# Implications of the Revised International Basic Safety Standards on Natural Sources

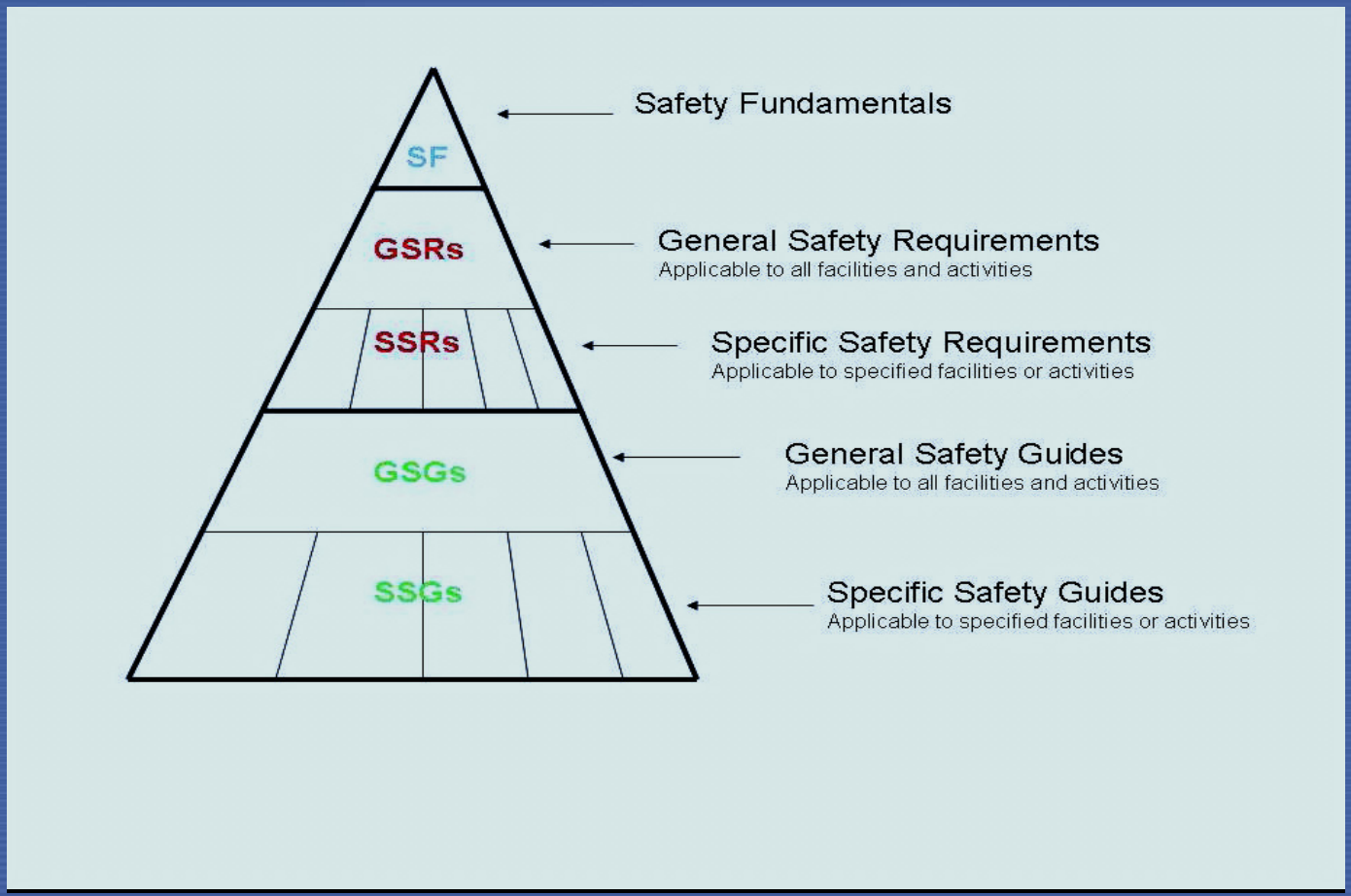
P.P. Haridasan
Radiation Safety and Monitoring Section
Division of Radiation, Transport and Waste Safety

