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CENTRE D'ÉTUDE SUR L'ÉVALUATION DE LA PROTECTION DANS LE DOMAINE NUCLÉAIRE

ALARA in Safety and Security of Radioactive Sources: an ICRP Perspective

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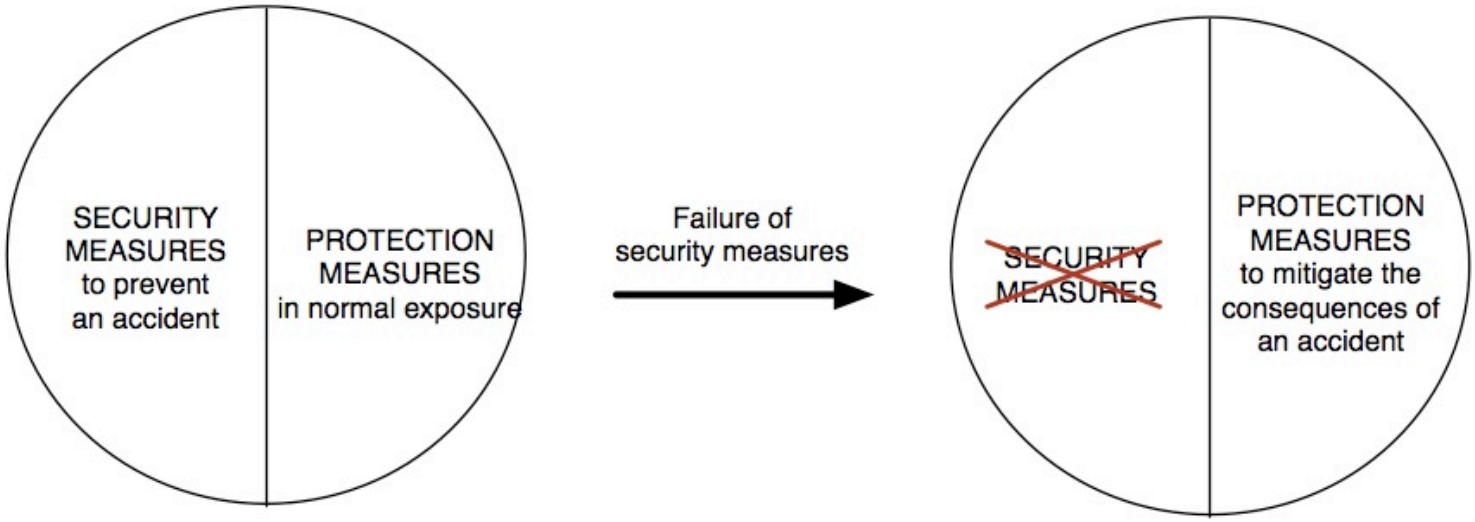
Definitions

- Definitions in ICRP 103 (2007):
  - **Safety**: achievement of proper operating conditions, prevention of accident or mitigation of accident consequences
  - **Security**: prevention and protection of, and response to, theft, sabotage, unauthorized access, illegal transfer, or other malicious acts involving nuclear material, other radioactive substances or their associated installations

- Definition in the Code of conduct on the safety and security of radioactive sources - IAEA (2004):
  - **Safety** means measures intended to minimize the likelihood of accidents involving radioactive sources and, should such an accident occur, to mitigate its consequences.
  - **Security** means measures to prevent unauthorized access or damage to, and loss, theft or unauthorized transfer of, radioactive sources.

Safety of radioactive sources



- *"Security of radioactive sources is a necessary, but not sufficient, condition to ensure source safety. Radioactive sources can be secure, i.e. under proper control, and still not safe, i.e. prone to accident*." (ICRP 103 § 271) :

Evolution of ICRP general recommendations
ICRP 60 (1990)

- **Practices** - human actions increasing exposure:
  - Justification of practice
  - Optimization of protection
  - Limitation of individual doses (Dose limits and constraints)

- **Interventions** - human actions that decrease the overall exposure:
  - Justification of each intervention
  - Optimization of each intervention (Intervention and action levels)

- **A system of protection with two regimes**

The ICRP 103 (2007) approach: three exposure situations

- **Planned exposures:** situations involving the deliberate introduction and operation of sources
- **Emergency exposures:** situations that may occur during the operation of a planned situation and which require urgent actions
- **Existing exposures:** situations that already exist when a decision on control has to be taken, including prolonged exposure situations after emergencies

