Training Course
on the IAEA Safety Standards Overview

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

Laura Urso

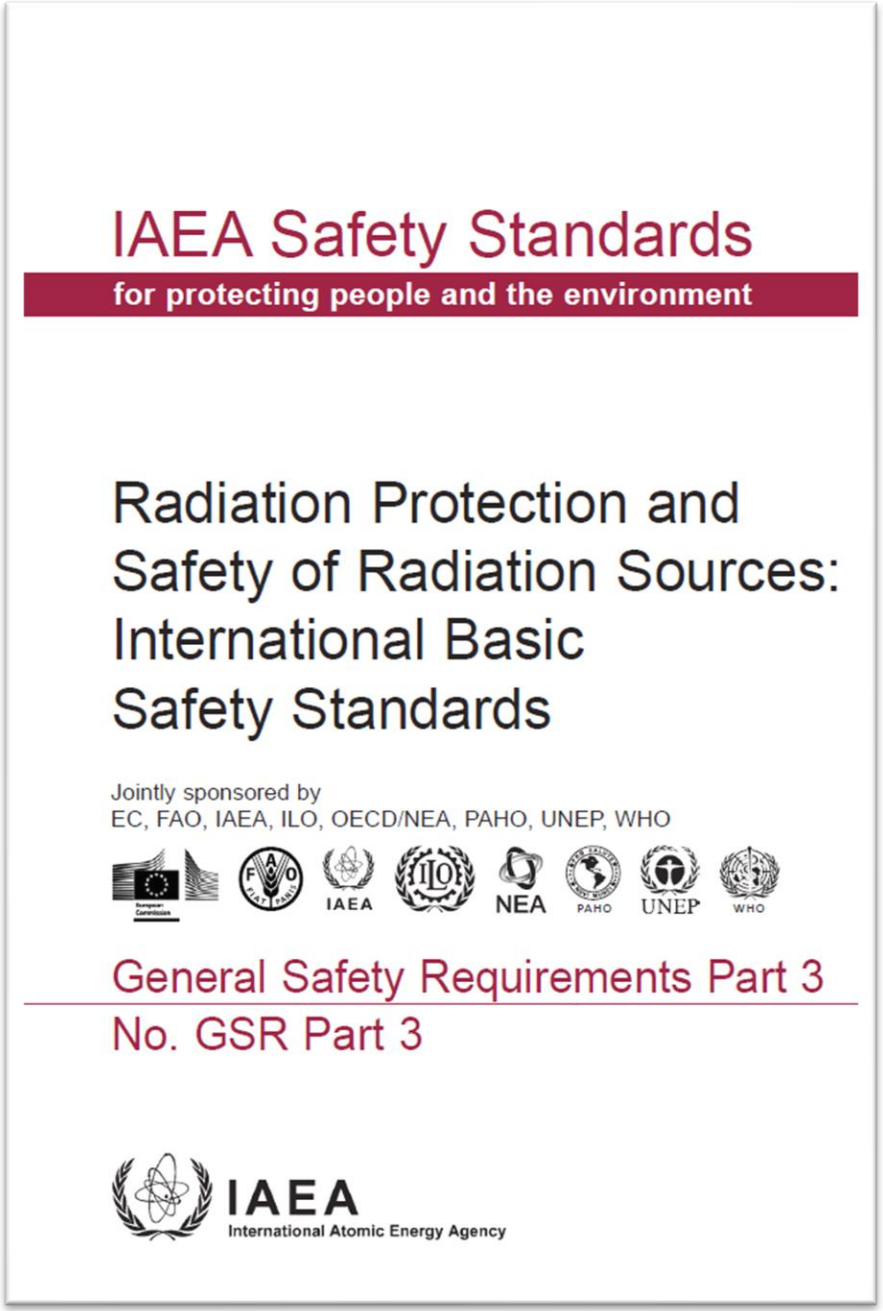
Radiation and Monitoring Section (RMS) Division of Radiation, Transport and Waste Safety (NSRW)
Department of Nuclear Safety and Security, IAEA

Shinagawa Campus, Tokai University, Tokyo, Japan

17-19, 21 March 2025

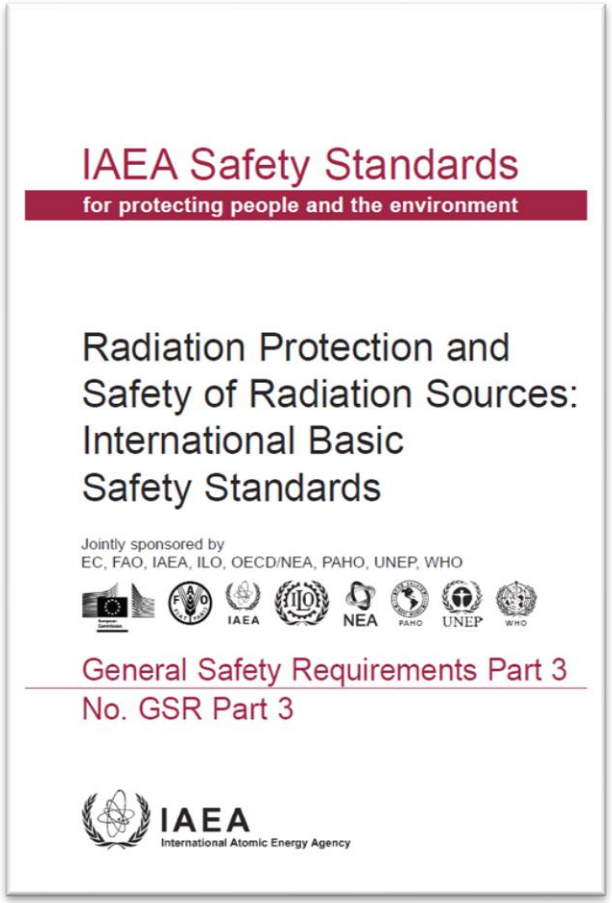
GSR Part 3 - Overview

- The **key document** for Member States to set and apply a solid framework for regulatory control of radiation sources and management of exposure from radiation sources
- A **radiation source** is anything that may cause radiation exposure — such as by emitting ionizing radiation or by releasing radioactive substances or radioactive material — and can be treated as a single entity for purposes of protection and safety
- Published in 2014
- 8 co-sponsoring International Organizations



GSR Part 3 in a nutshell

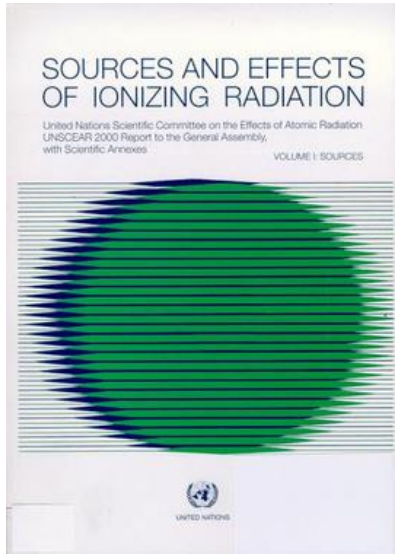
CONTENTS



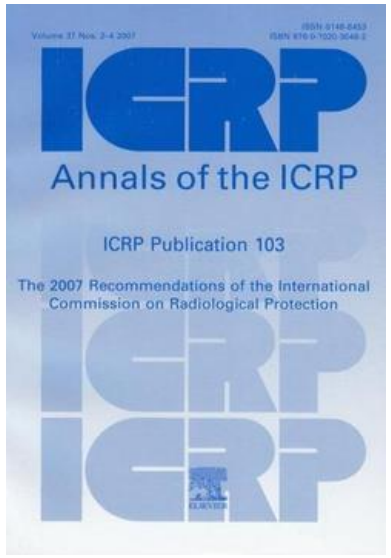
Total of 52 requirements

UNSCEAR & ICRP role in standards development

RP Science

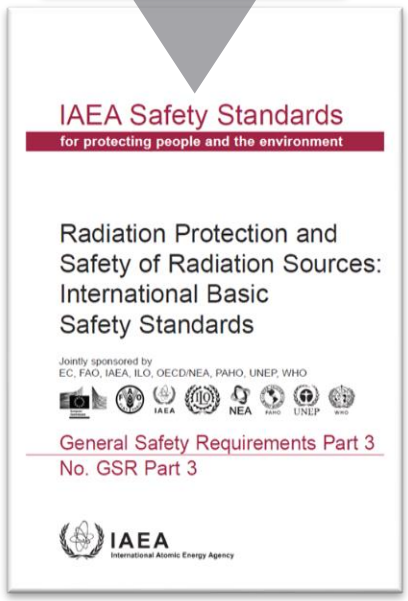


RP Principles



RP Standards

Essential principles (moral obligation)

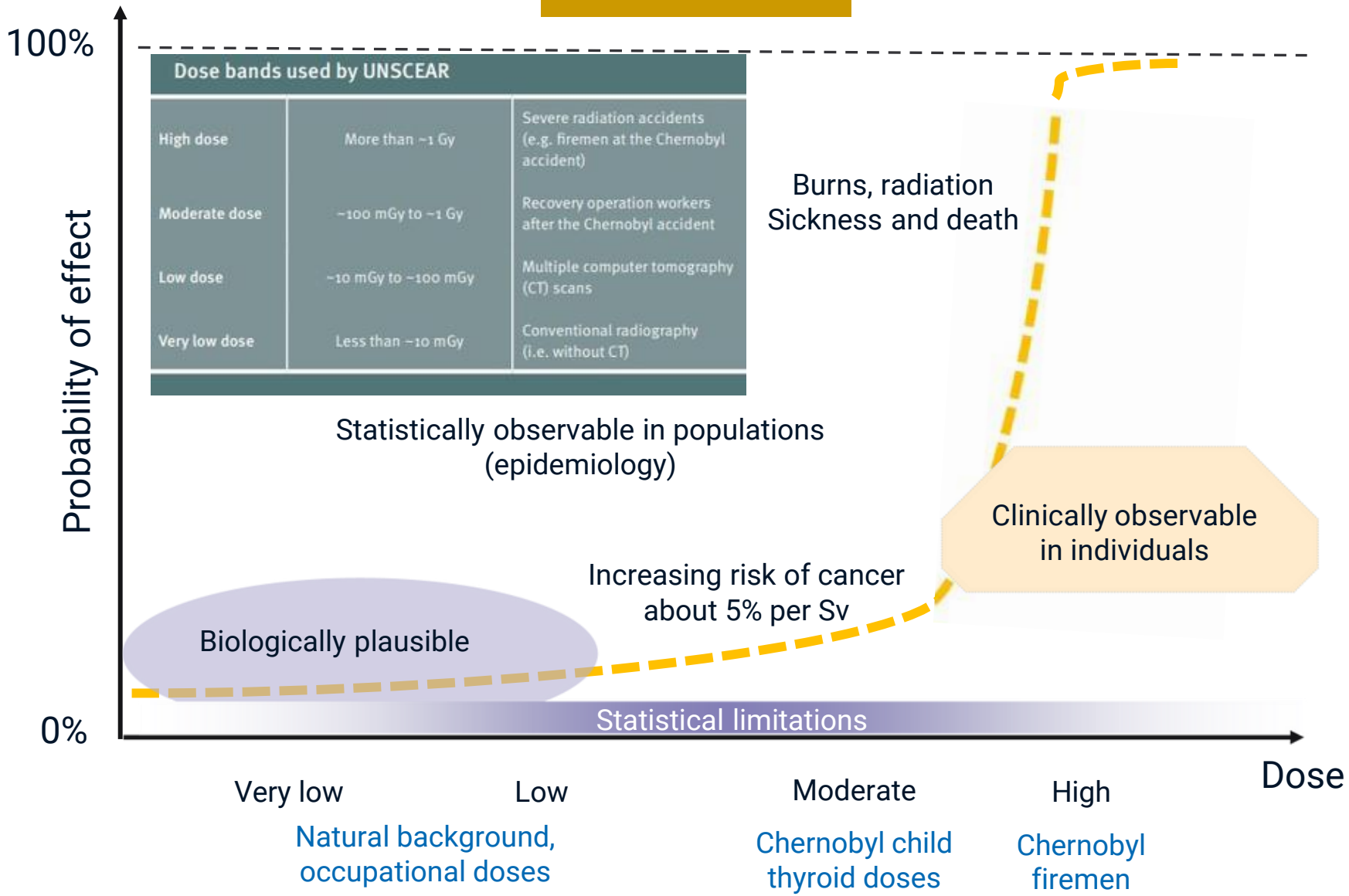


Essential requirements (legal obligation)

