IAEA Safety Standards relating to protection of public against exposure to radon

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Content

- IAEA Safety Standards
- Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, GSR Part 3 (revised BSS)
- Requirements for radon in dwellings in the revised BSS
- Radon Action Plan
- EU Directive
IAEA Safety Standards

Effects of radiation
Recommendations for protection

Essential principles (moral obligation)
Essential requirements (legal obligation)
Hierarchy of Safety Standards

Safety Fundamentals
- High level underlying principles aimed at politicians and regulatory authorities

Safety Requirements
- Specify obligations and responsibilities ("shall" statements)

Safety Guides
- Recommendations to support requirements ("should" statements) based on international best practices
Safety Standards for Radon


• GSR Part 3: Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (2014)

• SSG-32: Protection of the Public against Exposure Indoors due to Radon and Other Natural Sources of Radiation (to be published in 2014)
IAEA Safety Fundamentals


This publication embodies:

• a unified nuclear safety philosophy;
• the conceptual basis for the Agency’s safety standards.

• Principle 10: **Protective actions to reduce existing or unregulated radiation risks must be justified and optimized**
  • Radon in dwellings and workplaces
Safety Requirements

- GSR Part 3 (revised BSS) approved by Board of Governors in September 2011
- Interim edition - November 2011
- Cosponsored edition - July 2014
  - WHO
  - ILO
  - PAHO
  - EC
  - NEA/OECD
  - FAO
  - UNEP
Basic Safety Standards – Structure

Three exposure situations
- Planned exposure situation
- Existing exposure situations
- Emergency exposure situations

Three categories of exposure
- Occupational exposure
- Medical exposure
- Public exposure

Protection and Safety requirements of the BSS apply to all facilities and activities
Types of Exposure Situations

**Planned exposure situations**
situations involving the planned introduction and operation of sources *(including decommissioning, disposal of radioactive waste, rehabilitation)*

**Emergency exposure situations**
unexpected situations such as those that may occur during of a planned situation, or from a malicious act, requiring urgent attention

**Existing exposure situations**
situations that already exist when a decision on control has to be taken, such as those by natural background radiation and residues from past practices operated outside the system
Categories of Exposure

**Occupational exposures**
exposure of workers incurred as a result of their work *(with the exception of excluded exposures and exposures from exempt activities; medical exposure; and background)*

**Public exposures**
all exposures of the public other than occupational exposures and medical exposures of patients

**Medical exposures of patients**
incurred by patients as part of their own medical or dental diagnosis or treatment; volunteers helping in the support and comfort of patients; and biomedical research volunteers
## Radiation Protection Principles

<table>
<thead>
<tr>
<th>Principle</th>
<th>Planned Exposure Situations</th>
<th>Existing Exposure Situations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Justification</td>
<td>Any decision to introduce a new technology or type of practice which would give rise to additional exposure shall do more good than harm</td>
<td>Any decisions to implement a protective action to reduce the radiation exposure shall do more good than harm.</td>
</tr>
<tr>
<td>Optimization</td>
<td>process of determining what level of protection would result in the magnitude of individual doses, the number of individuals subject to exposure and the likelihood of exposure being ALARA</td>
<td>Constraint: prospective and source related value of individual dose or risk that serves as a boundary in defining the range of options in the process of optimization of protection and safety.</td>
</tr>
<tr>
<td></td>
<td>Reference level: the level of dose, risk or activity concentration above which it is not appropriate to plan to allow exposures to occur and below which optimization of protection and safety would continue to be implemented.</td>
<td></td>
</tr>
<tr>
<td>Dose Limits</td>
<td>Dose limits for workers and public not to be exceeded</td>
<td>No dose limits</td>
</tr>
</tbody>
</table>
• Radon indoors
  • Existing exposure situation
Requirement 47: Responsibilities of the government

• The government shall ensure that existing exposure situations that have been identified are evaluated to determine which occupational exposures and public exposures are of concern from the point of view of radiation protection.
Requirements of revised BSS - Radon

• When an existing exposure situation is identified:
  
  • Government to assign responsibilities for protection and safety and to establish appropriate reference levels
  
  • Government shall include in the legal and regulatory framework for protection and safety provision for the management of the management of existing exposure situations
    • Specify exposure situations included in scope of existing exposure
    • Specify general principles underlying the development of protection and safety strategies to reduce exposure
    • Assign responsibilities
    • Provide for the involvement of interested parties in decisions regarding the development and implementation of protective strategies
Requirement 48: Justification of protection actions and optimization of protection and safety

- The government and the regulatory body or other relevant authority shall ensure that remedial actions are justified and that protection and safety is optimized.
Glossary

Justification: the process of determining whether a proposed protective action or corrective action is likely, overall, to be beneficial i.e. whether the expected benefits to individuals and to society outweigh the cost of such action and any harm or damage caused by the action

- Protection strategy to be commensurate with risks (graded approach)
- Corrective actions or protective actions to be justified
Optimization: the process of determining what level of protection and safety would result in the magnitude of individual doses, the number of people subject to exposure and the likelihood of exposure being as low as reasonably achievable.