Evolution from ICRP 60 to ICRP 103

- No more distinction between practices and interventions. The two concepts are replaced by three generic exposure situations, which cover all conceivable exposure situations
- The three fundamental principles (justification, optimization and limitation) apply similarly to the three exposure situations
- Shift from a process-based approach (increasing or decreasing the exposure) to an approach based on the characteristics of three types of radiation exposure situations
- **A unified approach**

Application of the basic principles to sources and individuals in ICRP 103

- **Justification** and **optimization** principles apply to **sources** for the three types of exposure
- **Optimization** principle applies to sources below **dose constraints** (planned exposure situations) or under **reference levels** (emergency and existing exposure situations)
- **Limitation** principle applies to **individuals** only for planned exposure situations (excepted medical exposures)

Framework for selecting source-related dose constraints and reference levels (§ 238)

Dose (mSv)	Characteristics of the situation	Radiation Protection Requirements
20 to 100	- Not controllable sources - Disturbing actions - Action on exposure pathways (not at source)	- Dose reduction - Individual information on risks and on actions to reduce doses - Assessment of individual doses
1 to 20	- Direct individual benefit from the situation, but not necessarily from the exposure itself - Action on the source or on exposure pathways	- Individual or general information to reduce doses - Individual assessment of exposure and training (planned situations)
< 1	- Little or no individual benefit but benefits to society in general - Action on the source that can be planned in advance	- General information on the level of exposure - Periodic checks of level of exposure and exposure pathways

Normal operation of radioactive sources: a planned exposure situation

- All exposures related to the implementation of security and protection measures in normal operation of radioactive sources are considered as planned exposures
- ALARA applies below a dose constraint:
  - Between 1 and 20 mSv for exposed workers: for example, workers in industrial radiography
  - Below 1 mSv for the public and for security workers (non-exposed workers): for example, policemen affected to the security of nuclear sites
- Dose limit for the public and security workers: 1 mSv/year
- Dose limit for occupationally exposed workers: 20 mSv/year averaged over defined periods of 5 years
- For security workers (customs, fire-fighters, etc.) individual assessment of exposures and training may be relevant

Normal operation of radioactive sources: potential exposure

- "In planned exposure situations […] higher exposures may arise following deviations from planned operating procedures, accidents including the loss of control of radiation sources, and malevolent events. Such exposures are not planned to occur, although the situation is planned. […] Deviations from planned operating procedures and accidents can often be foreseen and their probability of occurrence estimated, but they cannot be predicted in detail. Loss of control of radiation sources and malevolent events are less predictable and call for a specific approach" (ICRP 103, § 262)
- "The use of probability assessment is limited by the extent that unlikely events can be forecast. In circumstances where accidents can occur as a result of a wide spectrum of initiating events, caution should be exercised over any estimate of overall probabilities because of the serious uncertainty of predicting the existence of all the unlikely initiating events. In many circumstances, more information can be obtained for decision-making purposes by considering the probability of occurrence and the resultant doses separately" (ICRP 103, § 269)

Mitigation of the consequences of a radioactive source accident: an emergency exposure situation

- Exposures received by the public in case of failure of security measures and by workers during urgent actions in order to avoid or reduce undesirable are **emergency exposures.**

- Protection of the public: global approach considering all countermeasures (sheltering, evacuation, etc.) combined in an overall protection strategy using the appropriate reference level (§ 276).

- For these situations, ICRP recommends to use reference levels between 20 and 100 mSv to protect the public (§ 278).

Emergency exposure situations: reference levels for first responders and emergency workers

Type of operation	Reference level
Saving life	No dose restrictions if, and only if, the benefit to others clearly outweighs the rescuer's own risk
Preventing serious injury, or actions to prevent the development of catastrophic situations	500 to 1000 mSv - Every efforts should be made to avoid deterministic effects: 1000 mSv should avoid serious deterministic health effects, and below 10 times the maximum single year limit (i.e. 50 mSv) should avoid other deterministic effects.
Other immediate and urgent actions to prevent injuries or large doses to many people	≤ 100 mSv All reasonable efforts should be made to keep doses below twice the maximum single year limit
Other operations, including recovery and restoration operations	Managed as a planned situation

Preparedness for emergency exposure situations (ICRP 109)

- Prepare plans for all type of emergency exposures: relevant stakeholders should be consulted during the process.
- Responsibilities of agencies, methods for communicating and organisation between them during the response and framework for guiding decision making.
- Preparation, information and training of emergency workers.

