Clearance and Recycling of Material from Decommissioning of Nuclear Installations in Various Countries

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Overview

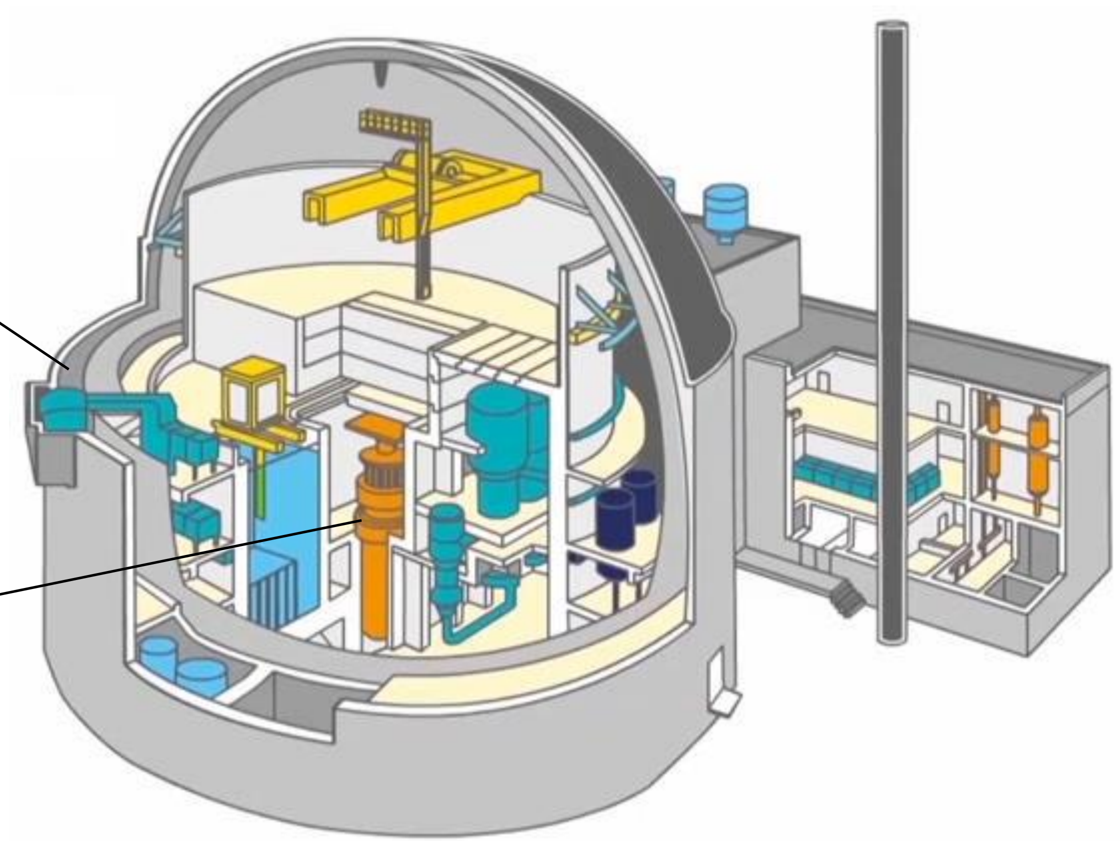
- Material from decommissioning of nuclear installations
  - material streams and quantities
  - radionuclides and activities
  - potential for recycling/reuse
- Clearance as prerequisite for recycling
- Clearance options and clearance levels
  - historical development
  - IAEA guidance and national regulations
  - current international practice
- Future role of recycling for successful decommissioning of nuclear installations
- Conclusions

Material from Decommissioning - Material Streams and Quantities

- Main materials from nuclear power plants:
  - steel (carbon steel, austenitic steel)
  - concrete
  - cable, others

Concrete: 200.000 – 400.000 Mg

Steel: 10.000 – 30.000 Mg



Material from Decommissioning - Activities

- Metals and concrete in NPPs
  - activated in inner parts
    - reactor pressure vessel, internals
    - biological shield
    - adjacent structures
  - contaminated
    - most of the material, at different levels

- Contaminated material can be decontaminated
  - prerequisite for clearance and recycling