National regulations

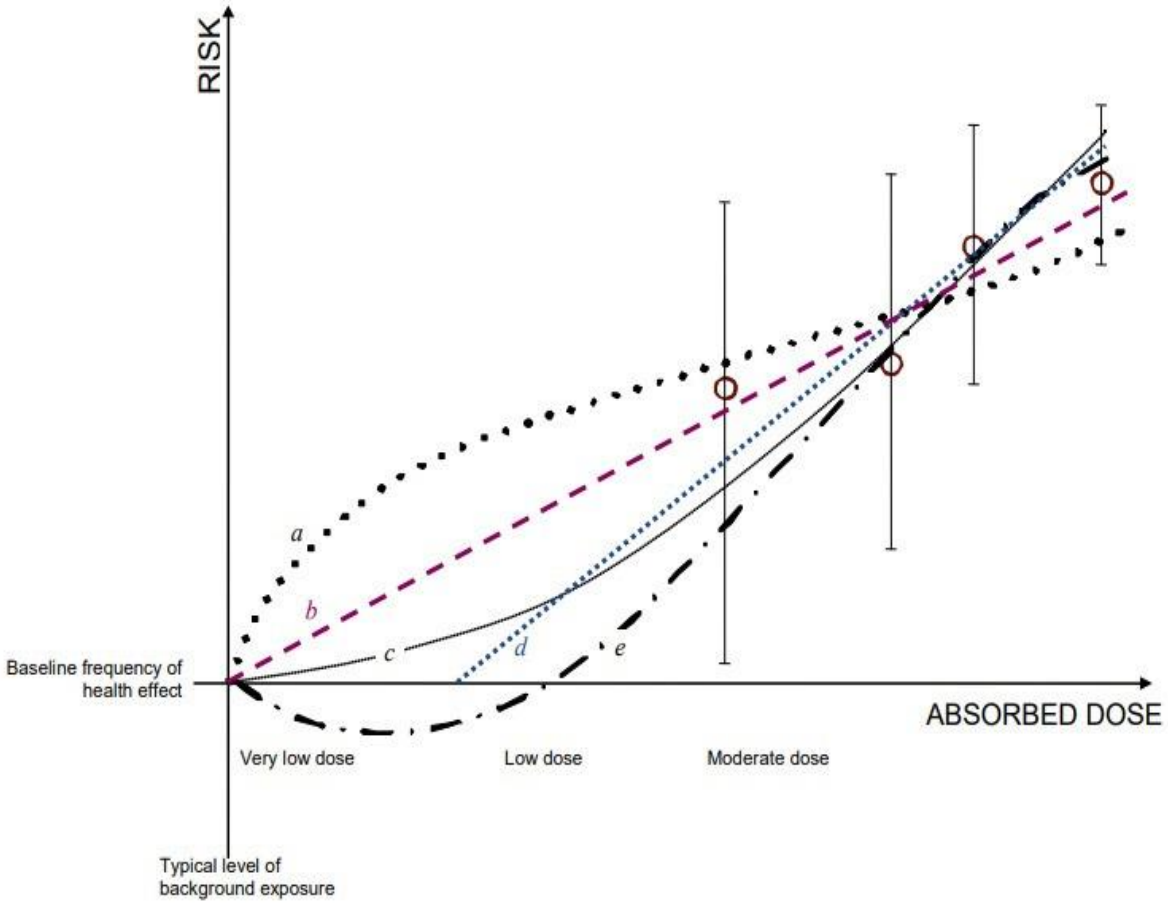
Relationship of radiation doses and health effects

RP Science



Adapted from: UNEP, Radiation Effects and Sources, 2016

What do we know at low doses?



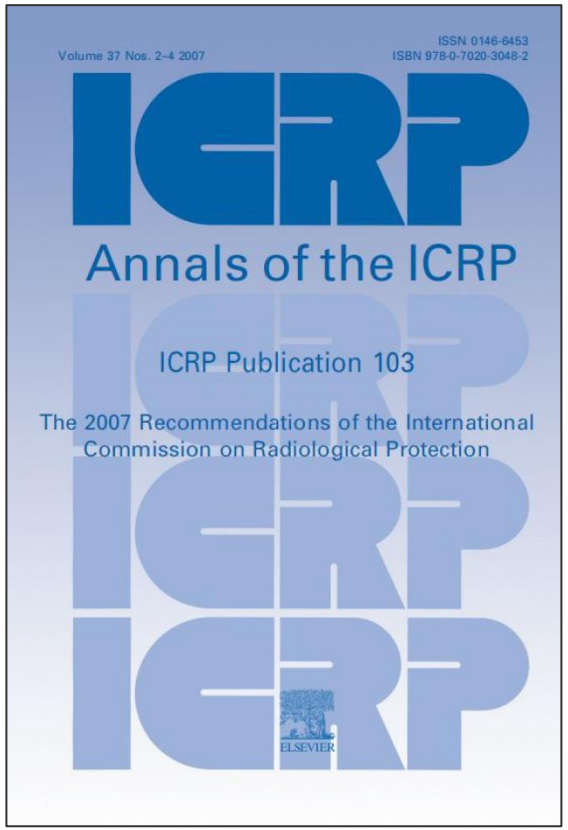
Source: UNSCEAR, 2012 Report – Sources, effects and risks of ionizing Radiation, Annex A, p. 27

- The doses in the figure are in addition to the total background exposure to natural sources of radiation.
- The data points and confidence intervals marked on the graph represent observations of increased frequency of occurrence of a specific cancer type in populations exposed to moderate doses.
- The various lines represent the following plausible dose–response relationships for inferred risk of cancer for exposures in the ranges of low and very low doses:

  (a) supralinear;
  (b) linear-non-threshold (LNT);
  (c) linear–quadratic;
  (d) threshold; and
  (e) hormetic.

The LNT dose–response relationship is assumed for the purposes of radiation protection

Linear-non-threshold (LNT) model: dose-response model which is based on the assumption that, in the low dose range, radiation doses greater than zero will increase the risk of excess cancer and/or heritable disease in a simple proportionate manner.