IAEA
International Atomic Energy Agency

# The IAEA Statute

- **Develop safety standards and provide for their application**

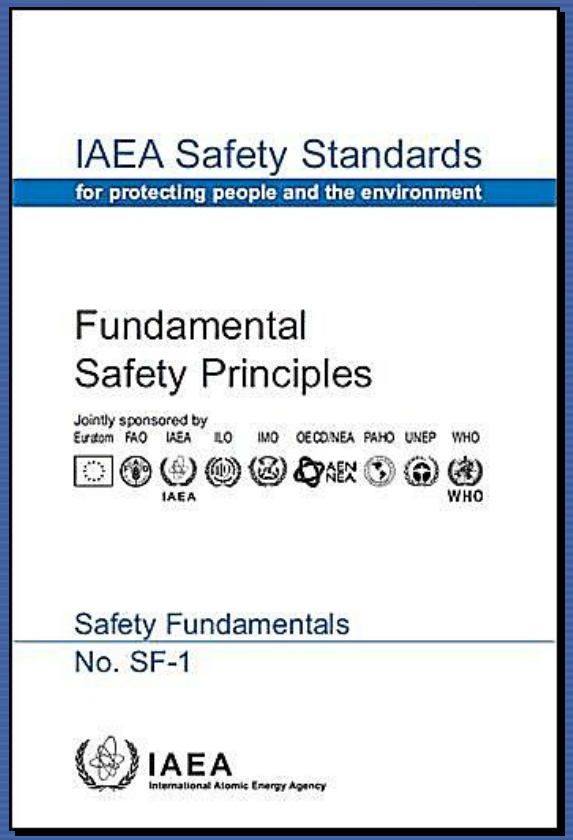
# IAEA Safety Standards



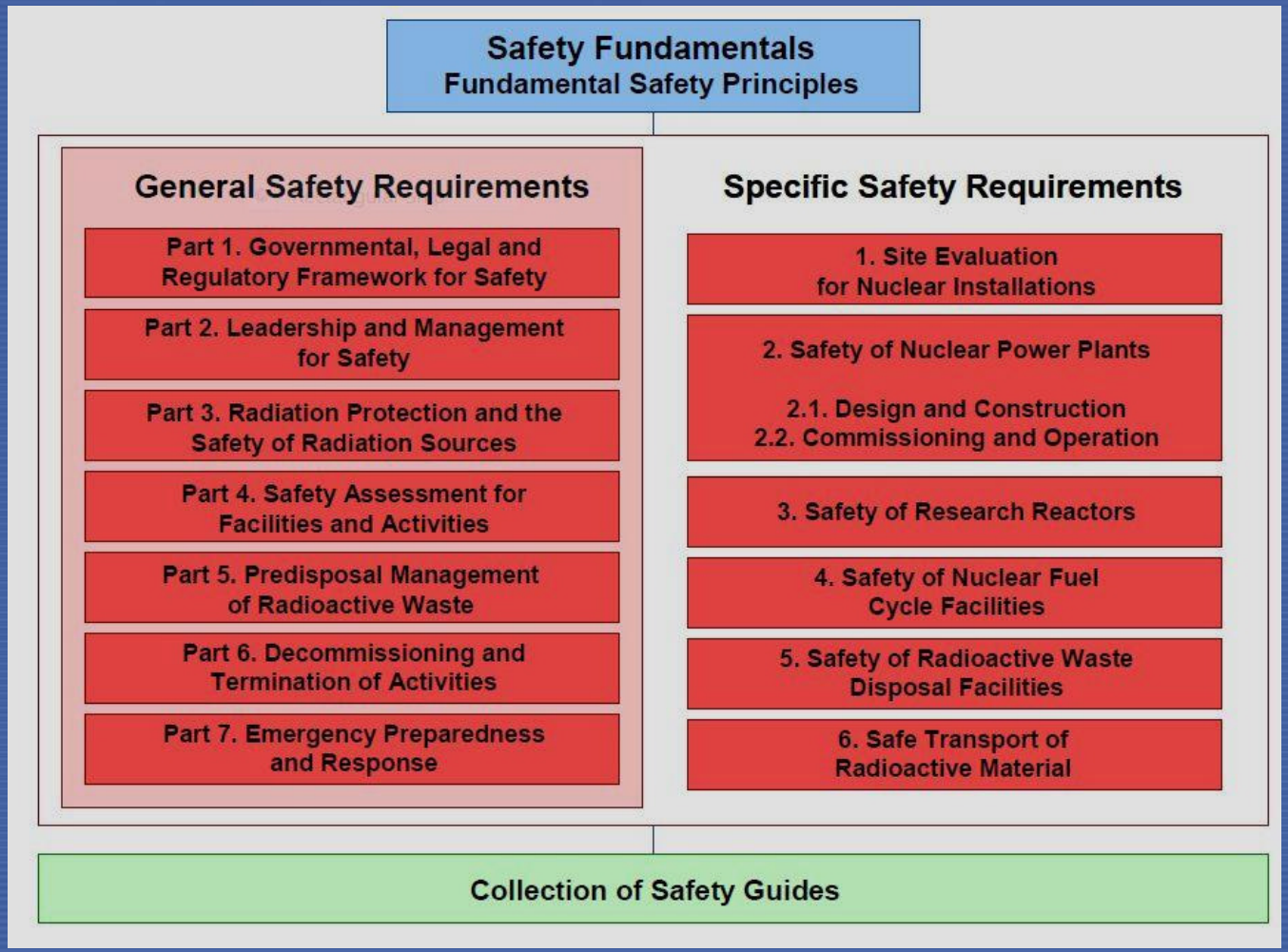
# Main basis

Fundamental Safety Principles (2006)

- the conceptual basis for the Agency's safety standards.

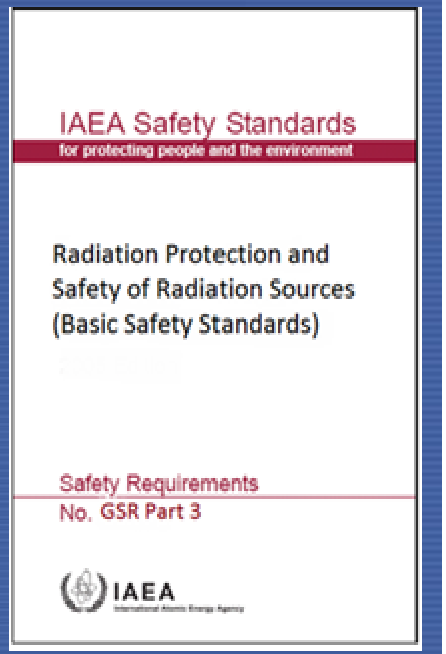


# Structure


Safety Fundamentals
Fundamental Safety Principles
General Safety Requirements
Part 1. Governmental, Legal and Regulatory Framework for Safety
Part 2. Leadership and Management for Safety
Part 3. Radiation Protection and the Safety of Radiation Sources
Part 4. Safety Assessment for Facilities and Activities
Part 5. Predisposal Management of Radioactive Waste
Part 6. Decommissioning and Termination of Activities
Part 7. Emergency Preparedness and Response
Specific Safety Requirements
1. Site Evaluation for Nuclear Installations
2. Safety of Nuclear Power Plants
2.1. Design and Construction
2.2. Commissioning and Operation
3. Safety of Research Reactors
4. Safety of Nuclear Fuel Cycle Facilities
5. Safety of Radioactive Waste Disposal Facilities
6. Safe Transport of Radioactive Material
Collection of Safety Guides

# The new BSS – Interim Edition Published

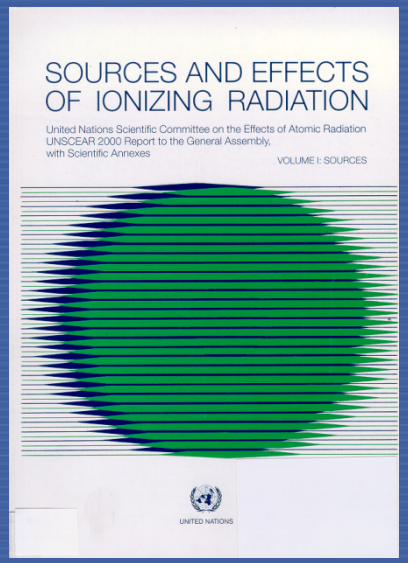
## Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards GSR Part 3



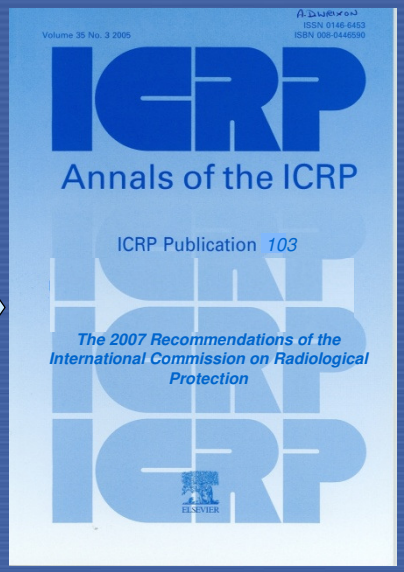
# The International Safety Standards

- The IAEA Safety Standards reflect **international consensus**
- This consensus is necessary to promote a **common approach for ensuring safety**