- Protection and safety is optimized means that the result of the process of optimization has been implemented
- Establish reference levels
- Periodically review reference levels
• optimised protective actions or strategy should be aimed at reducing any exposures that are above the reference level to a level that is below the reference level

Actual dose
Reference level
Residual dose
Optimized dose reduction
Requirement 50: Public exposure due to radon indoors

- The government shall provide information on radon indoors and the associated health risks and, if appropriate, shall establish and implement an action plan for controlling public exposure due to radon indoors.
Requirements of revised BSS - Radon

• The government shall ensure that:

  • Information is gathered on activity concentrations of radon in dwellings and other buildings of high occupancy factors for members of the public through appropriate means such as representative radon surveys

  • Relevant information on the exposure due to radon and the associated health risks, including increased risks relating to smoking, is provided to members of the public and other interested parties;
Requirements of revised BSS - Radon

- Where radon levels that are of concern for public health are identified, the government shall ensure that an action plan is established comprising coordinated actions to reduce radon levels for existing buildings and for future buildings, which includes:
  - Establishing an appropriate reference level for $^{222}$Rn for dwellings and other buildings of high occupancy factors of the public with account taken of the prevailing social and economic circumstances that in general will not exceed 300 Bq/m$^3$;
  - Reducing activity concentrations of $^{222}$Rn and consequent exposures to a level at which protection is optimized;
  - Giving priority to reducing activity concentrations of $^{222}$Rn in those situations for which such action is likely to be most effective;
  - Including appropriate preventive measures and corrective actions for $^{222}$Rn exposure in building codes to prevent ingress of radon and to facilitate possible remedial actions where necessary.
Requirements of revised BSS - Radon

• The government shall assign responsibility for:

  • Establishing and implementing the action plan for controlling public exposure due to $^{222}\text{Rn}$ indoors

  • Determining the circumstances under which corrective action is to be mandatory or is to be voluntary, with account taken of legal requirements and of the prevailing social and economic circumstances
Safety Guides

- GSG-32: Protection of the Public against Exposure Indoors due to Natural Sources of Radiation
  - NEW Safety Guide
  - Published May 2015
  - Cosponsored by WHO
Radon Action Plan

• **National radon policy**
  • Government to assign responsibility for establishing and implementing the action plan (organization for radiation safety)
  • Consultation with other national organizations – radiation measurements, public health, building standards

• **Provision of information**
  • Information on radon action plan
  • Public, homeowners, building professionals

• **National survey of radon in dwellings**
  • Estimate average exposure to radon of the population and the range of exposures occurring
  • Identify areas where higher than average radon levels are likely to be found
Radon Action Plan

- **Measurement protocols**
  - Measurement period, type of detectors, correction factors
  - Quality control programme
  - Inter-comparison exercises

- **Setting a reference level for dwellings and buildings**
  - Not to exceed an average annual concentration of 300 Bq/m$^3$
  - Take into account prevailing social and economic circumstances
  - Chosen so that resulting activities are practicable and manageable

- **Radon prone areas**
  - “high radon area” or “radon affected area”
  - Identify those regions where the highest radon concentrations are likely to be found so that these can be specifically targeted e.g. by specifying particular building techniques, making measurements
Radon Action Plan

- **Control and reduction of exposure to radon**
  - Corrective measures for existing dwellings
    - Priority for those dwellings that greatly exceed the reference level
    - Availability and effectiveness of cost effective radon mitigation techniques
    - Decision on whether mitigation is carried out left to owners of dwellings
  - Government to determine the circumstances under which remedial action is to be mandatory or is to be voluntary
    - Rental accommodation
    - Sale of dwellings
  - Building codes for new dwellings
  - Definition of radon prone areas

- **Evaluation of effectiveness**
  - Reduction in number/percentage of dwellings above reference level
  - Reduction in average radon level
• Radon in workplaces
  • Planned exposure situations
  • Existing exposure situations
Radon in workplaces – Planned exposure situations

- Exposure to radon takes places in workplaces that involve the mining and processing of raw materials that involve exposure to radioactive material, regardless of the levels of radon
  - e.g. uranium mine, mineral sand mine
- Workplaces where it is not possible or not acceptable to reduce the radon level below the reference level for workplaces
  - e.g. show cave

- Apply graded approach to control of such workplaces
- Subject to dose limit for planned exposure situations
- Radon may be one of several pathways for exposure of workers – gamma, inhalation of dust
• In other workplaces, radon is managed as an existing exposure situation, and controlled through the use of reference level for workplaces and optimization of protection.