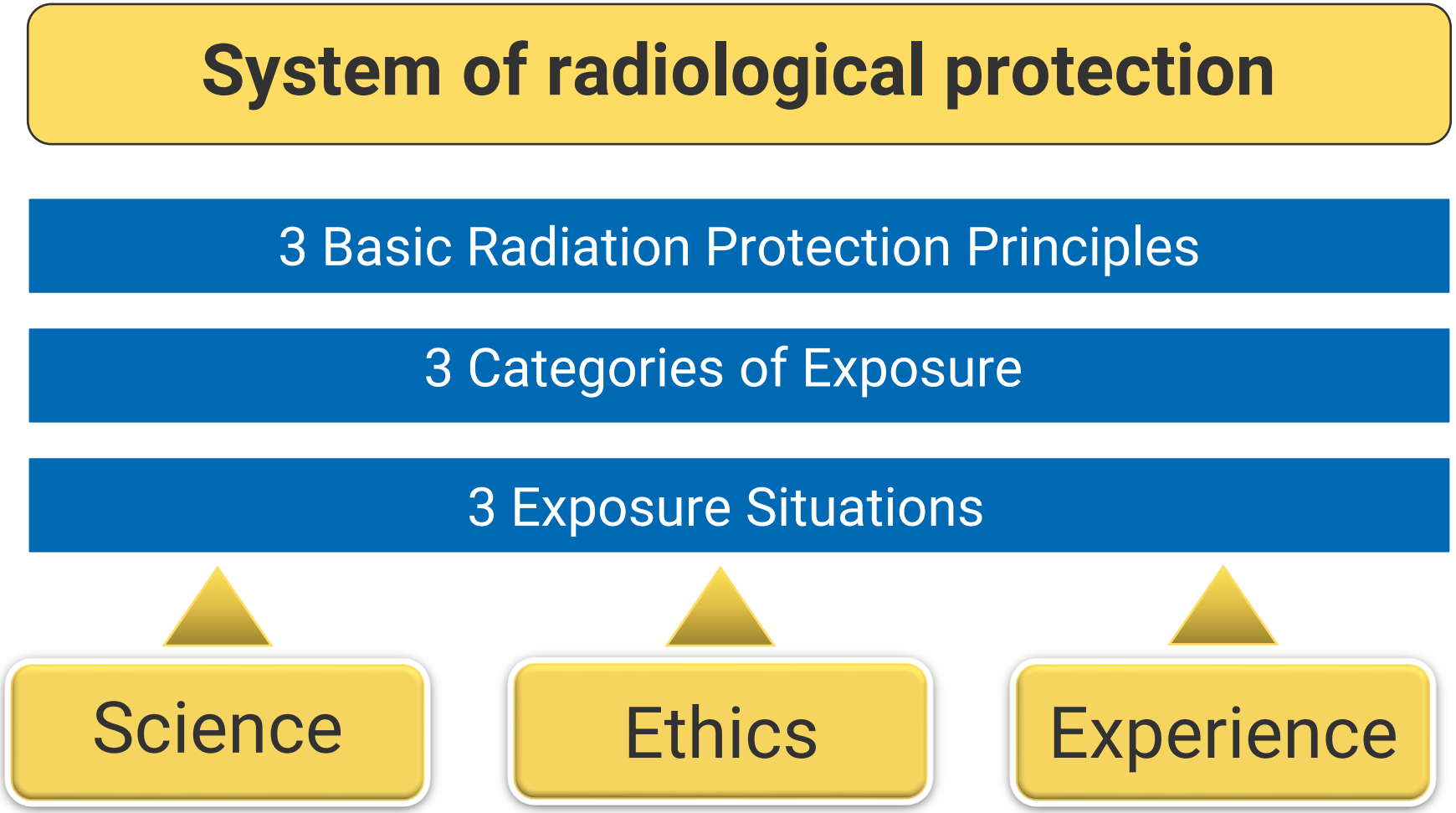


ICRP Publication 103, 2007

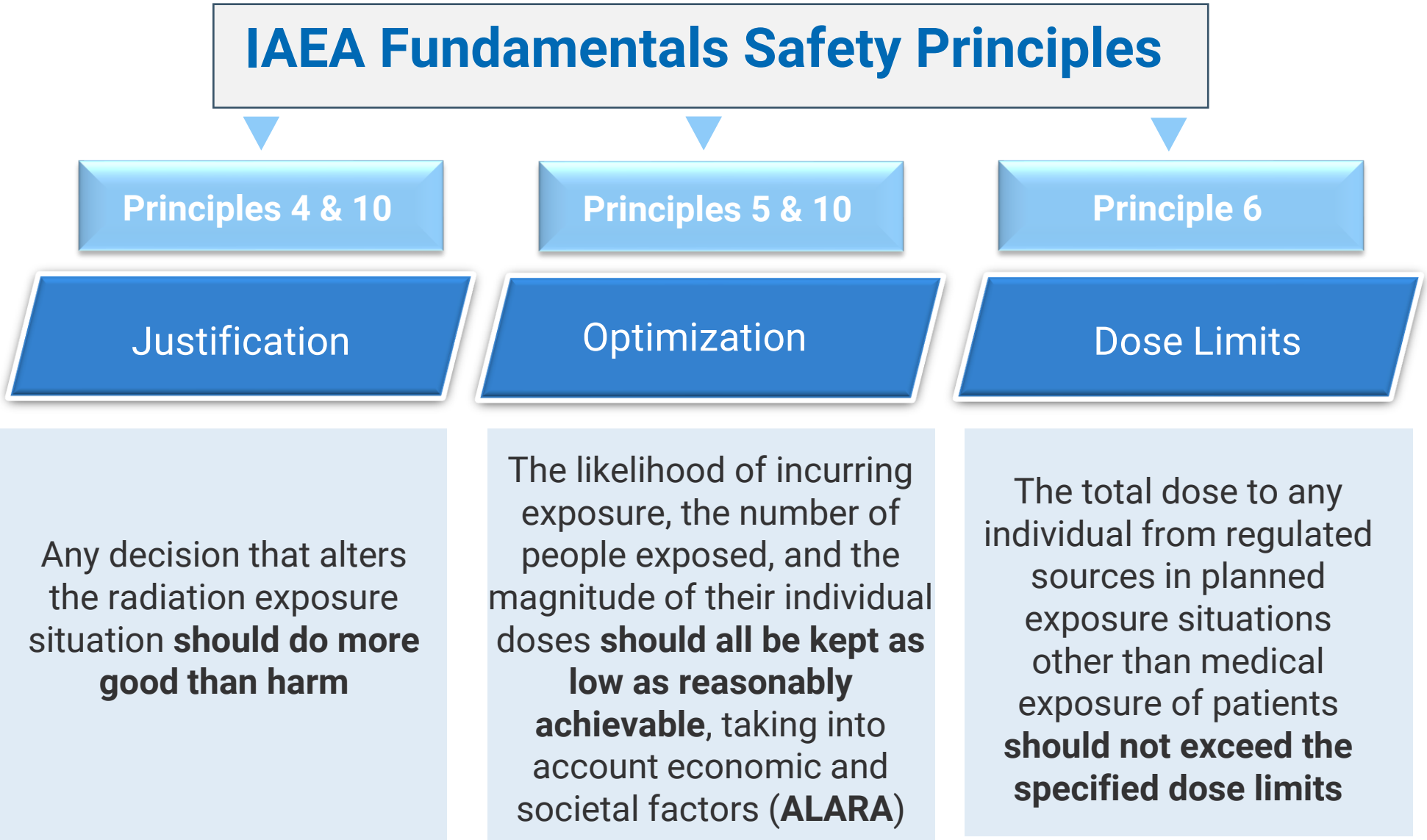
- ✓ *The practical system of radiological protection recommended by the Commission will continue to be based upon the assumption that at doses below about 100 mSv a given increment in dose will produce a directly proportionate increment in the probability of incurring cancer or heritable effects attributable to radiation.*
- ✓ *The Commission considers that the adoption of the LNT model combined with a judged value of a dose and dose rate effectiveness factor (DDREF) provides a prudent basis for the practical purposes of radiological protection, i.e., the management of risks from low-dose radiation exposure.*
- ✓ ***RP system needs to be practical and management of risks commensurate to precautionary principle** (UNESCO, 2005)*

Evolution of BSS and ICRP Recommendations

The system of radiological protection – Rule of three



3 Basic Radiation Protection Principles



3 Exposure Situations

Planned exposure situation

Situations involving the planned introduction and operation of sources (including decommissioning, disposal of radioactive waste, rehabilitation)

Emergency exposure situation

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

Existing exposure situation

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

3 Categories of Exposure

Public exposure

"Exposure incurred by members of the public due to sources in planned exposure situations, emergency exposure situations and existing exposure situations, excluding any occupational exposure or medical exposure." GSR Part 3

Occupational exposure

Exposure of workers incurred in the course of their work. GSR Part 3

Medical exposure

"Radiation exposures of patients occur in diagnostic, interventional, and therapeutic procedures." ICRP 103, §181

See also: Definitions in GSR Part 3

General requirements 1-5

Section 2: General Requirements for Protection and Safety

Requirement 1: Application of the principles of radiation protection	All parties: application of principles of Radiation Protection: justification, optimization, limitation and use of a graded approach
Requirement 2: Establishment of a legal and regulatory framework	Governments: establishment of legal and regulatory framework; efficient and independent regulatory body
Requirement 3: Responsibilities of the regulatory body	Authorities: establishment/adoption of regulations and ensure implementation
Requirement 4: Responsibilities for Protection and Safety	The person or organization responsible for facilities and activities that give rise to radiation risks shall have the prime responsibility for protection and safety.
Requirement 5: Management for Protection and Safety	The principal parties shall ensure that protection and safety are effectively integrated into the overall management system of the organizations for which they are responsible

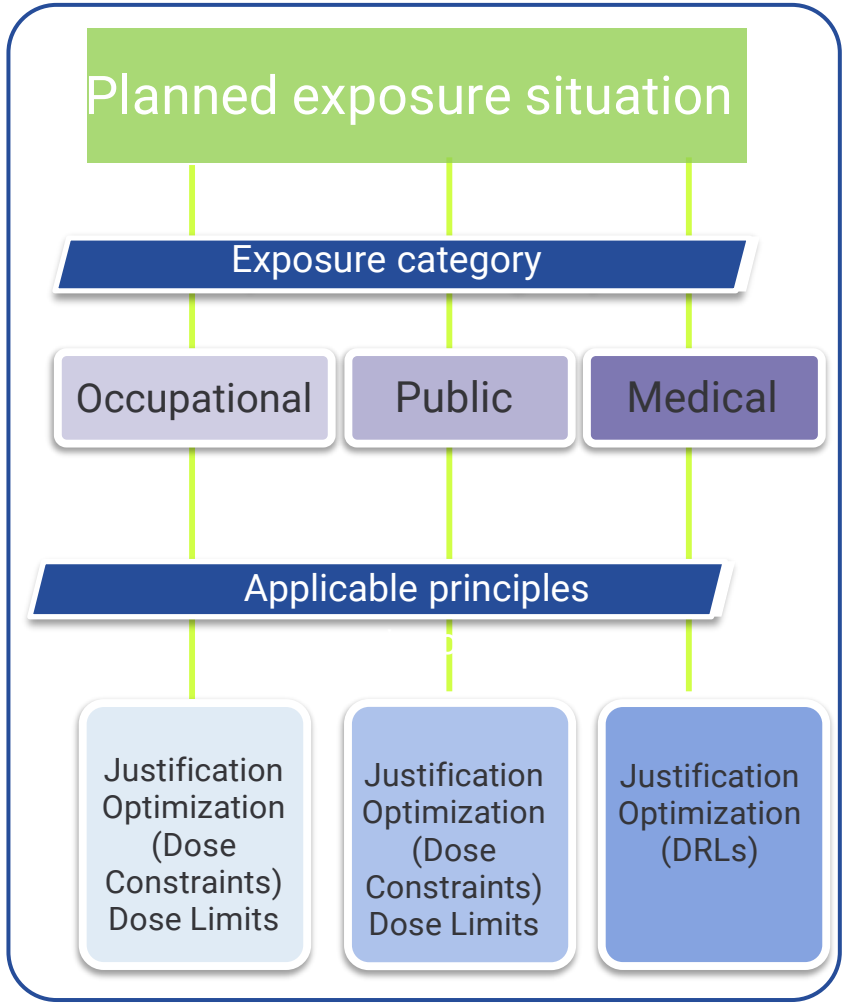
PLANNED EXPOSURE SITUATIONS

Generic requirements

Planned exposure situations

GSR Part 3 - Section 3 (requirements 6 – 42)

Exposure situations involving the planned introduction and operation of sources to enable regulatory control and radiation protection measures to be provided from the start of activities.

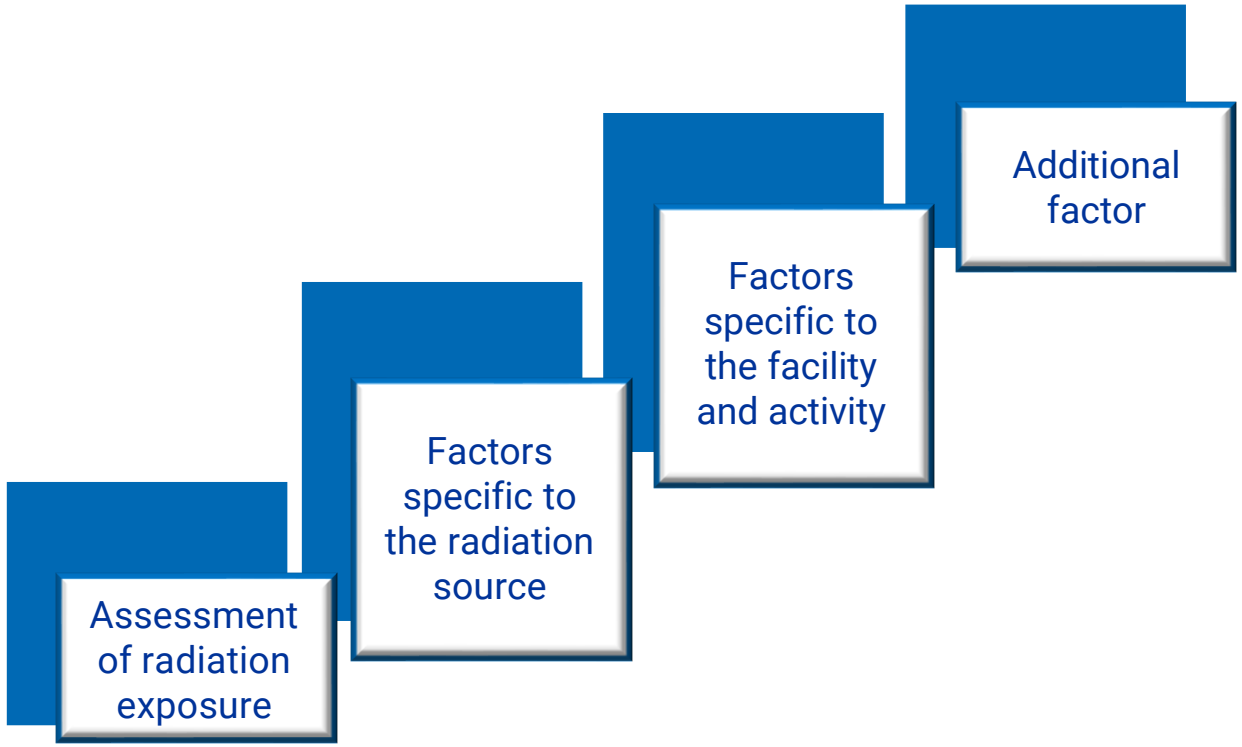


Requirements 6-18

- ❑ **Requirement 6** Graded approach
- ❑ **Requirement 7** Notification and authorization
- ❑ **Requirement 8** Exemption and clearance
- ❑ **Requirement 9** Responsibilities of registrants and licensees in planned exposure situations
- ❑ **Requirement 10** Justification of practices
- ❑ **Requirement 11** Optimization of Protection and Safety
- ❑ **Requirement 12** Dose limits
- ❑ **Requirement 14** Monitoring for verification of compliance
- ❑ **Requirement 15** Prevention and mitigation of accidents
- ❑ **Requirement 16** Investigations and feedback of information on operating experience
- ❑ **Requirement 17** Radiation generators and radioactive sources
- ❑ **Requirement 18** Human imaging using radiation for purposes other than medical diagnosis, medical treatment or biomedical research