# Paradigm to be maintained

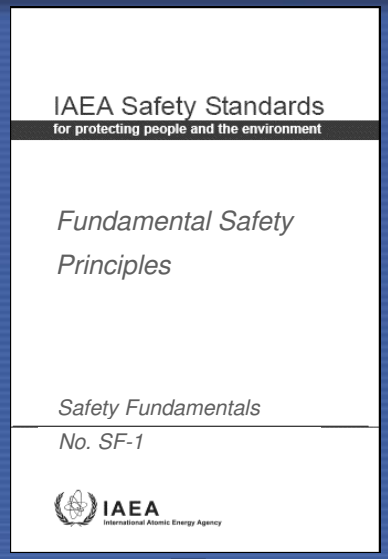



*Effects of radiation*



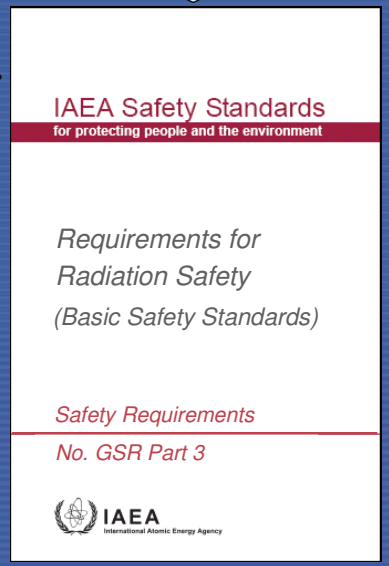

*

*Recommendations for protection*




*

*Essential principles (moral obligation)*




*

*Essential requirements (legal obligation)*

IAEA



**indicative covers only*

# The BSS - New structure

The structure of the revised BSS follows from the recommendations of ICRP 103

- three exposure situations:
  - Planned
  - Emergency
  - Existing
- three categories of exposure
  - Occupational
  - Public
  - Medical
- **52 Overarching requirements**

1. INTRODUCTION

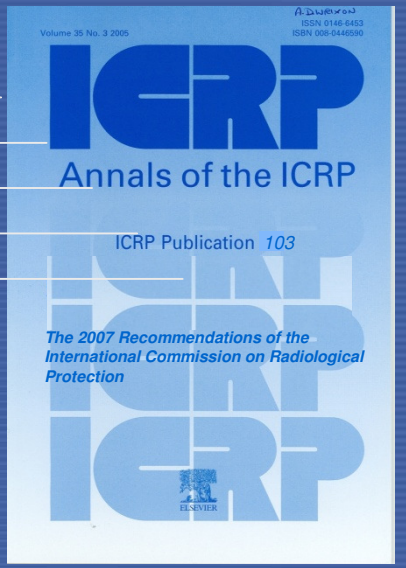
2. GENERAL REQUIREMENTS FOR PROTECTION AND SAFETY
Implementation of radiation protection principles
Responsibilities of government
Responsibilities of the regulatory body
Responsibilities of other parties
Management requirements

3. PLANNED EXPOSURE SITUATIONS
Scope
Generic requirements
Occupational exposure
Public exposure
Medical exposure

4. EMERGENCY EXPOSURE SITUATIONS
Scope
Generic requirements
Public exposure
Exposure of emergency workers
Transition from an emergency exposure situation to an existing exposure situation

5. EXISTING EXPOSURE SITUATIONS
Scope
Generic requirements
Public exposure
Occupational exposure

SCHEDULES
- Schedule I EXEMPTION AND CLEARANCE
- Schedule II CATEGORIZATION OF SEALED SOURCES
- Schedule III DOSE LIMITS FOR PLANNED EXPOSURE SITUATIONS
- Schedule IV CRITERIA FOR USE IN EMERGENCY PREPAREDNESS AND RESPONSE



# ICRP recommendations

- **ICRP has previously distinguished between practices that add doses and interventions that reduce doses.**

- **In its 2007 recommendations, ICRP now uses a situation based approach to characterize the possible situations where radiation exposure may occur as *existing, planned*, and *emergency exposure situations*; and applies one set of fundamental principles of protection for all of these situations**

# ICRP recommendations - General principles

## Existing exposure situations

- ***Existing exposure situations*** **are exposure situations that already exist when a decision on control or remediation has to be taken**

  - **This includes natural background radiation and most of the exposure situations to radon, as well as residues from past practices (legacies) that have been operated outside the Commission's recommendations (long-term exposure situations).**
  - **Exposure control is based on the use of Reference levels (levels of dose or risk above which it is judged inappropriate to allow exposures to occur and below which optimization of protection is implemented)**

# ICRP recommendations - General principles

## Planned exposure situations

- ***Planned exposure situations*** **are situations involving the planned introduction and operation of sources.**
  - **This also includes their decommissioning, disposal of associated radioactive waste, and rehabilitation of the previously occupied land in the case of installations.**
- **Planned exposure situations include both normal exposures and potential exposures**