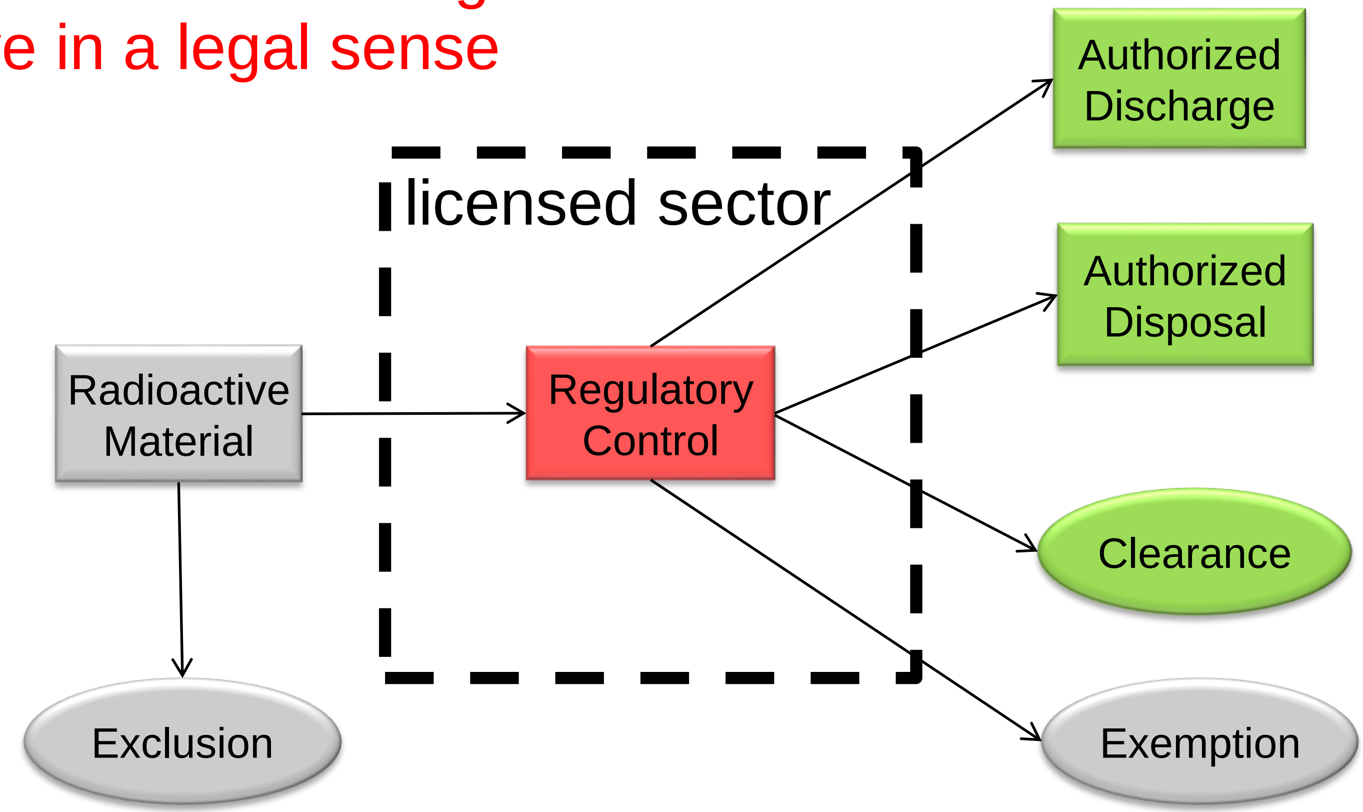
Material from Decommissioning - Potential for Recycling/Reuse

- Material from 1 NPP block eligible for recycling/reuse
  - a few 10,000 Mg steel
  - a few 100,000 Mg concrete

- Distribution:
  - largest part free or almost free of activity, immediate release
  - a few 10 % clearance after decontamination
  - a few % remain as radioactive waste

Clearance as Prerequisite for Recycling

- Material from a regulated (licensed) practice must be released for reuse/recycling in "conventional" sector
- Cleared material is no longer radioactive in a legal sense