Requirement 6: Graded approach

The application of the requirements of these Standards in planned exposure situations shall be commensurate with the characteristics of the practice or the source within a practice, and with the likelihood and magnitude of exposures.



Requirement 8 : Exemption and clearance

Exemption

Sources or practices, with low radiation risk , or no benefit from regulatory control can be exempted from some or all the BSS requirements.

The determination by a regulatory body that a source or practice need not be subject to some or all aspects of regulatory control on the basis that the exposure and the potential exposure due to the source or practice are too small to warrant the application of those aspects or that this is the optimum option for protection irrespective of the actual level of the doses or risks.

Clearance

Materials, with low radiation risk , or no benefit from further regulatory control can be cleared from all requirements of the BSS.

The removal of regulatory control by the regulatory body from radioactive material or radioactive objects within notified or authorized practices.

See also: GSR Part 3, Schedule I, and GSG-17

Requirement 10: Justification of practices

The government or the regulatory body shall ensure that only justified practices are authorized

Justification

Process of determining whether a practice is, overall, beneficial, i.e., whether the expected benefits from introducing the practice outweigh the harm.

In many cases, decisions relating to benefit and risk are taken at the highest levels of government, such as a decision by a State to embark on a nuclear power programme. (SF 1, para. 3.19)

NOT Justified

- × Deliberate addition of radionuclides (or activation) in food.
- × “Frivolous uses ” (toys, jewellery).
- × Human imaging for art, publicity or theft detection.

Only justified in exceptional circumstances

- Human imaging for occupational, legal or insurance reasons.
- Human imaging for concealed objects (smuggling, criminal acts/national security threat).

Requirement 11: Optimization of Protection and Safety

The government or the regulatory body shall establish and enforce requirements for the optimization of protection and safety, and registrants and licensees shall ensure that protection and safety is optimized.

Optimization

Process of determining what level of protection and safety would result in individual doses, the number of exposed and the likelihood of exposure being as low as reasonably achievable, economic and social factors being taken into account ” (ALARA).

Does not imply minimization or elimination of risk.

Optimization is an iterative process that involves:

- Evaluation of exposure situation
- Selection of appropriate value for the dose constraint
- Identification and quantification of possible protection options
- Selection of the best option under prevailing circumstances
- Implementation of the selected option

Dose constraint

A prospective and source related value of individual dose that is used as a parameter for the optimization of protection and safety for the source, and that serves as a boundary in defining the range of options in optimization.

Factors to consider in setting dose constraint:

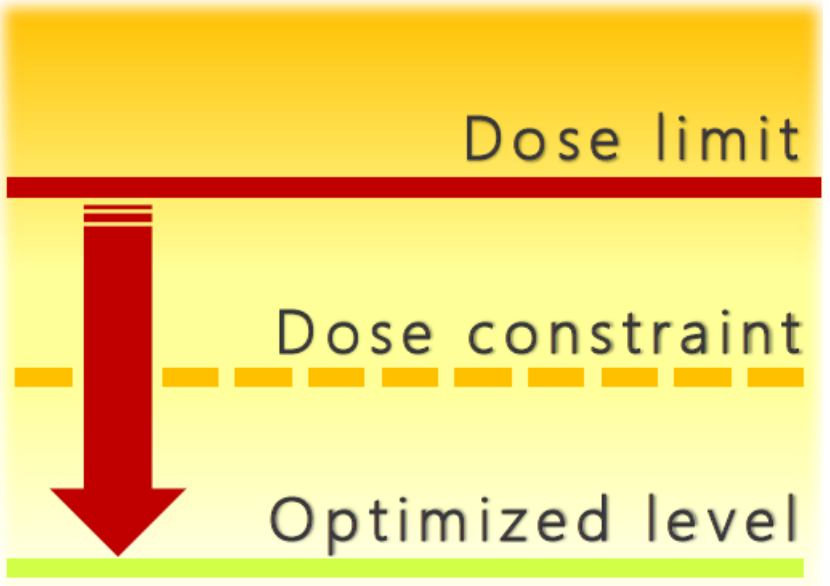
The characteristics of the source and the practice

Good practice in the operation of similar sources

Dose contributions from other authorized practice

The views of interested parties

Licensees are required to use constraints in the process of optimization



Requirement 12: Dose limits

The government or the regulatory body shall establish dose limits for occupational exposure and public exposure , and registrants and licensees shall apply these limits.

	Occupational Dose Limits	Public Dose Limits
Effective dose (whole body)	20 mSv/year, averaged over 5 consecutive years and not exceeding 50 mSv in any single year	1 mSv/year, or exceptionally more in a 1 year provided that the 5 year average does not exceed 1 mSv/year
Equivalent dose (lens of the eye)	20 mSv/year, averaged over 5 consecutive years (and 50 mSv/year)	15 mSv/year
Equivalent dose (skin)	500 mSv/year	50 mSv/year
Equivalent dose (hands and feet)	500 mSv/year	-

See: GSR Part 3, Schedule III

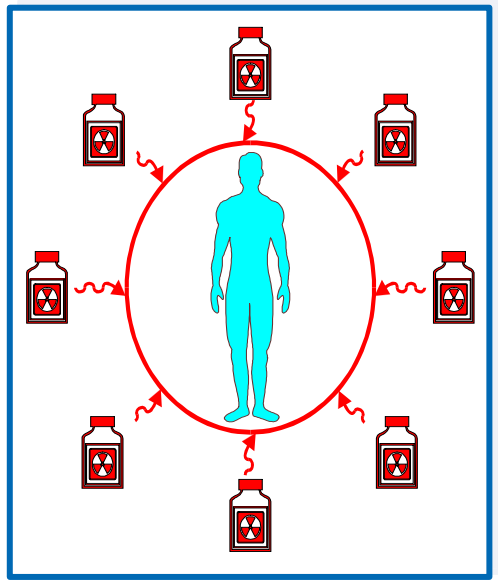
Concepts of dose limit and dose constraint

Dose limits

Dose constraints

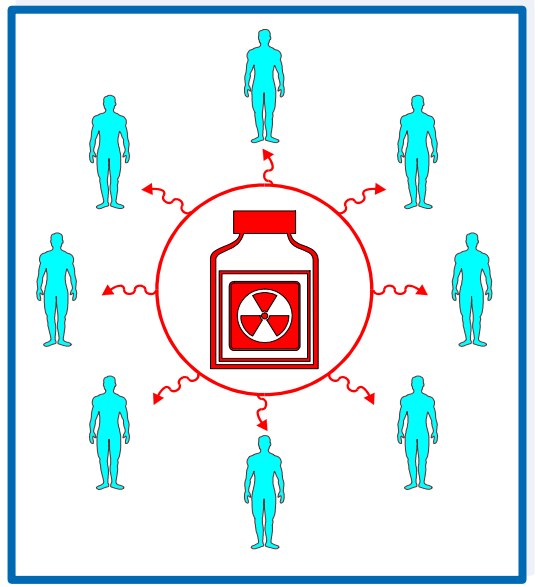
Protect individual workers from occupational exposure and the representative person from public exposure

Exposure based approach



From all regulated sources in planned exposure situations

Source based approach



From a source in all exposure situations

Occupational exposure

Occupational exposure ➔ Exposure of workers incurred in the course of their work.

Worker ➔ Any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relations to occupational radiation protection.

See also: GSG-7 General Safety Guide Occupational Radiation Protection

Specific requirements on responsibilities of regulatory bodies:

- ❑ Requirement 19: The regulatory body shall establish and enforce requirements that protection and safety is optimized, and that doses from occupational exposure comply with dose limits.
- ❑ Requirement 20: The regulatory body shall establish and enforce requirements for the monitoring and recording of occupational exposure in planned exposure situations.

Specific responsibilities of employers, registrants and licensees:

- ❑ Requirement 21: Employers, registrants and licensees shall be responsible for the protection of workers against occupational exposure. They shall ensure that protection and safety is optimized and that the dose limits are not exceeded.

Compliance by workers:

- ❑ Requirement 22: Workers shall fulfil their obligations and carry out their duties for protection and safety.

Occupational exposure

Cooperation between employers and registrants and licensees:

- Requirement 23: Employers and registrants and licensees shall cooperate to the extent necessary for compliance by all responsible parties with the requirements for protection and safety.

Arrangements under the radiation protection programme:

- Requirement 24: Employers, registrants and licensees shall establish and maintain organizational, procedural and technical arrangements for the designation of controlled areas and supervised areas, for local rules and for monitoring of the workplace, in a radiation protection programme for occupational exposure.

Assessment of occupational exposure and workers' health surveillance:

- Requirement 25: Employers, registrants and licensees shall be responsible for making arrangements for assessment and recording of occupational exposures and for workers' health surveillance.

Occupational exposure

Information, instruction and training:

- ❑ Requirement 26: Employers, registrants and licensees shall provide workers with adequate information, instruction and training for protection and safety.