# ICRP recommendations-General principles

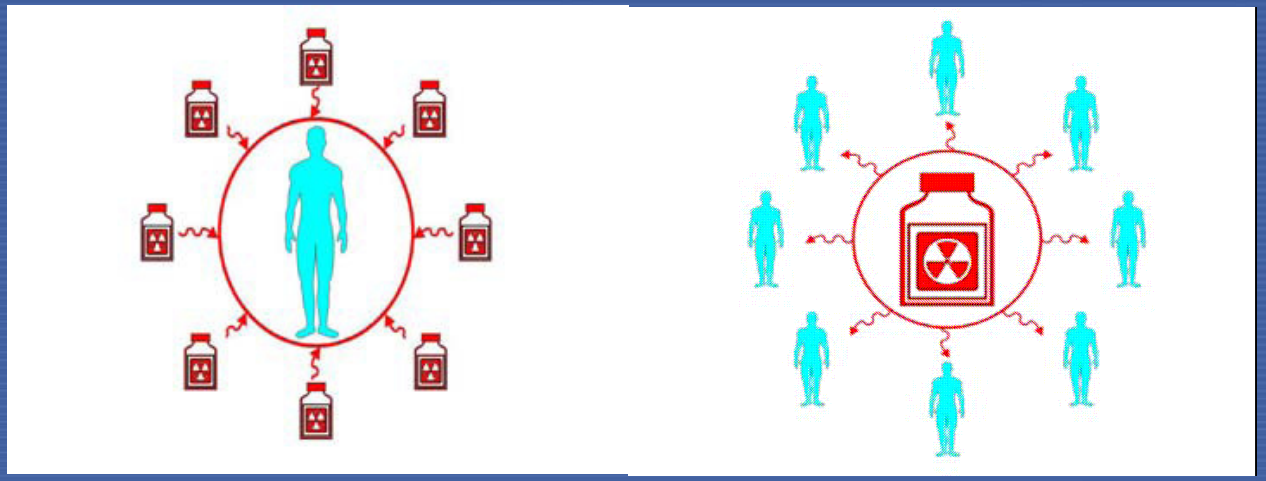
## Emergency exposure situations

- ***Emergency exposure situations*** **are unexpected situations that occur during the operation of a planned situation, or from a malicious act, requiring urgent action.**
  - **Not relevant for NORM industries**

# Dose limits compared with dose constraints and reference levels

**Dose Limits**

**Constraints and Reference Levels**



**From all regulated sources in planned situations**

**From a single source in all exposure situations**

# The types of dose restrictions

| Type of situation | Occupational | Public | Medical |
|---|---|---|---|
| Planned exposure | Dose limit<br>Dose constraint | Dose limit<br>Dose constraint | Diagnostic reference level |
| Emergency exposure | Reference level[a] | Reference level | N.A. |
| Existing exposure | Reference level | Reference level | N.A. |

[a] Long-term recovery operations should be treated as part of planned occupational exposure

# Definitions: IAEA Safety Glossary (version 2.0):

## Radioactive material

Material designated in national law or by a regulatory body as being subject to regulatory control because of its radioactivity

## NORM

**Radioactive material (as defined above)**

containing no significant amounts of radionuclides other than naturally occurring radionuclides

***So if it's not subject to regulation, it's not NORM !***

TENORM:

- Not defined in the IAEA Safety Glossary
- Its use is discouraged

# Application of the Standards to NORM

1. **What** should fall within the scope of regulation?

2. If within the scope of regulation, **how** to regulate?

In both cases, follow the principle of **optimization of protection**

- Maximum net benefit
- Sometimes, no regulation is the best option
- If regulation is warranted, apply **graded approach**

# Application of the standards to NORM
## (1) Scope of regulation

- Selection of criteria for defining the scope of regulatory control is a critical issue for NORM
- Average concentration of natural radionuclides in earth crust ranges from few hundredths to few Bq/g
- Corresponding terrestrial doses (excl. Rn) ranges from few tenths to few mSv/y
- Applying a trivial dose criterion of 10 μSv/y to NORM activities would bring large areas of the world under regulatory control

# Application of the standards to NORM
## (2) Scope of regulation

**Distinction between:**

**Planned situations (practices)**

- Subject to requirements for planned situations, unless:
  - Exposure is excluded
  - Practice is exempted

**Existing situations (interventions)**

- Reference levels to decide on remedial or protective actions to reduce exposure in existing *de facto* situations
  - Radon in workplaces
  - Existing exposure from past activities

# Application of the standards to NORM
## (3) Scope of regulation

**Exclusion in the new BSS :**

- "Exposures deemed to be unamenable to control are excluded from the scope of Standards*…*"

- **Relates to amenability to control, rather than to the actual magnitude of the exposure**

  - **Exposure from $^{40}K$ in the body**
  - **Cosmic radiation at the surface of the earth**
  - **Unmodified concentrations of radionuclides in *most* raw materials**

**Doses to individuals unlikely to exceed about 1 mSv/y**

# Application of the standards to NORM
## (4) Scope of regulation (RS-G-1.7 & the new BSS)

- Usually unnecessary to regulate material below:

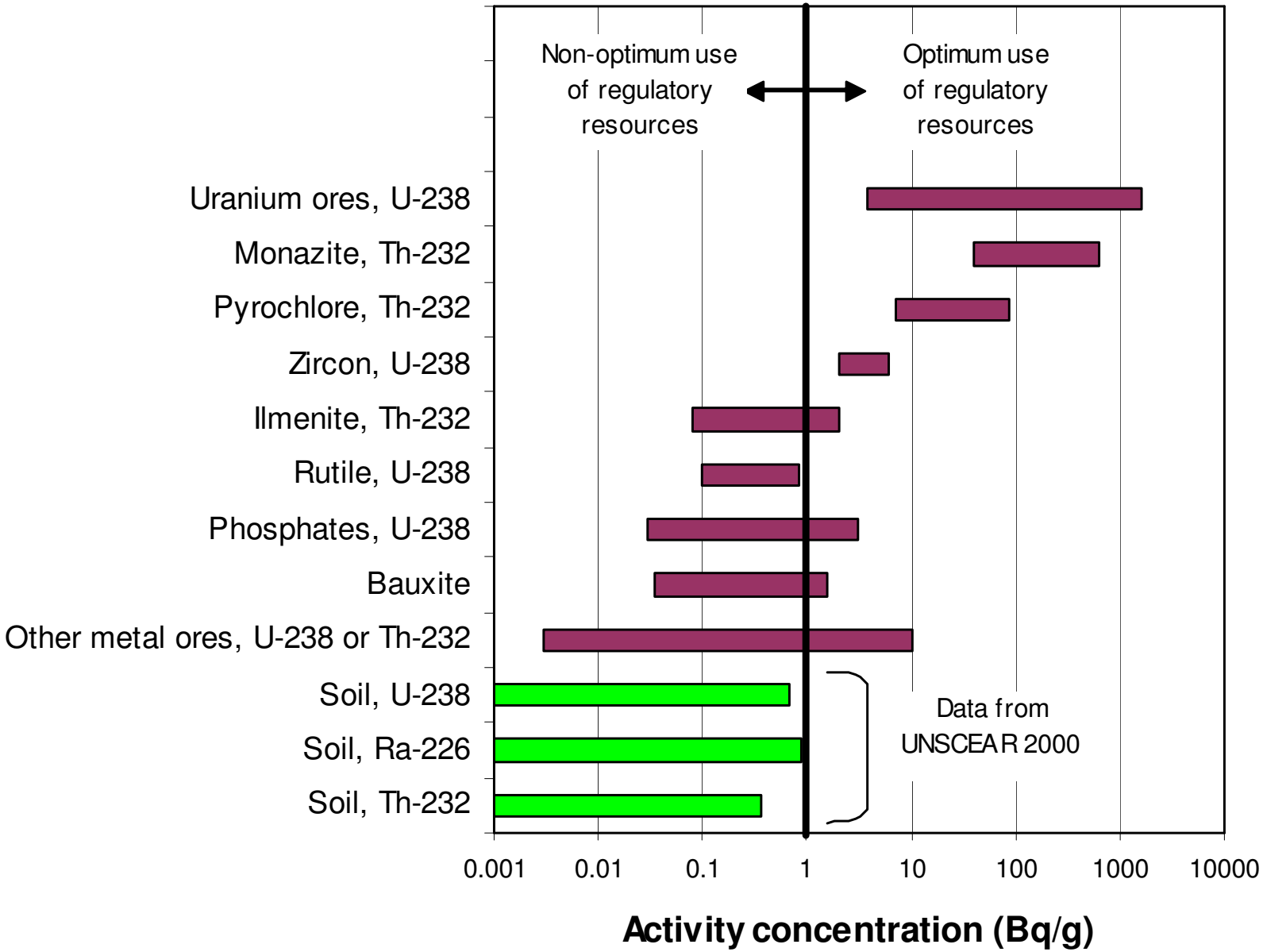
  **1 Bq/g** **individual U, Th series radionuclides**