HISTORICAL DEVELOPMENT

Historical Development
The Early Years – 1980s

- The first nuclear decommissioning projects brought with them the necessity to deal with large material quantities with contamination too low for treatment as radioactive waste
  - Examples of early decommissioning projects:
    - Elk River – 1968, Shippingport – 1982 (USA)
    - Gundremmingen – 1977, Niederaichbach – 1974 (GER)
    - JPDR – 1976 (JAP)
    - Windscale – 1981 (UK)
- Decisions on clearance on case-by-case basis
- Clearance levels from early radiological studies

Historical Development
Development of Guidance ~1990-1998

- Increase of decommissioning activities led to development of standardised clearance regulations
- Examples:
  - German Commission on Radiological Protection (SSK) – Clearance of metal scrap for recycling - 1989, 1992
  - European Commission – Radiological Protection Criteria for the Recycling of Materials from the Dismantling of Nuclear Installations (RP43) – 1988
  - IAEA – Clearance levels for radionuclides in solid materials (TECDOC 855) – 1996, Clearance of materials resulting from the use of radio-nuclides in medicine, industry and research (TECDOC 1000) – 1998
- Early large-scale radiological studies, first international guidance

Historical Development
Development of Guidance 1998-2005 (1)

- Further increase, era of international harmonisation
- Examples:
  - USA: Radiological Assessments for Clearance of Materials from Nuclear Facilities (NUREG 1640) – 1998/2003
  - EU:
    - Recommended radiological protection criteria for the recycling of metals from the dismantling of nuclear installations (RP 89) – 1998
    - Recommended radiological protection criteria for the clearance of buildings and building rubble from the dismantling of nuclear installations (RP 113) – 2000
    - Practical Use of the Concepts of Clearance and Exemption – Part I: Guidance on General Clearance Levels for Practices (RP 122/I) – 2000

Historical Development
Development of Guidance 1998-2005 (2)

- Examples: (cont.)
  - IAEA:
    - Application of the Concepts of Exclusion, Exemption and Clearance, Safety Standards Series RS-G-1.7 (2004)
    - Derivation of Activity Concentration Values for Exclusion, Exemption and Clearance, Safety Rep. Ser. 44 (2005)
  - Germany:
    - various SSK recommendations, leading to full set of clearance levels in German Rad. Prot. Ordinance, 2001
- Era of full-scale, comprehensive national and international studies, bringing clearance to maturity
- Basis for coping with really large quantities from industrial-scale decommissioning

Historical Development
Current Era – since 2005

- Decommissioning as routine industrial operation
  - No large-scale national or international studies any more
  - Existing regulations applied for material management from decommissioning
- Comparative studies on clearance practices in various countries, e.g. by OECD/NEA - WPDD
  - The Release of Sites of Nuclear Installations - A Status Report (No. 6187) – 2006
  - Release of Radioactive Materials and Buildings from Regulatory Control – A Status Report (No. 6403) – 2008
- Case-by-case evaluations emerging for dealing with non-standard situations

HOW TO DERIVE CLEARANCE LEVELS

Link between Dose and Activity (1/5)

- Clearance levels
  - are generally expressed in terms of bulk activity (e.g., Bq/g) because this is a parameter that can be measured
  - correspond to levels of radiation exposure (dose) that are generally considered to be below any concern (“trivial dose range”)
  - are derived from the primary dose criterion by assuming reasonable exposure scenarios

Link between Dose and Activity (2/5)

- Primary dose criteria for exemption and clearance are defined in the BSS:
  - in reasonably forseeable circumstances, effective dose for any individual from the cleared material is on the order of 10 µSv or less in a year, and
  - and for low probability scenarios not to exceed 1 mSv in a year

Link between Dose and Activity (3/5)

- Primary criteria for annual dose are not directly measurable
  - 10 µSv/a corresponds to dose rate in range of nSv/h (1 a = 8,760 h)
- Models are needed to establish a link between
  - dose criteria and
  - measurable quantities, e.g.
    - mass related activities (Bq/g)
    - surface related activities (Bq/cm²)
    - volume related activities (Bq/l, Bq/m³)

Link between Dose and Activity (4/5)