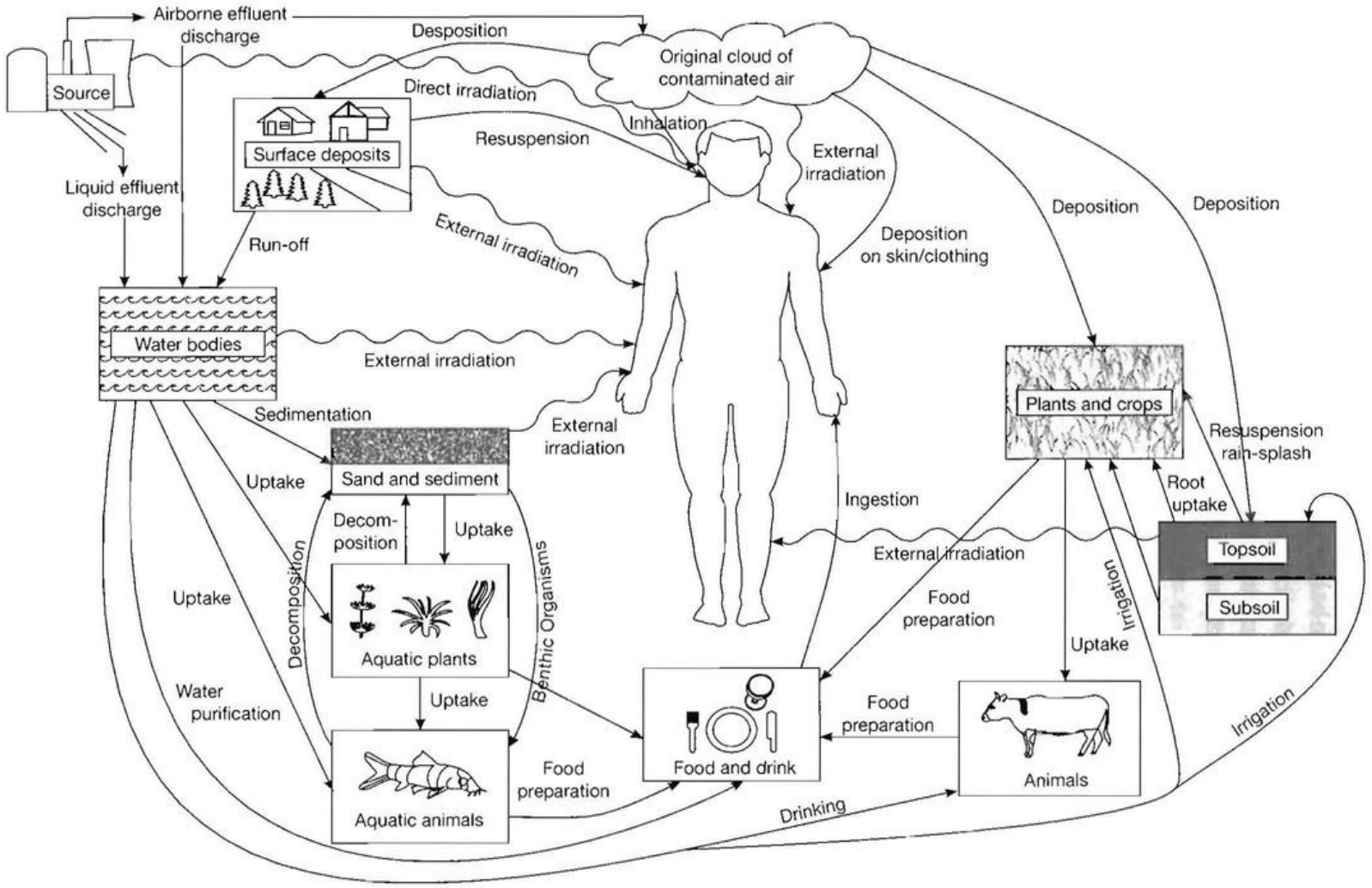
Conditions of service:

- ❑ Requirement 27: Employers, registrants and licensees shall not offer benefits as substitutes for measures for protection and safety.

Special arrangements for protection and safety for female workers and for persons under 18 years of age undergoing training:

- ❑ Requirement 28: Employers, registrants and licensees shall make special arrangements for female workers, as necessary, for protection of the embryo or fetus and breastfed infants. Employers, registrants and licensees shall make special arrangements for protection and safety for persons under 18 years of age who are undergoing training.

Public exposure



Source: IAEA Safety Standards Series No. RS-G-1.8 Environmental and Source Monitoring for Purposes of Radiation Protection

Public exposure

Responsibilities of the government and the regulatory body specific to public exposure:

- Requirement 29: The government or the regulatory body shall establish the responsibilities of relevant parties that are specific to public exposure, shall establish and enforce requirements for optimization, and shall establish, and the regulatory body shall enforce compliance with, dose limits for public exposure.

  - ✓ Establish responsibilities of relevant parties,
  - ✓ Establish and enforce requirements,
  - ✓ Enforce compliance with dose limits for public exposure,
  - ✓ Review design criteria and features related to exposure of the public,
  - ✓ Establish and approve operational limits and conditions including authorized limits on discharges.

Responsibilities of Responsibilities of relevant parties specific to public exposure:

- Requirement 30: Relevant parties shall apply the system of protection and safety to protect members of the public against exposure.

  - ✓ Apply the system of protection and safety for protection of members of the public,
  - ✓ Implement and maintain policies and procedure of public protection
  - ✓ Monitoring programmes
  - ✓ Emergency procedures,
  - ✓ Ensure adequate control of public access.

Registrants and licensees shall ensure that if a source can give rise to external exposure of members of the public shielding and other protective measures, including access control, are provided for restricting public exposure

Public exposure

Radioactive waste and discharges:

- ❑ Requirement 31: Relevant parties shall ensure that radioactive waste and discharges of radioactive material to the environment are managed in accordance with the authorization.

Registrants and licensees, in cooperation with suppliers, as appropriate shall ensure that:

- Any radioactive waste generated is kept to the minimum practicable in terms of both activity and volume.
- There is separate processing of radioactive waste of different types, where warranted by differences in factors.
- Activities for the predisposal management of and for the disposal of radioactive waste are conducted in accordance with the requirements of applicable IAEA standards.

Also:

- Shall maintain an inventory of all radioactive waste that is generated, stored, transferred or disposed of.
- Shall develop and implement a strategy for radioactive waste management and shall include appropriate evidence that protection and safety is optimized.

See also: IAEA Safety Standards Series No. GSR Part 5: Predisposal Management of Radioactive Waste, and

IAEA Safety Standards Series No. SSR-5: Disposal of radioactive Waste

Public exposure

Monitoring and reporting:

- Requirement 32: The regulatory body and relevant parties shall ensure that programmes for source monitoring and environmental monitoring are in place and that the results from the monitoring are recorded and are made available.

Regulatory Body

- Reviews and approves the monitoring programmes of licensees.
- Review of periodic reports on public exposure submitted by licensees.
- Making provision for independent monitoring programmes.
- Assessment of total public exposure from authorized sources and practices in the State.

Licensees

- Establishes and implements monitoring programmes to ensure that public exposure due to sources is adequately assessed and demonstrate compliance with the authorization. To include monitoring of (i) external exposure (…); (ii) Discharges; (iii) Radioactivity in the environment;
- Maintain appropriate records of the results of the monitoring programmes and estimated doses to members of the public;
- Report or make available to the regulatory body the results…
- Report promptly any levels exceeding authorized limits on discharges ...
- Publish or make available the results

Public exposure

Consumer products:

- Requirement 33: Providers of consumer products shall ensure that consumer products are not made available to the public unless their use by members of the public has been justified, and either their use has been exempted or their provision to the public has been authorized.

Consumer product ➔ A device or manufactured item into which radionuclides have deliberately been incorporated or produced by activation, or which generates ionizing radiation, and which can be sold or made available to members of the public without special surveillance or regulatory control after sale.

Examples include:
Smoke detectors, luminous dials, ion generating tubes. It doesn't include the building materials, ceramic tiles, spa waters, minerals and foodstuffs and produces installed in public places (e.g. exit signs).

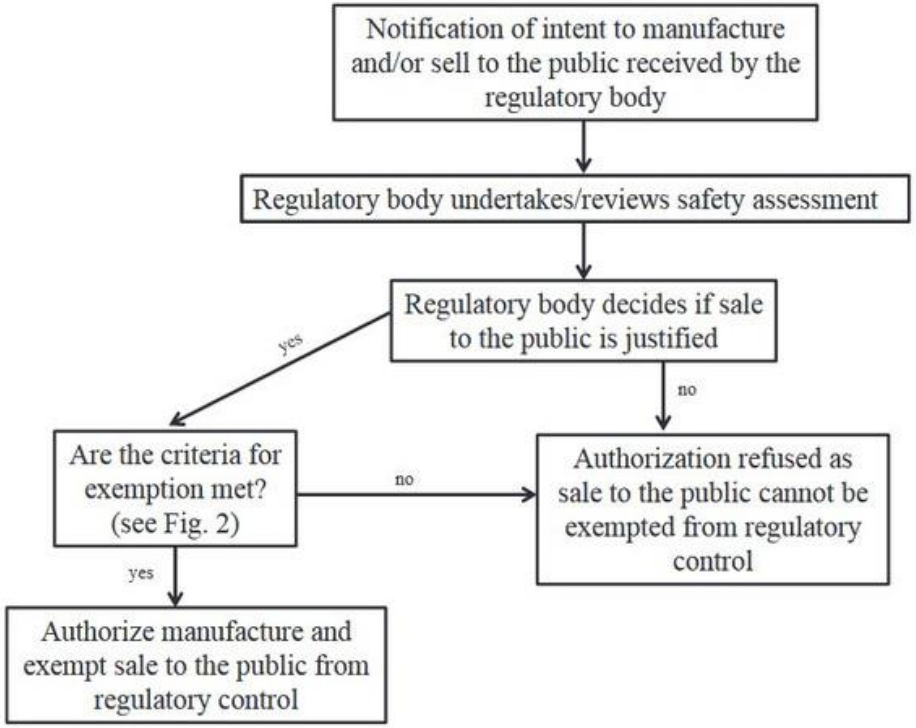


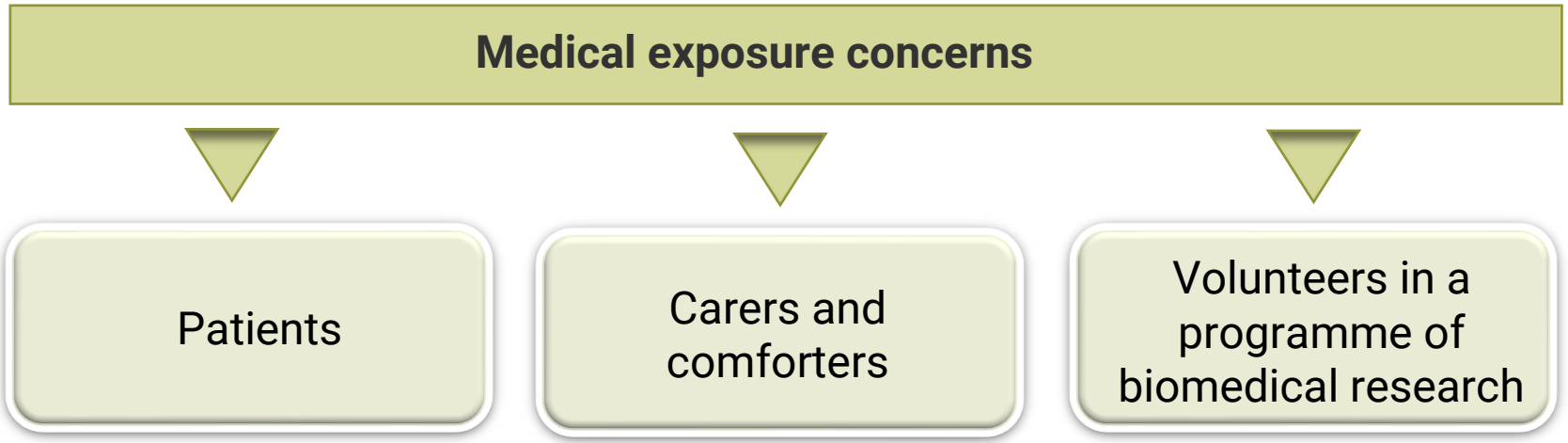
FIG. 1. Regulatory control for consumer products.