  10 Bq/g K-40

  irrespective of quantity, or whether natural or processed

- These values do not apply to drinking water, foodstuffs, residues in the environment, materials in transport – separate standards exist for these
- These values can also be used as **clearance** levels for release of NORM residues
- Use of NORM residues in building materials may require further consideration – guidance being developed – not treated as a practice

# What is the basis for the 1 Bq/g?
## -- activity concentrations in natural materials



# Worker doses due to gamma and dust from NORM

| Category of material | Radionuclide activity concentration where dose may exceed 1–2 mSv/a |
|---|---|
| Large quantity, e.g. orebody, large stockpile | 5 Bq/g or more |
| Small quantity, e.g. mineral concentrate, scale, sludge | 50 Bq/g or more |
| Condensed furnace fume & dust ($^{210}$Pb, $^{210}$Po) | 500 Bq/g or more |

***Note: Public doses likely to be well below worker doses***

# Application of the standards to NORM
# Planned exposure situations

## (1) Exemption

- Responsible authority should establish exemption criteria based on dose

  - Taking into account economical, social and political factors

  - Balancing the consequences of regulatory control, in terms of necessary resources and impact on the regulated NORM activity, against the benefit in terms of approved radiation protection

# Application of the standards to NORM
## (2) Exemption

**Exemption criteria**

- Dose
  - 1 mSv/a for workers
  - Will restrict doses to the public to lower values

**This dose criterion will generally correspond to higher activity concentrations than the values of RS-G-1.7**

# What if the material is >1 Bq/g (or >10 Bq/g K-40)?

Apply a **graded approach** to regulation

1. Exemption (Decision not to regulate)
   - **If dose from gamma and dust is less than about 1 mSv/a, after taking existing industrial hygiene controls into account**
2. Notification
   - **If dose from gamma and dust << dose limit, after taking existing industrial hygiene controls into account (similar to exemption but regulator remains informed)**
3. Notification + registration
   - **Minimal additional controls for gamma and dust needed, after taking existing industrial hygiene controls into account**
4. Notification + licensing
   - **Specific measures to control actions of workers – needed only when dealing with very high activity material in significant quantities**

# Application of the standards to NORM
## (1) Existing exposure situations

**The Standards apply to:**

- **Radioactive residues in human habitats, including exposure to radionuclides in residues from:**
  - **Past practices that were not regulated on the basis of the current system of radiological protection, or that were subject to an earlier, less rigorous regime of control;**
  - **Past activities that were not regulated at all with respect to radiological protection;**
  - **Recovery phase of unforeseeable incidents and accidents from nuclear installations, medical, industrial and research facilities, etc.** (not generally applicable to NORM industries)

# Application of the standards to NORM
## (2) Existing exposure situations

**The Standards apply to:**

- **The incorporation of radionuclides into commodities from an environment contaminated with radioactive residues in human habitats, including foodstuffs and drinking water**
- **Natural sources, including exposure to radon in buildings and workplaces and exposure to radionuclides of natural origin in construction materials.**

# Application of the standards to NORM
# (3) Existing exposure situations

## Responsibilities of the Government

- A legal framework shall be established such that it
  - Specifies the situations that are included in its scope
  - Sets objectives and principles for protective or remedial actions
  - Assigns responsibilities between the regulatory authority, national and local intervening organizations, registrants, licensees or other legal persons
  - Provide for the involvement of stakeholders

# Application of the standards to NORM
## (4) Existing exposure situations

### Responsibilities of the Government

- Establish a programme to identify existing exposure situations and to determine which exposures are of concern for radiation protection.

- Establish a strategy for controlling those existing exposure situations of concern for radiation protection.

# Application of the standards to NORM
## (5) Existing exposure situations

### Strategy requirements

- The nature and extent of remedial or protective actions shall be commensurate with the risks associated with the existing exposure
- The remedial or protective actions shall be justified in the sense that they do more good than harm,
  - i.e. the actions yield sufficient benefit to outweigh the radiation risks and other detriments associated with taking them
- The form, scale and duration of the remedial or protective actions shall be optimized so as to produce the maximum net benefit,
  - understood in a broad sense, under the prevailing social and economic circumstance

# Application of the standards to NORM
## (6) Existing exposure situations

**Reference levels**

- The relevant national authority shall establish reference levels to be used in conjunction with the implementation of the optimization process.
- Optimized protection strategies, or a progressive range of such strategies, shall be implemented with the objective of reducing doses to below the reference level.
- Exposures below the reference level shall not be ignored; these exposure situations shall be assessed to ascertain whether protection is optimized or whether further dose reduction measures are needed

# Application of the standards to NORM
## (7) Existing exposure situations

### Reference levels

- The reference level … shall typically be expressed as an annual effective dose to the representative person in the range 1–20 mSv or other equivalent quantity
  - activity concentration per unit mass, unit volume or unit surface area as appropriate

- A reference level above this range shall be considered only when the relevant national authority specifically determines that remedial or protective actions at lower levels of exposure are not justified

# Application of the standards to NORM
## (1) Radon

- The relevant national authority shall establish specific reference levels for exposure to radon,
  - taking into account the prevailing economic and societal circumstances and applying the process of optimization

- The reference level shall not exceed an upper bound of 10 mSv.