- Radiological models to establish clearance values
  - describe typical exposure situations on a realistic to conservative basis
  - establish the link between activity and dose
  - bounding or enveloping scenarios for use and disposal
  - cover external irradiation, inhalation, ingestion
  - parameter values and assumptions are based on results of many detailed calculations

Link between Dose and Activity (5/5)

- Radiological model has been devised by e.g. IAEA for unconditional clearance in Safety Report 44
- Scenarios include:
  - Worker (as member of the general public)
    - on landfill or other type of facility, in a foundry
    - other type of workers
    - truck drivers (transport)
  - Member of the general public
    - near a foundry or near a landfill
    - in house constructed of contaminated material
    - using water from private well

CURRENT GUIDANCE ON CLEARANCE

Where Are We?

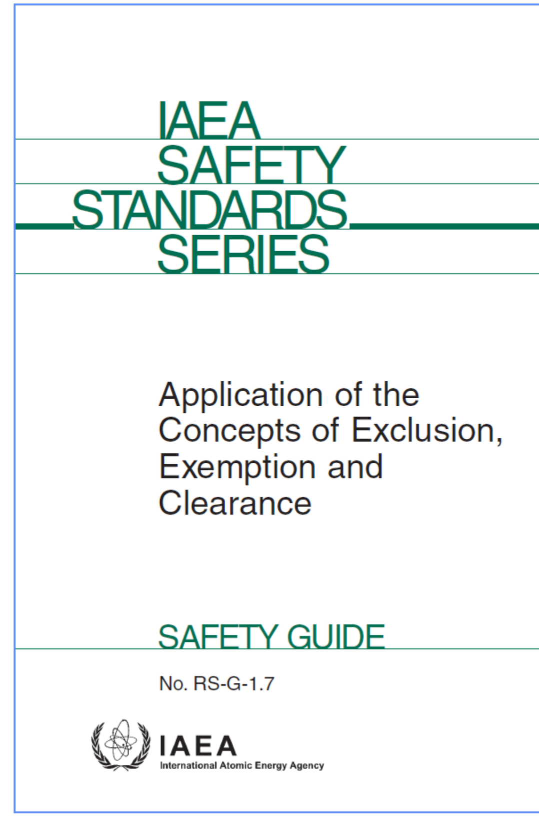
- Clearance is the most important and useful concept to apply to decommissioning waste management
  - intended to be applied to large volumes of material potentially contaminated or activated with artificial or natural radionuclides
  - exclusions and exemptions do not apply in the context of decommissioning of nuclear facilities
- Regulations apply
  - on EU level
  - on national level

Basic Safety Standards (BSS) IAEA and European Commission

- BSS set out general criteria for exemption and clearance
  - radiation risks arising from the practice or material are sufficiently low as not to warrant regulatory control and there is no appreciable likelihood of scenarios that could lead to a failure to meet the general criterion for exemption
  - continued regulatory control of the material would yield no net benefit for radiation protection
  - 2 sets of levels:
    - clearance levels: large (bulk) quantities, up to 100,000 Mg
    - exemption values: small/moderate quantities, few Mg

Unconditional Clearance Levels (1/2)

- Application of the Concepts of Exclusion, Exemption and Clearance, RS-G-1.7
  - Table 2 provides radionuclide specific activity concentration levels (in Bq/g) for radionuclides of artificial origin below which bulk material can be cleared
  - Provides a method for calculating a clearance level for multiple radionuclides mixtures