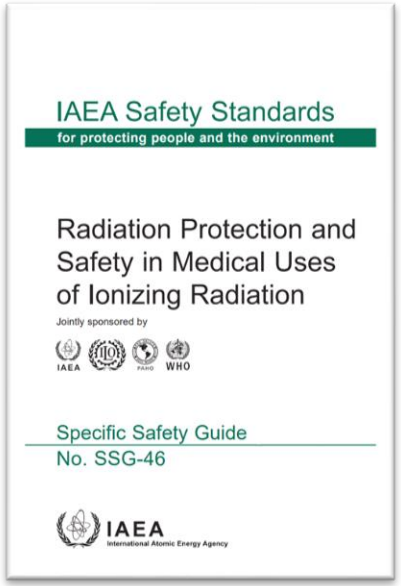
See more: IAEA Safety Standards No. SSG-36 Radiation Safety for Consumer Products

Medical exposure

Section 3: Requirements 34 – 42

➔ Apply to all medical exposures, including intended, unintended and accidental exposures.





See also SSG-46 Specific Safety Guide Radiation protection and Safety in Medical uses of Ionizing Radiation

Patients for the purpose of medical or dental diagnosis and treatment (includes promotion of health; prevention of illness or injury; monitoring of health);

Carers and comforters are persons who willingly and voluntarily help (other than in their occupation) in the care, support and comfort of patients;

Medical exposure

Responsibilities

Requirement 34: Government

- Ensures that relevant parties are **authorized** to assume their roles and responsibilities Ensures the establishment of **dose constraints and diagnostic reference levels** Establishes guideline for the **release of nuclear medicine patients**.

Requirement 35: Regulatory body

- Ensures health professionals fulfil the requirements for **education and training and have the competence in Radiation Protection**.

Requirement 36: Registrants and licensees

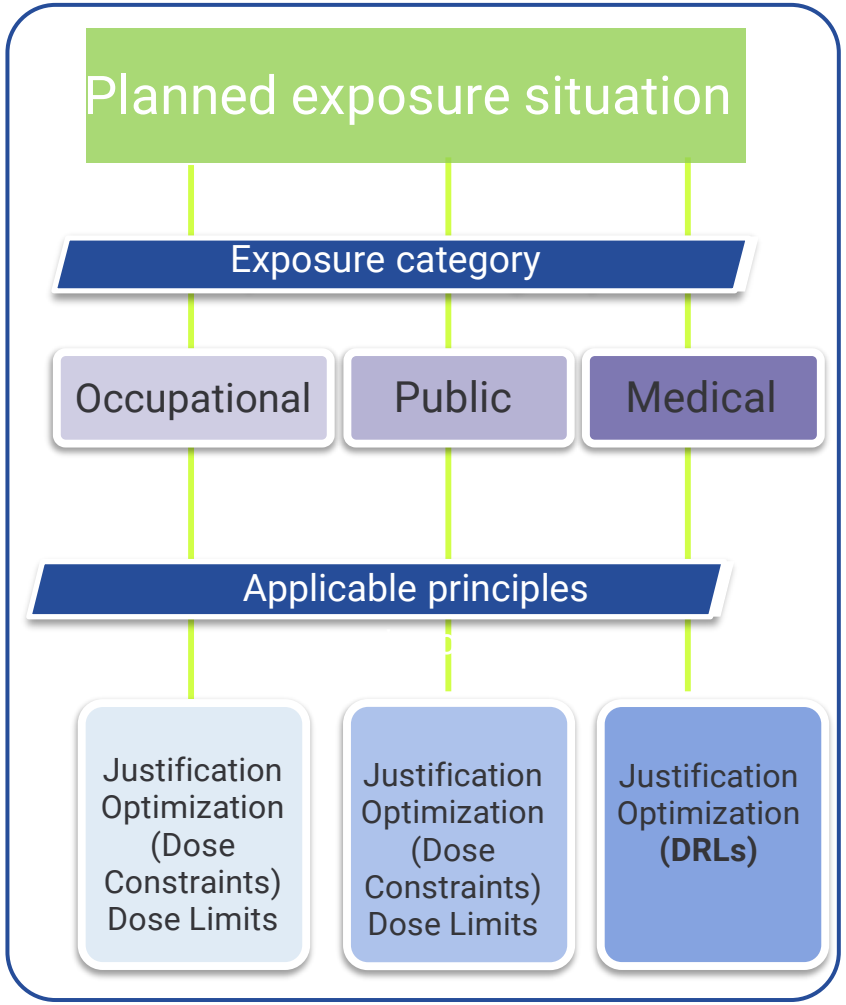
- Ensure **no person receives a medical exposure without an appropriate referral**.
- Inform patients of the **expected benefits and risks** of the medical exposure.
- **Ensure protection and safety**.

Medical exposure

Radiation protection principles

The main tool for optimization of medical exposures for patients is the **diagnostic reference level**.

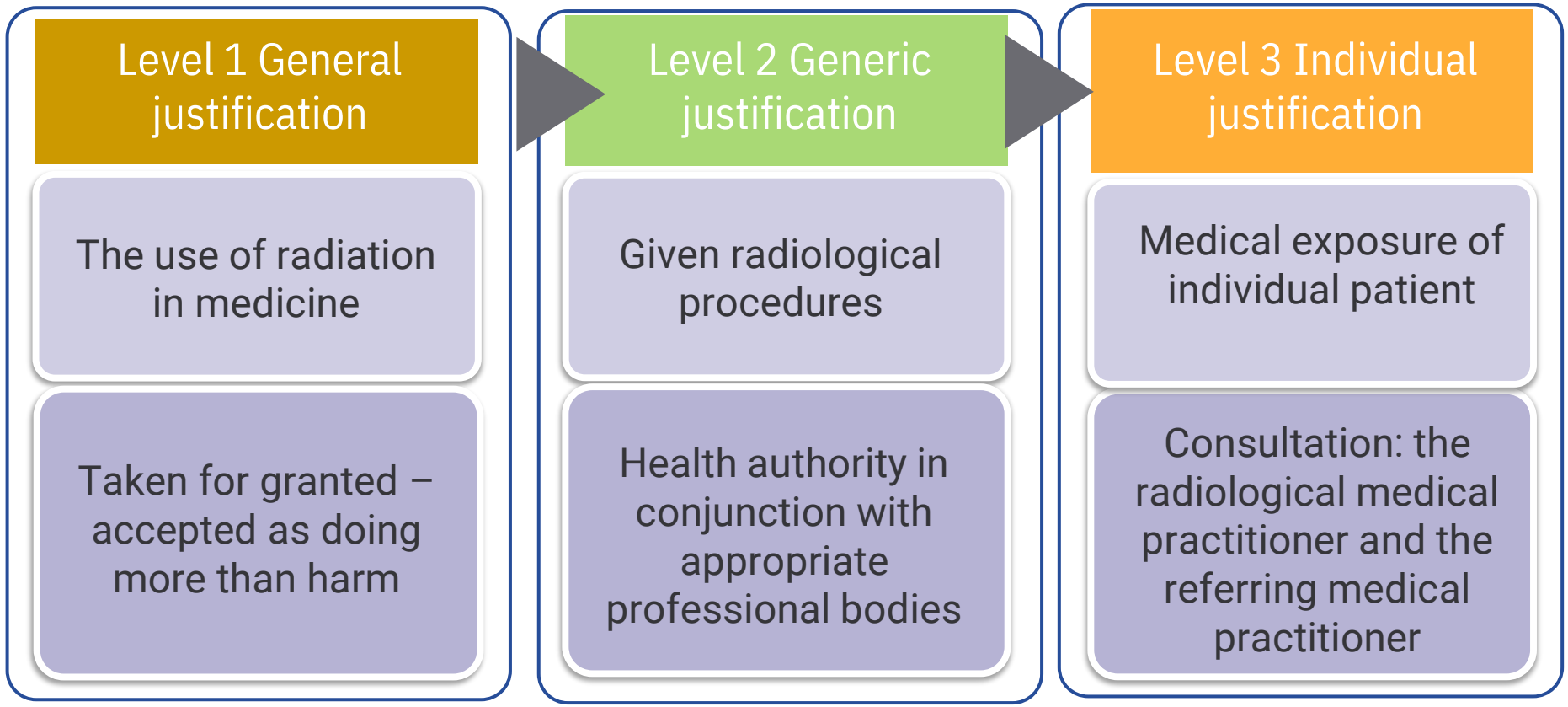
Dose limits do not apply to medical exposures, i.e., exposure of patients, carers or comforters, and volunteers as part of a programme of biomedical research.



Medical exposure

Requirement 37: Relevant parties shall ensure that medical exposures are justified.

Justification: The diagnostic or therapeutic benefits produced by exposures are weighed against the radiation detriment they might cause, taking into account the benefits and risks of available alternative techniques that do not involve medical exposure.



Medical exposure

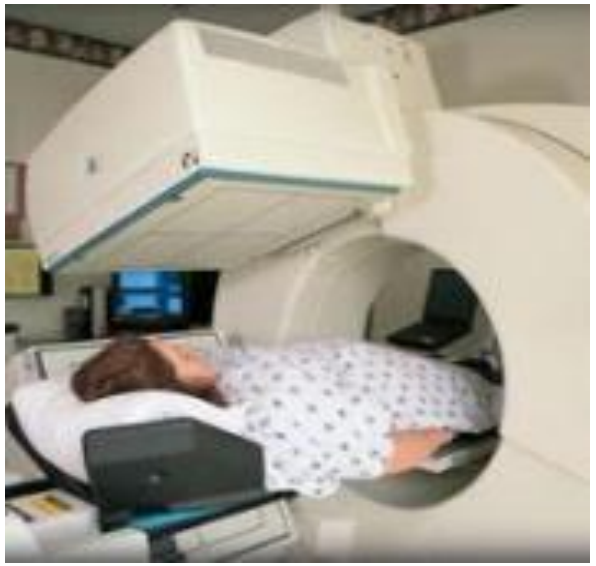
Optimization of protection and safety

Requirement 38: Registrants and licensees and radiological medical practitioners shall ensure that protection and safety is optimized for each medical exposure.

Optimization principle

The principle of optimization of protection is being applied to every exposure:

- ✓ Design considerations for equipment
- ✓ Operational considerations
- ✓ Calibration Dosimetry of patients
- ✓ Diagnostic Reference Levels (DRLs)
- ✓ Quality assurance for medical exposures
- ✓ Dose constraints for caregivers



- ❑ Too low a radiation dose could be as bad as too high a radiation dose.
- ❑ It is of paramount importance that the medical exposure leads to the required outcome.

Medical exposure

Requirement 39: Pregnant or breast-feeding female patients: Registrants and licensees shall ensure that there are arrangements in place for appropriate radiation protection in cases where a female patient is or might be pregnant or is breast-feeding.