• The value of the reference level not to exceed an average annual concentration of 1000 Bq/m$^3$
  
  • e.g. offices, factories
For workplaces such as offices and factories in which exposure to radon is not managed as a planned exposure situation, the national authority is required to set a reference level for $^{222}\text{Rn}$ that does not exceed an annual average activity concentration of $^{222}\text{Rn}$ of 1000 Bq/m$^3$ (GSR Part 3, para. 5.27).
The criteria for choosing the value of the reference level are the same as those that apply to dwellings and the value chosen should be based on an evaluation of the distribution of concentrations of $^{222}\text{Rn}$ in such workplaces.

The national authority should also define the measurement criteria for workplaces in the same manner as outlined in para. 3.25 for dwellings. (measurement protocols)
A different approach to controlling $^{222}\text{Rn}$ exposure in workplaces is to set the same reference level for all indoor environments, i.e. the same reference level would apply to all dwellings, other buildings with high occupancy factors for members of the public and workplaces [ICRP].
Workplaces

- Other buildings with high occupancy factors for members of the public e.g. schools, kindergartens, [reference level of 300 Bq/m$^3$]

- Workplaces such as offices, (without high occupancy factors for members of the public) [reference level of 1000 Bq/m$^3$]

- Workplaces where activity concentration of radon exceed reference levels for workplaces [reference level of 1000 Bq/m$^3$] – planned exposure situation

- Workplaces that involve the mining and processing of raw materials that involve exposure to radioactive material – planned exposure situation irrespective of radon level – dose limit apply.
• EU Directive 2013/59
EU Directive 2013/59

• Article 54: Radon in workplaces

1. Member States shall establish national reference levels for indoor radon concentrations in workplaces. The reference level for the annual average activity concentration in air shall not be higher than 300 Bq/m$^3$, unless it is warranted by national prevailing circumstances.

2. Member States shall require that radon measurements are carried out:
   • (a) in workplaces within the areas identified in accordance with Article 103(3), that are located on the ground floor or basement level, taking into account parameters contained in the national action plan as under point 2 of Annex XVIII, as well as
   • (b) in specific types of workplaces identified in the national action plan taking into account point 3 of Annex XVIII.
EU Directive 2013/59

- Article 54: Radon in workplaces (cont.)

- 3. In areas within workplaces, where the radon concentration (as an annual average), continues to exceed the national reference level, despite the action taken in accordance with the principle of optimisation as set out in Chapter III, Member States shall require this situation to be notified in accordance with Article 25(2) and Article 35(2) shall apply.
• **Article 74**: Indoor exposure to radon

• 1. Member States shall establish national reference levels for indoor radon concentrations. The reference levels for the annual average activity concentration in air shall not be higher than 300 Bq/m$^3$.

• 2. Under the national action plan referred to in Article 103, Member States shall promote action to identify dwellings, with radon concentrations (as an annual average) exceeding the reference level and encourage, where appropriate by technical or other means, radon concentration-reducing measures in these dwellings.

• 3. Member States shall ensure that local and national information is made available on indoor radon exposure and the associated health risks, on the importance of performing radon measurements and on the technical means available for reducing existing radon concentrations.
EU Directive 2013/59

• Article 103: Radon action plan

1. In application of Article 100(1), Member States shall establish a national action plan addressing long-term risks from radon exposures in dwellings, buildings with public access and workplaces for any source of radon ingress, whether from soil, building materials or water. The action plan shall take into account the issues set out in Annex XVIII and be updated on a regular basis.

2. Member States shall ensure that appropriate measures are in place to prevent radon ingress into new buildings. These measures may include specific requirements in national building codes.

3. Member States shall identify areas where the radon concentration (as an annual average) in a significant number of buildings is expected to exceed the relevant national reference level.