IAEA
SAFETY
STANDARDS
SERIES

Application of the Concepts of Exclusion, Exemption and Clearance

SAFETY GUIDE

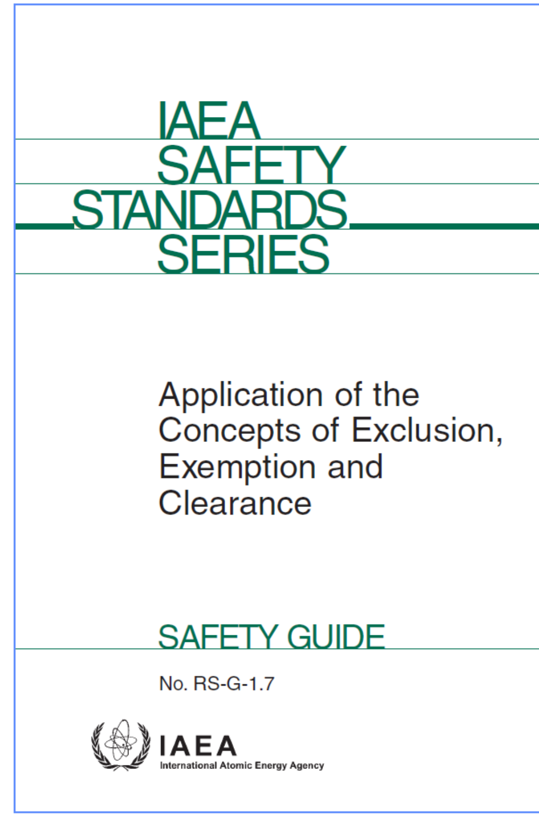
No. RS-G-1.7

IAEA
International Atomic Energy Agency

Unconditional Clearance Levels (2/2)

TABLE 2. VALUES OF ACTIVITY CONCENTRATION FOR RADIONUCLIDES OF ARTIFICIAL ORIGIN IN BULK (see para. 4.4)

Radio-nuclide	Activity concen-tration (Bq/g)		Radio-nuclide	Activity concen-tration (Bq/g)		Radio-nuclide	Activity concen-tration (Bq/g)	
H-3	100		Mn-56	10	*	Se-75	1	
Be-7	10		Fe-52	10	*	Br-82	1	
C-14	1		Fe-55	1000		Rb-86	100	
F-18	10	*	Fe-59	1		Sr-85	1	
Na-22	0.1		Co-55	10	*	Sr-85m	100	*
Na-24	1	*	Co-56	0.1		Sr-87m	100	*
Si-31	1000	*	Co-57	1		Sr-89	1000	
P-32	1000		Co-58	1		Sr-90	1	
P-33	1000		Co-58m	10000	*	Sr-91	10	*
S-35	100		Co-60	0.1		Sr-92	10	*
Cl-36	1		Co-60m	1000	*	Y-90	1000	
Cl-38	10	*	Co-61	100	*	Y-91	100	
K-42	100		Co-62m	10	*	Y-91m	100	*
K-43	10	*	Ni-59	100		Y-92	100	*
Ca-45	100		Ni-63	100		Y-93	100	*



Clearance Options and Clearance Levels – National Regulations

- National regulations define numerous clearance options
- Example: Rad. Prot. Ordinance (StrlSchV), Germany
  - Options for unconditional clearance:
    - all solid materials (reuse, recycling or disposal) and specific liquids
    - building rubble/soil of more than 1000 Mg per year
    - buildings for reuse or demolition
    - nuclear sites (after removal of the buildings)
  - Options for clearance for specific purpose:
    - solid materials for disposal on (conventional) landfills or for incineration, liquids for incineration
    - buildings for demolition only
    - metal scrap for smelting only (conventional foundry)

Clearance Options and Clearance Levels – Current International Practice

- Harmonisation achieved to a large extent
  - on EU level
  - among many countries outside EU
  - by applying international BSS
    - IAEA BSS and EU BSS contain same levels for unconditional clearance
  - by applying similar principles

THE FUTURE ROLE OF CLEARANCE

Future Role of Clearance of Recycling for Successful Decommissioning (1)

- Clearance will continue to be the fundamental principle for waste management from decommissioning
  - at least in countries without cheap surface disposal facilities (like USA)
- Clearance is no longer the bottleneck of material management
  - many measurement techniques available

Future Role of Clearance of Recycling for Successful Decommissioning (2)

- General pathway to clearance regulations:
  - Clearance levels for unconditional clearance from BSS need to be incorporated into national legislation
    - without changes to the values
  - Specific clearance regulations for metals scrap for melting should be adopted
    - opens possibility of dealing with metal scrap in much easier way than by lower CL for unconditional clearance
  - Clearance regulations for buildings will be necessary in later phases of decommissioning
- Benefit:
  - Decommissioning and material management will become a manageable task!
  - … even without availability of a national repository

Thank you for your attention