Requirement 40: Release of patients after radionuclide therapy: Registrants and licensees shall ensure that there are arrangements in place to ensure appropriate radiation protection for members of the public and for family members before a patient is released following radionuclide therapy.

Requirement 41: Unintended and accidental medical exposures: Registrants and licensees shall ensure that all practicable measures are taken to minimize the likelihood of unintended or accidental medical exposures. Registrants and licensees shall promptly investigate unintended or accidental medical exposures and, if appropriate, shall implement corrective actions.

Requirement 42: Reviews and records: Registrants and licensees shall ensure that radiological reviews are performed periodically at medical radiation facilities and that records are maintained.

EMERGENCY EXPOSURE SITUATIONS

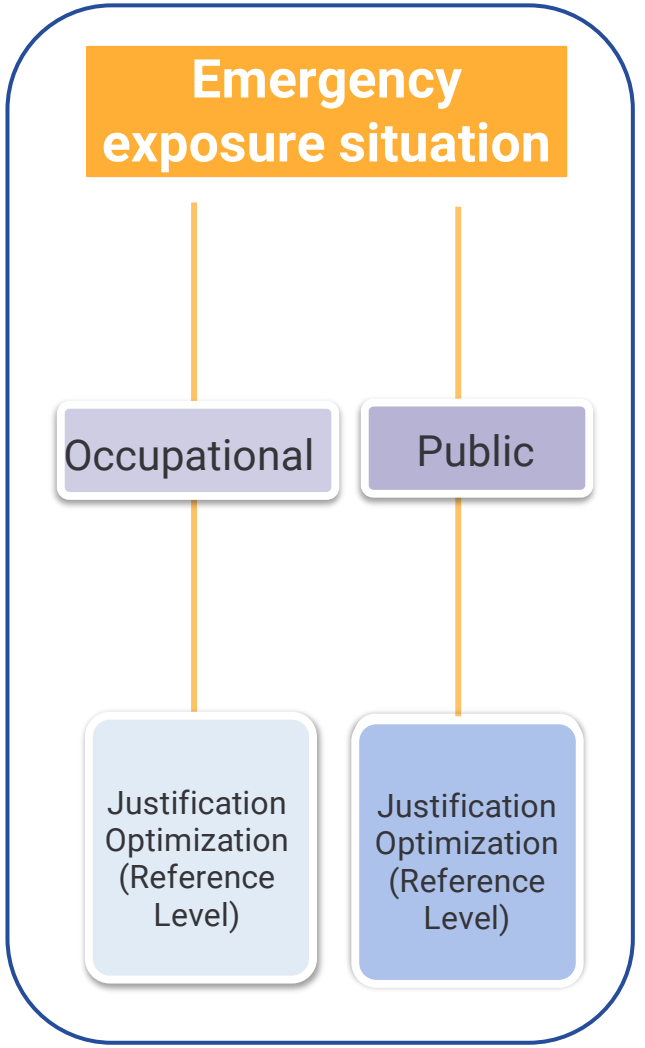
Generic requirements

Emergency exposure situations

Section 4: Requirements 43 – 46

An emergency exposure situation is a situation of exposure that arises as a result of an accident, a malicious act or any other unexpected event, and requires prompt action in order to avoid or to reduce adverse consequences. Preventive measures and mitigatory actions have to be considered before an emergency exposure situation arises. However, once an emergency exposure situation actually arises, exposures can be reduced only by implementing protective actions.

- Justification and optimization of protection measures
- Dose limits and emergency dose limits for occupational exposure
- Dose reference levels for public exposure



See also:
IAEA Safety Standards GSR Part 7: Preparedness and Response for a Nuclear or Radiological Emergency

Transition to existing exposure situation

Requirement 46: The government shall ensure that arrangements are in place and are implemented as appropriate for the transition from an emergency exposure situation to an existing exposure situation.

Emergency exposure situation → **Existing exposure situation**

The government arrangements are in place and are implemented for this transition which shall be made in a coordinated and orderly manner.

The responsible authority shall take the decision to make the transition transfer responsibilities to the appropriate parties in accordance with the government's emergency preparedness plan.

Workers involved in the transition:
Requirements for occupational exposures in planned exposure situations apply

IAEA

EXISTING EXPOSURE SITUATIONS

Existing exposure situations - scope

GSR Part 3 - Section 5, Requirements 47 – 52

Situations of exposure that already exists when a decision on the need for control needs to be taken.

- ✓ situations of exposure to natural sources (when amenable to control).
- ✓ situations of exposure due to residual radioactive material that:
  - derives from past practices that were not subject to regulatory control
  - remains after an emergency exposure situation.

Contamination or areas by residual radioactive material arising from:

Past activities that were never subject to regulatory control

A nuclear or radiological emergency, after emergency has been terminated

Exposure due to radionuclides in:

Food, drinking water, animal feed, construction materials and other commodities

Exposures due to natural sources

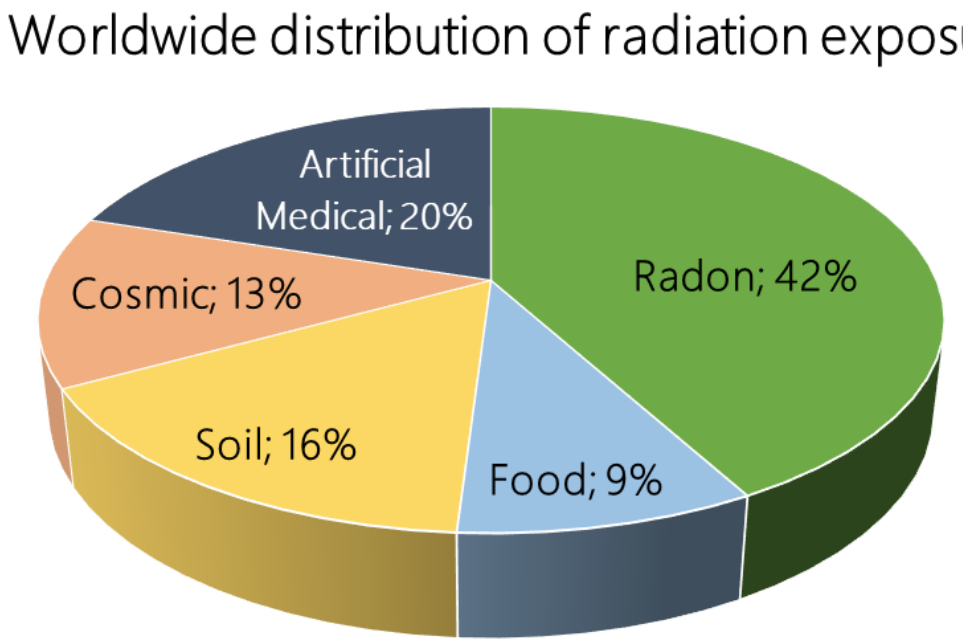
Radon with respective progeny

Natural radionuclides in commodities

Materials containing uranium and thorium chains ≤ 1 Bq/g and K-40 ≤ 10 Bq/g

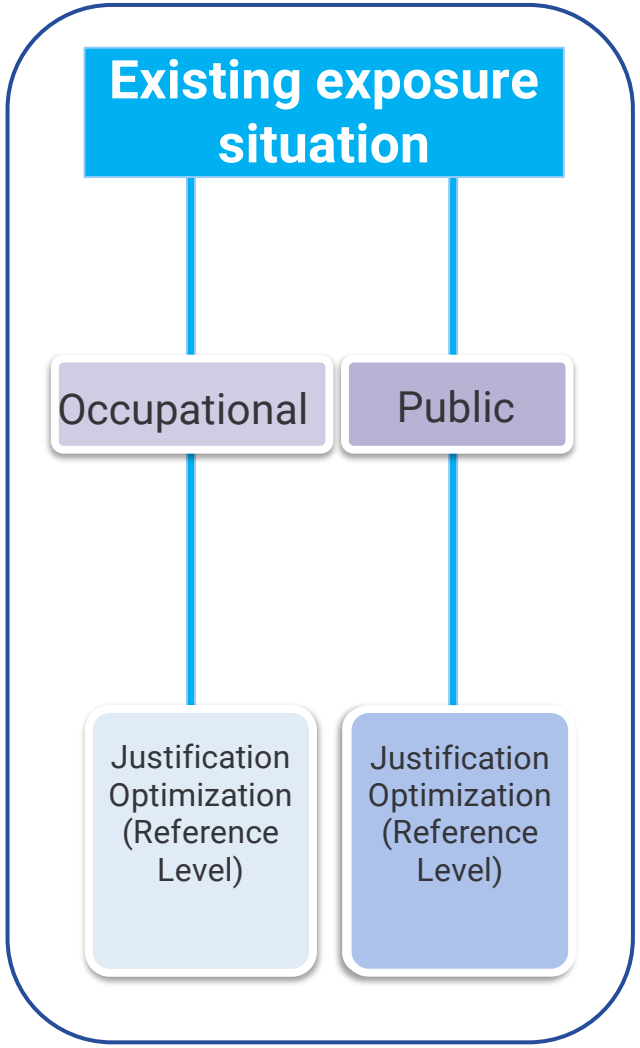
Exposure of aircrew and space crew

Existing exposure situations



Graph adapted from UNEP, Radiation effects and sources, 2016

About 80% of the global average annual effective dose per person (about 2.4 mSv) is due to natural sources.



Existing exposure situations

Requirement 47: Responsibilities of the government specific to existing exposure situations.
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.

The government

- ✓ Identifies the exposures of concern
- ✓ Ensures assignment of responsibilities
- ✓ Identifies responsible parties for site remediation and put in place waste management strategies
- ✓ Provides for involvement of interested parties
- ✓ Ensures establishment of reference levels
- ✓ Gathers and provides information on exposure levels to radon and health risks to the public

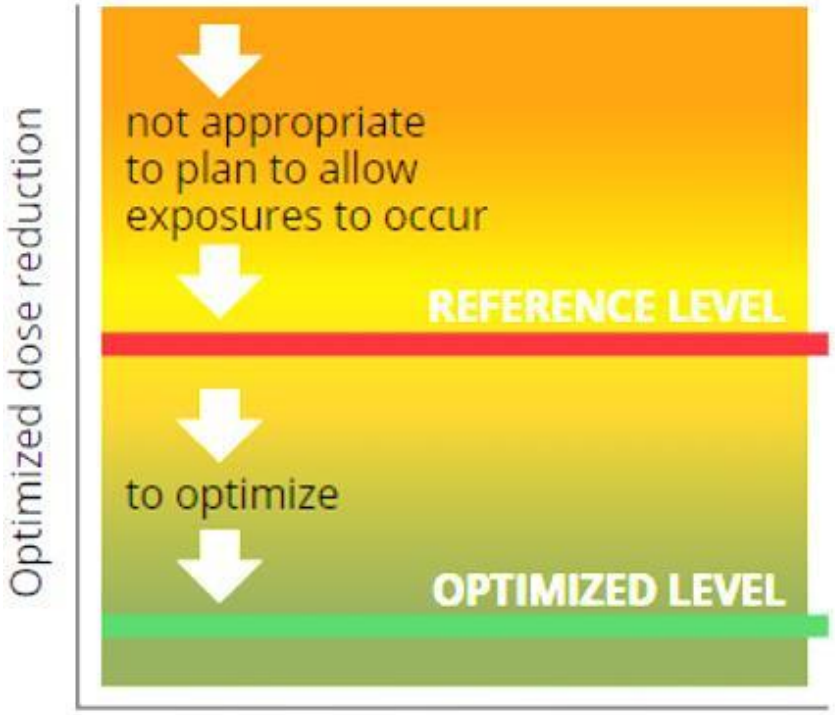
Regulatory Body
or other relevant authority

- ✓ Implements protection of strategies
- ✓ Ensures that remedial and protective actions are justified and optimized
- ✓ Establishes references levels
- ✓ Is responsible for authorization or remediation

Requirement 48: Justification for protective actions and optimization of protection and Safety.
The government and the regulatory body or other relevant authority shall ensure that remedial actions and protective actions are justified and that protection and safety is optimized.