Expressed as activity concentrations:

- yearly average concentrations of $^{222}Rn$ in air of 300 Bq/m3 in dwellings and other buildings with high occupancy of members of the public (such as schools, hospitals and prisons)
- 1000 Bq/m3 in workplaces

# Application of the standards to NORM
## (1) Remediation from past activities

**Legacy issues**

- Many NORM related industrial sites were abandoned in the past with little or no remediation and inefficient residue management
- Such sites may include tailings facilities, fertiliser plants, thorium mantle factories, metal refineries, old oil production fields or scrap metal dumps associated with such operations
- Many of these legacy sites now need remediation, for example they may be close to urban centres

# Application of the standards to NORM
## (2) Remediation from past activities

- The goal of the remedial actions shall be the timely and progressive reduction of the hazard and eventually, if possible, the removal without restrictions of regulatory control from the area.

- In cases where the removal of control cannot practicably be achieved, at least the unacceptable risks to human health and the environment shall be removed and any restrictions on access to or use of the area and any other restrictions shall be established on the basis of an optimization process.

# Application of the standards to NORM
## (3) Remediation from past activities

- The remediation shall be justified by means of a decision aiding process requiring a positive balance of all relevant attributes relating to the contamination.

- In addition to the avertable annual doses, both individual and collective, other relevant attributes shall be assessed.
  - Health detriments;
  - Expected reduction in anxiety caused by the situation;
  - Benefits, social costs, disruption and environmental effects

# Application of the standards to NORM
## (4) Remediation from past activities

- The remediation shall be optimized following the general approach to the optimization of protection.
- The optimum nature, scale and duration of the remedial actions shall be selected from a set of justified options for remediation.
- In some cases, the need for protective action in the form of restricted use of human habitats may be the outcome of the optimization process for remediation.

# Application of the standards to NORM
## (5) Remediation from past activities

- In some cases, the need for protective action in the form of restricted use of human habitats may be the outcome of the optimization process for remediation.

- The results of such a decision aiding process for justification and optimization shall be used as an input to a decision making process which may encompass other considerations (such as residual doses).

# Main changes from SS 115
## -- New or modified requirements

- Legal and governmental framework
- Planned exposure situations
  - Exemption and clearance
  - Radiation generators and radioactive sources
  - Use of radiation for non-medical human imaging
- Emergency exposure situations
- Existing exposure situations
  - Reference levels instead of action levels
  - Reference levels for indoor radon
  - Remediation of contaminated areas
  - Occupational exposure to cosmic rays above ground level

# Implications for exposure to natural sources

- Exclusion from the Standards – essentially no change (amenability to control)
- Planned exposure situation or existing exposure situation?
- Existing exposure situations
  - Reference levels
- Planned exposure situations
  - Exemption and clearance

# Planned exposure situation or existing exposure situation?

- By default: Treat as **existing exposure situation**
- By exception: Apply requirements for planned exp. situation
- Exceptions are relatively few
- No real change from SS 115
- Don't interpret the words "planned" and "existing" too literally
  - Practicability is the most important consideration
  - Exposure is controlled regardless of the type of situation, it's just the mechanism of control that differs

# Planned exposure situation or existing exposure situation?

The following exposures are always controlled in accordance with the requirements for existing exposure situations (i.e. no exceptions to the general approach):

- Exposure to natural radionuclides in:
  - Everyday commodities food, feed, drinking water, fertilizer and soil amendments, building material
  - Residual radioactive material in the environment (other than exposure of remediation workers)
- Public exposure to radon
- Exposure to cosmic rays above ground level
  - Occupational exposure only – public exposure is not amenable to control and should thus be excluded (see ICRP)

# Planned exposure situation or existing exposure situation?

The following exposures are always controlled in accordance with the requirements for planned exposure situations (i.e. always treated as exceptions to the general approach):

- Public exposure delivered by effluent discharges or the disposal of radioactive waste arising from a practice involving natural sources

# Planned exposure situation or existing exposure situation?

The following exposures are controlled in accordance with the requirements for EITHER existing OR planned exposure situations:

| *Source of exposure* | *Existing exposure situation* | *Planned exposure situation* |
|---|---|---|
| Material other than environmental residues and food, drinking water etc. | ≤1 Bq/g (U, Th series) and ≤10 Bq/g ($^{40}$K) | >1 Bq/g (U, Th series) or >10 Bq/g ($^{40}$K) |
| Radon in workplaces:<br>• Exposure required by or directly related to the work | × | √ |
| • Exposure incidental to the work | ≤1000 Bq/m$^3$ | >1000 Bq/m$^3$ |

# Existing exposure situations – reference levels

## Reference levels are not the same as action levels

- Action levels are levels at or below which remedial action (and thus the need for optimization) is not normally necessary
- Reference levels are levels above which it is inappropriate to plan to allow exposures to occur, and below which optimization of protection should be implemented
- ***In moving from action levels to reference levels, ICRP has generally retained the same numerical values of dose, thus implying that a reference level is simply another name for an action level, which of course it is not***
    - Retaining the same numerical value implies a significant increase in the stringency of control

# Existing exposure situations – reference levels

General reference levels (applicable to both natural and artificial sources):

- Normally in the range 1–20 mSv/a
- Commodities: ≤1 mSv/a
- Radon:
  - Expressed in terms of radon activity concentration in air
  - ≤300 Bq/$m^3$ in homes
  - ≤1000 Bq/$m^3$ in workplaces
  - These values are roughly equivalent to 10 mSv/a in terms of latest ICRP thinking:
    - The risk per unit intake is now thought to be about twice the ICRP65 value

# Planned exposure situations – exemption and clearance

## Exemption

There are two alternative approaches to exemption:

1. Exemption on a case-by-case basis
   - *Qualitative criteria*

2. Automatic exemption without further consideration
   - *Numerical criteria*

# Planned exposure situations – exemption and clearance

## 1. Exemption on a case-by-case basis

- Risks to individuals are sufficiently low as not to warrant regulatory control, and the exempted practice is inherently safe
  – the so-called “trivial dose” principle
  (Unchanged from SS 115)

***OR***

- Regulation would provide no net benefit, in that no reasonable control measures would achieve a worthwhile return in reduction of individual doses or risks
  (NEW – particularly relevant to natural sources)