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EU Directive 2013/59 – Annex XVIII

- Items to consider in preparing the national radon action plan

- (1) Strategy for conducting surveys of indoor radon concentrations or soil gas concentrations for the purpose of estimating the distribution of indoor radon concentrations, for the management of measurement data and for the establishment of other relevant parameters (such as soil and rock types, permeability and radium-226 content of rock or soil).

- (2) Approach, data and criteria used for the delineation of areas or for the definition of other parameters that can be used as specific indicators of situations with potentially high exposure to radon.

- (3) Identification of types of workplaces and buildings with public access, such as schools, underground workplaces, and those in certain areas, where measurements are required, on the basis of a risk assessment, considering for instance occupancy hours.
Items to consider in preparing the national radon action plan (cont.)

(4) The basis for the establishment of reference levels for dwellings and workplaces. If applicable, the basis for the establishment of different reference levels for different uses of buildings (dwellings, buildings with public access, workplaces) as well as for existing and for new buildings.

(5) Assignment of responsibilities (governmental and non-governmental), coordination mechanisms and available resources for implementation of the action plan.

(6) Strategy for reducing radon exposure in dwellings and for giving priority to addressing the situations identified under point 2.

(7) Strategies for facilitating post construction remedial action.
• Items to consider in preparing the national radon action plan (cont.)

• (8) Strategy, including methods and tools, for preventing radon ingress in new buildings, including identification of building materials with significant radon exhalation.

• (9) Schedules for reviews of the action plan.

• (10) Strategy for communication to increase public awareness and inform local decision makers, employers and employees of the risks of radon, including in relation to smoking.

• (11) Guidance on methods and tools for measurements and remedial measures. Criteria for the accreditation of measurement and remediation services shall also be considered.
EU Directive 2013/59 – Annex XVIII

- Items to consider in preparing the national radon action plan (cont.)

- (12) Where appropriate, provision of financial support for radon surveys and for remedial measures, in particular for private dwellings with very high radon concentrations.

- (13) Long-term goals in terms of reducing lung cancer risk attributable to radon exposure (for smokers and non-smokers).

- (14) Where appropriate, consideration of other related issues and corresponding programmes such as programmes on energy saving and indoor air quality.
Thank you for your attention
Planned exposure situation or existing exposure situation

In the BSS, exposure due to the natural sources, is in general, considered an existing exposure situations and is subject to the requirements in Section 5 of the BSS.

The requirements for planned exposure situation in Section 3 of the BSS apply to some activities specified in para 3.4 of BSS.
Graded approach to regulatory control in planned exposure situation

Apply graded approach to the regulatory control of NORM
- Exemption (dose less than 1 mSv)
- Notification
- Registration
- Licensing
Planned exposure situations – exemption

Exemption (Schedule I of GSR Part 3)

• Risks to individuals are sufficiently low as not to warrant regulatory control, and the exempted practice is inherently safe
  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

• For radionuclides of natural origin, exemption of bulk amounts of material is necessarily considered on a case by case basis by using a dose criterion of the order of 1 mSv in a year, commensurate with typical doses due to natural background levels of radiation.

• The levels of 1 Bq/g for radionuclides in U or Th decay chains and 10 Bq/g for $^{40}$K are not exemption levels
### Planned exposure situation or existing exposure situation?

<table>
<thead>
<tr>
<th>Source of exposure</th>
<th>Existing exposure situation</th>
<th>Planned exposure situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>(other than those listed above) No r/nuclide in U or Th decay chains is &gt;1 Bq/g and $^{40}\text{K} \leq 10$ Bq/g</td>
<td>Practice (listed in para 3.1) in which Any r/nuclide in U or Th decay chains is &gt;1 Bq/g or $^{40}\text{K} &gt; 10$ Bq/g</td>
</tr>
<tr>
<td>Radon in workplaces:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• occ. exposure due to other r/nuclides in U or Th decay chain is controlled as a planned exposure situation</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>• Other workplaces</td>
<td>≤1000 Bq/m³</td>
<td>&gt;1000 Bq/m³</td>
</tr>
</tbody>
</table>
What are the implications for control of NORM?

Activity concentration (Bq/g)

- Uranium ores, U-238
- Monazite, Th-232
- Pyrochlore, Th-232
- Zircon, U-238
- Ilmenite, Th-232
- Rutile, U-238
- Phosphates, U-238
- Bauxite
- Other metal ores, U-238 or Th-232
- Soil, U-238
- Soil, Ra-226
- Soil, Th-232

Data from UNSCEAR 2000

Non-optimum use of regulatory resources
Optimum use of regulatory resources
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