Reference level

Reference level is 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.



Reference levels are typically expressed as an annual effective dose

Bands for reference levels:

- ➔ No greater than 1 mSv: commodities containing radionuclides of natural origin
- ➔ 1-20 mSv: situations of exposure due to natural sources or from residual radioactive material
- ➔ 20-100 mSv: situations of exposure where individuals are exposed to radiation where actions to reduce doses would be disproportionately disruptive

Reference levels are not limits – but should initiate action if exceeded

Public exposure

Requirement 49: Responsibilities for remediation of areas with residual radioactive material

The government shall ensure that provision is made for identifying those persons or organizations responsible for areas with residual radioactive material; for establishing and implementing remediation programmes and post-remediation control measures, if appropriate; and for putting in place an appropriate strategy for radioactive waste management.

The government is responsible for ensuring that provision is made to:

- Identify those persons or organizations responsible for areas with residual radioactive material
- Establish and implement a remediation programme and post-remediation control measures
- Establish an appropriate strategy for radioactive waste management

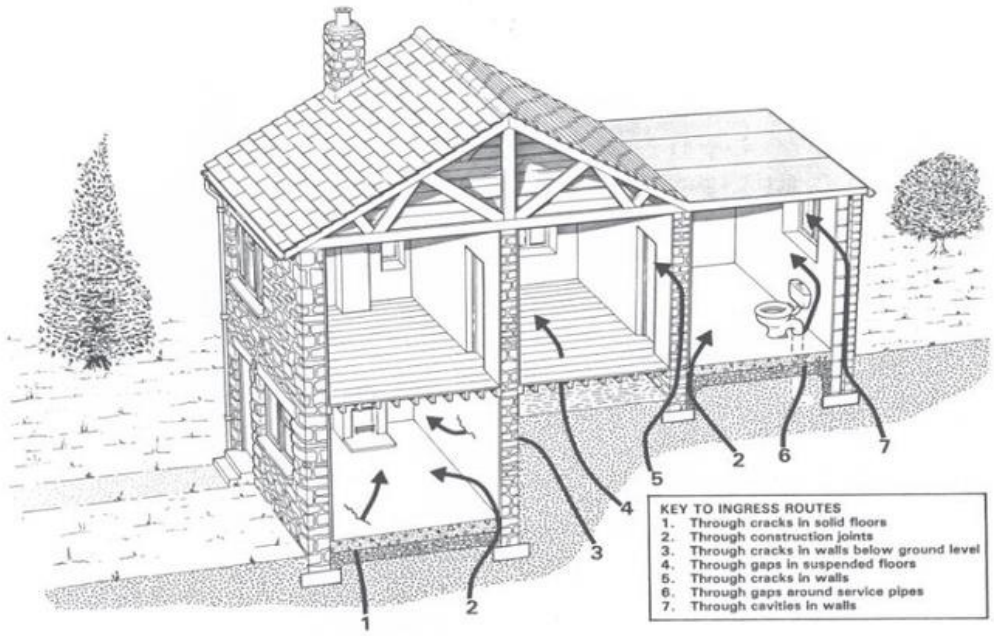
Remedial action plan includes:

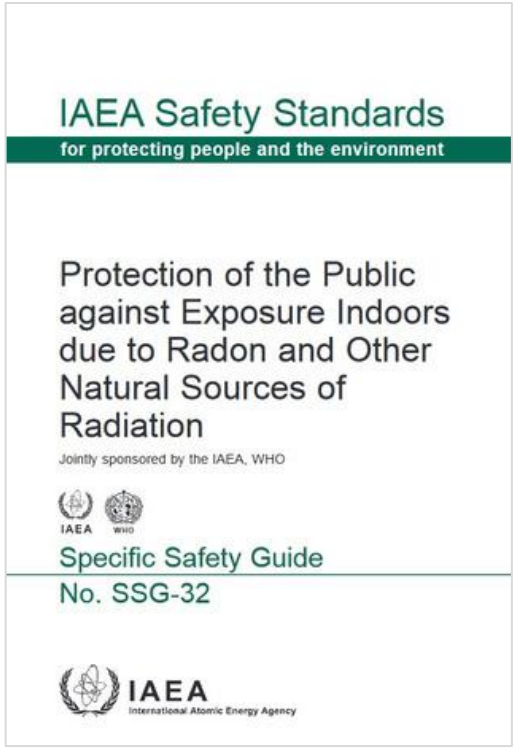
- Sharing of public information
- Establishing and implementing a monitoring programme
- Maintaining records

Public exposure

Requirement 50: Public exposure due to radon indoors

The government shall provide information on levels of 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.





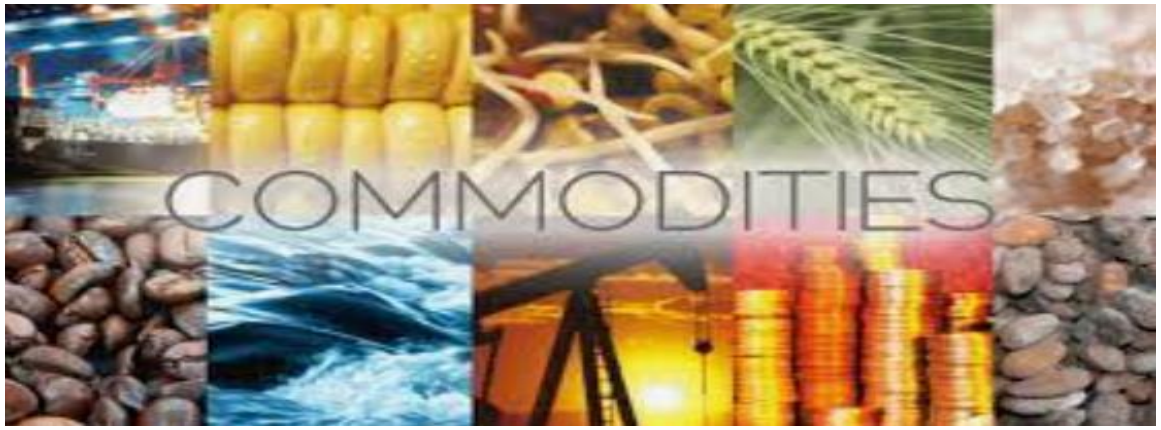
If there are significant radon levels, then the **national action plan** shall be established

Public exposure

Requirement 51: Exposure due to radionuclides in commodities

The regulatory body or other relevant authority shall establish reference levels for exposure due to radionuclides in commodities.

- Specific reference levels for exposure due to radionuclides in commodities such as construction materials, food and feed, and in drinking water, each of which shall typically be expressed as, or be based on, an annual effective dose to the representative person that generally does not exceed a value of about 1 mSv.



- Consider the “guideline levels” for radionuclides in food traded internationally that could contain radioactive substances as a result of a nuclear or radiological emergency, published by the Joint FAO/WHO Codex Alimentarius Commission and the “guidance levels” for radionuclides in drinking water published by WHO.

Occupational exposure

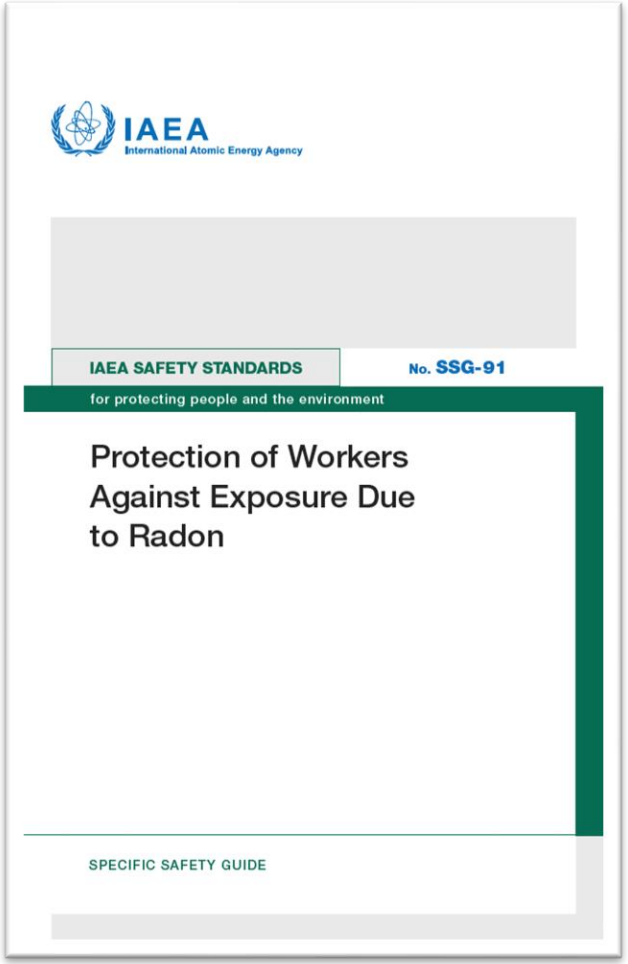
Requirement 52: Exposure in workplaces

The regulatory body shall establish and enforce requirements for the protection of workers in existing exposure situations.

Requirements in respect of public exposure shall be applied for protection and safety for workers in existing exposure situations, other than in those specific situations which include:

- ✓ Situations involving the remediation of areas with residual radioactive material
- ✓ Exposure of aircrew and space crew to cosmic radiation
- ✓ Protection of workers against exposure to radon

- ❑ Employers shall ensure that activity concentrations of ^{222}Rn in workplaces are as low as reasonably achievable below the reference level established set at a value that does not exceed an annual average activity concentration of ^{222}Rn of 1000 Bq/m^3 and shall ensure that protection is optimized.
- ❑ If, despite all reasonable efforts by the employer to reduce activity concentrations of radon, the activity concentration of ^{222}Rn in workplaces remains above the reference level, the relevant requirements for occupational exposure in planned exposure situations as stated in Section 3 of GSR Part 3 shall apply.



Conclusion

This lecture aimed at providing insights into GSR Part 3 on

- ✓ how GSR Part 3 applies the Fundamental Safety Principles
- ✓ the application of radiation protection principles to each exposure situation
- ✓ how requirements are applied for each exposure situation
- ✓ the responsibilities assigned to Governments, Regulatory Bodies, Licensees and Workers by the requirements for radiation protection

Thank you!

Safety-Standards.Contact-Point@iaea.org