# Planned exposure situations – exemption and clearance

## 2. Automatic exemption without further consideration

- For natural radionuclides incorporated into consumer products or used as radioactive source or for properties as chemical elements (always in moderate quantities):
  - Use “Schedule 1” values of activity or activity concentration
  - Depending on radionuclide, $10^4$–$10^6$ Bq or 1–1000 Bq/g
  - Based on ~10 μSv/a
- For all other cases (including bulk quantities) – particularly applicable to NORM:
  - Exemption if dose is less than ~1 mSv/a
    - Activity concentrations of 1 Bq/g (U, Th series) or 10 Bq/g ($^{40}$K) will satisfy this criterion in all reasonable situations
    - But these values are generally too conservative for use as exemption levels
    - For material below these activity concentrations, the requirements for planned exposure situations would not even apply

# Planned exposure situations – exemption and clearance

## Clearance

Same 2 alternative approaches as for exemption:

1. Case-by-case (qualitative criteria)
2. Automatic, without further consideration (numerical criteria):
   - ≤1 Bq/g for U, Th series

     AND
   - ≤10 Bq/g for $^{40}K$

# Planned exposure situations – exemption and clearance

## Summary

| | Criterion | | |
|---|---|---|---|
| | Max dose | Max activity | Max activity conc. |
| Exemption:<br>• Moderate quantities, consumer prod., source, chem. props | ~10 μSv/a | $10^4$–$10^6$ Bq<br>dep. on nuclide | 1–1000 Bq/g<br>dep. on nuclide |
| • All other (general NORM) | ~1 mSv/a | -- | -- |
| Clearance | -- | -- | 1 Bq/g (U, Th ser)<br>10 Bq/g ($^{40}$K) |

# Transport regulations on NORM

- IAEA Transport regulations TS-R-I, 2009
  - Basis for Transport of dangerous goods regulations (UN)
  - Int. Maritime dangerous goods code IMDG
  - Technical instructions for transport by air, ICAO
- CRP – Appropriate level of regulatory control for the safe transport of NORM

# Transport regulations on NORM

The concentration and total activity exemption levels both have to be exceeded in a consignment before transport regulations apply.

Para 107 (e) of TSR-I

“Natural material or ores containing naturally occuring radionuclides which are either in their natural state, or have only been processed for purposes other than for extraction of the radionuclides, and which are not inteneded to be processed for use of these radionuclides, provided the activity concentration of the material does not exceed 10 times the values specified in Table 2 or calculated in accordance with paras 403-407”.

For NORM, the exemption level for transport purposes is10 Bq/g for Th-nat and U-nat.

What about if the radionuclides are not in equilibrium ?

For example Ra-226 separated from its parent…

# Exposure to NORM – the questions

- Radiological hazard to workers ?
- Radiological hazard to public ?
- Could doses from NORM be higher than doses from nuclear industries?
- How do we separate the natural background from NORM-related concentrations?
- Are the exposure pathways the same as those in the nuclear industry?

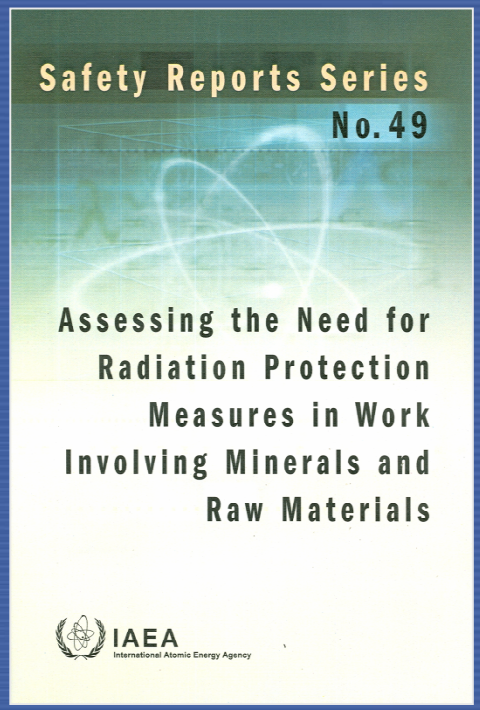
# Emerging NORM Issues

- **Public/industry awareness and perception**
  **(of special concern in developing countries)**
- **Waste disposal ?**
- **Acceptance criteria and grounds for refusal**
- **Cross boundary issues**

# Industry sectors

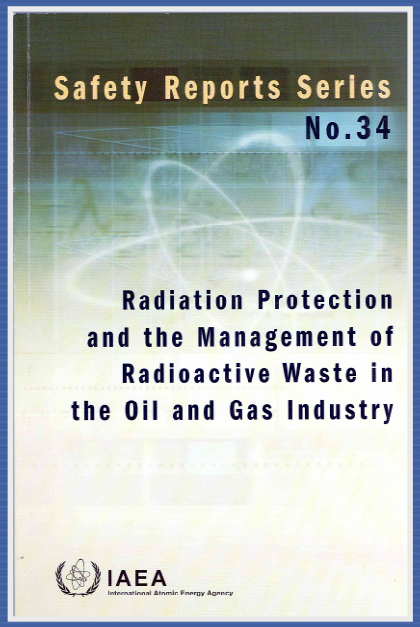
***Industry sectors most likely to require some form of regulatory consideration***

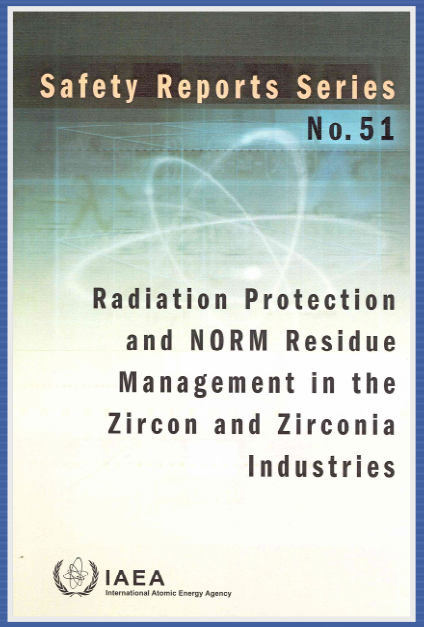
1. *Uranium mining and processing*
2. *Rare earths extraction*
3. *Thorium extraction & use*
4. *Niobium extraction*
5. *Non-U mining – incl. radon*
6. *Oil and gas*
7. *Production and use of $TiO_2$*
8. *Phosphate Industry*
9. *Zircon & zirconia*
10. *Metals production (Sn, Cu, Al, Fe, Zn, Pb)*
11. *Burning of coal etc.*
12. *Water treatment – incl. radon*

