiological models and for decision making with regard to clearance, characterization of radioactive waste and release of sites
- **Radiochemical methods** for determination of DMT radionuclides are of **key importance**

References



IAEA GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Safety Standards (2014)

IAEA GSR Part 5, Predisposal Management of Radioactive Waste (2009)

IAEA GSR Part 6, Decommissioning of Facilities (2014)

IAEA SSG-47, Decommissioning of Nuclear Power Plants, Research Reactors and Other Nuclear Fuel Cycle Facilities – in publication, revision of WS-G-2.1 and WS-G-2.4

IAEA RS-G-1.7, Application of Concepts of Exclusion, Exemption and Clearance (2004) – under revision (DS499 and DS500)

IAEA WS-G-5.1, Release of Sites from Regulatory Control on Termination of Practices (2006)

IAEA SRS 44, Derivation of Activity Concentration Values for Exclusion, Exemption and Clearance (2005)

IAEA SRS 67, Monitoring for Compliance with Exemption and Clearance Levels (2012)

IAEA SRS 72, Monitoring for Compliance with Remediation Criteria for Sites (2012)



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Thank you!