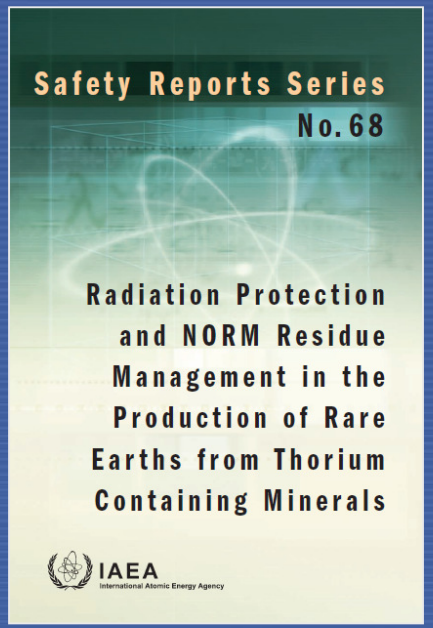


# IAEA Safety Reports on NORM

## Industry-specific reports



# IAEA Safety Reports on NORM – either draft or planned

## Industry-specific reports (in draft)

*Phosphate Industry*

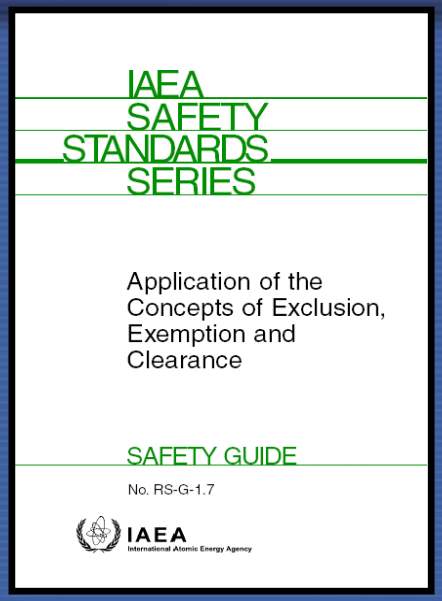
*Titanium Dioxide and Related Industries*

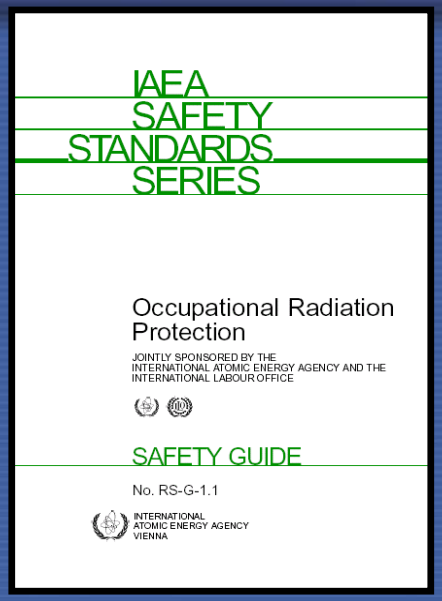
*Industrial uses of Thorium*

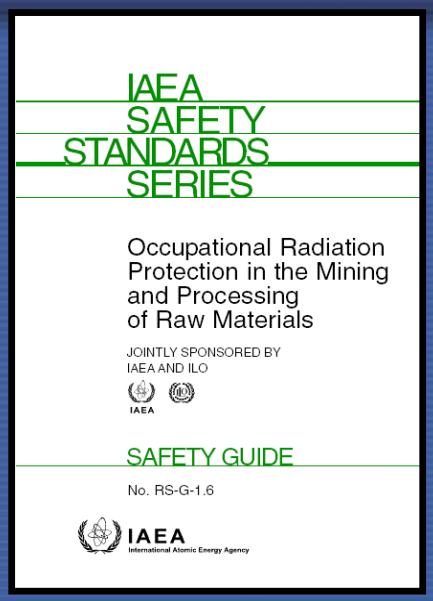
*Coal Industry*

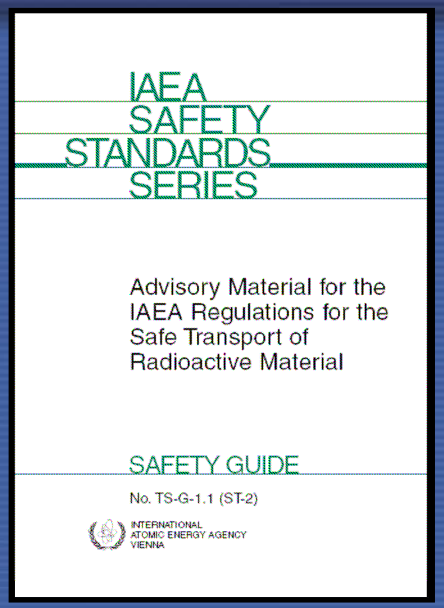
*Metal Production Industries*

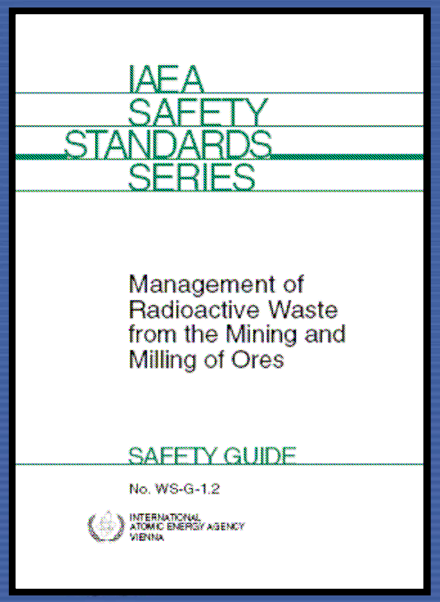
# Safety Guides containing specific recommendations on natural sources




**DS 421**

**Public exposure to natural sources**

# Summary

- The new BSS follows closely the ICRP 2007 Recommendations
- A more harmonized approach to regulatory control of exposure to natural sources
- The new “reference level” approach for existing exposure situations will increase the stringency of control over exposure to natural sources, including exposure to radon in homes and workplaces
- The new draft BSS incorporates more numerical criteria, especially for exposure to natural sources
- IAEA safety reports – for industry specific guidance

# Summary

- The selection of criteria for the scope of regulatory control is a critical issue for NORM industries. If the activity concentration exceeds the exemption criterion, a graded approach for regulatory control should be applied.
- The relevant national authority should establish a programme to identify existing exposure situations and to determine which exposures are of concern for radiation protection
- The relevant national authority shall establish specific reference levels for exposure to radon
- The remediation shall be justified and optimised. The optimum nature, scale and duration of the remedial actions shall be selected from a set of justified options for remediation

## *Many thanks for your attention…*

IAEA E-mail: **P.P.Haridasan@iaea.org**