Emergency exposure situations: the case of a radiological attack (ICRP 96)

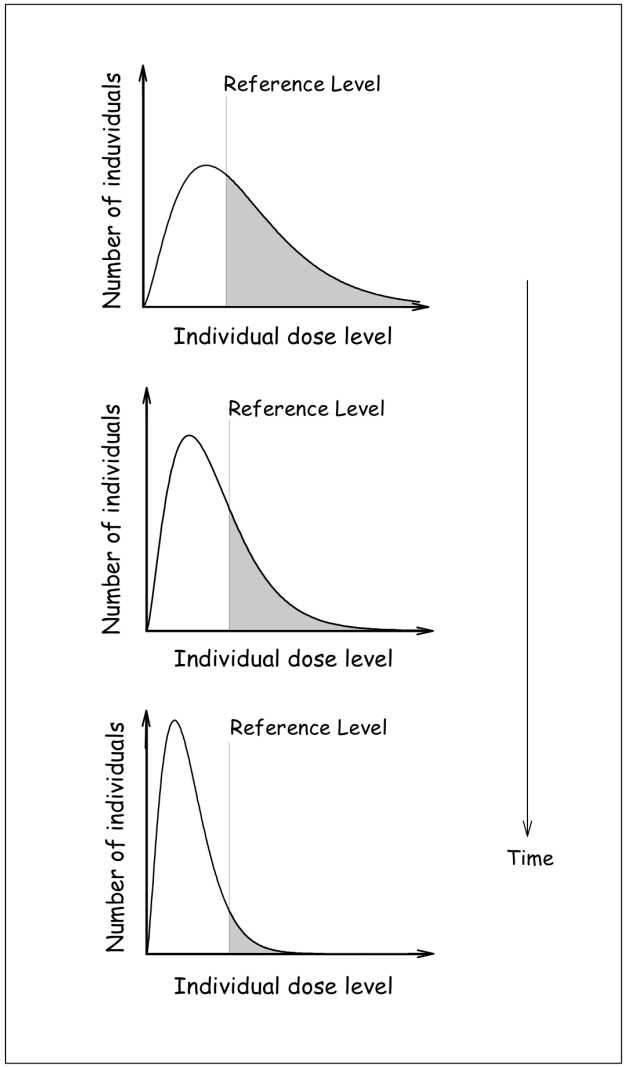
- ICRP 96 does not give advice on actual security measures to prevent an event
- Some differences in comparison with emergency situations due to a radiological accident:
  - Most likely targeted at a public area, possibly in an urban environment: presence of radiation is not anticipated
  - Characterization of the radiation source may be difficult
  - Radiological source possibly used in combination with biological and/or chemical agents, etc…
- Development of a specific response plan, including an "all-hazard" approach and adapted training for emergency workers

Contaminated area after a radioactive source accident : an existing exposure situation

- Exposures received by people living in a contaminated area resulting from a radiological event after are considered as **existing exposures**
- The transition from an emergency to an existing situation after an accident is characterized by a change of management
- **Justification** of protection strategies:
  - The decision of authorizing people to stay on contaminated territories should take into account not only the radiological situation but also psychological, social, economical and political aspects. Mandatory relocation may be necessary. Voluntary relocation must always be an option for inhabitants
- **Optimisation** of protection strategies:
  - Step-by-step process needing regular reassessment. Reference level to reduce individual exposures. A priori, no minimum dose
  - ICRP recommends to use **1 mSv/year as a typical reference level** for the long-term management of exposures

Existing exposure situations: use of reference level for optimization

- Individual dose distribution evolves in time when protection actions are implemented



Existing exposure situations: implementation of protection strategies

- Combination of protection actions implemented by authorities at the national and local levels and by the population itself (self protection actions)

- Authorities are responsible for establishing conditions, which allow an effective commitment of the population, and in particular for giving means necessary to assess individual dose distribution (through direct measurements or through estimates)

- Feedback experience has showed that implication of local professionals and inhabitants in the implementation of protection actions and the development of a practical radiation protection culture within the population are key factors for the sustainability of rehabilitation programme after an accident in case of long term consequences

Conclusion

- The new system of radiation protection recommended by ICRP in Publication 103 and subsequent publications (ICRP 109 and 111) is complete and coherent to manage all exposures (planned, emergency and existing exposures) that may result from the handling of radioactive sources

- ALARA is the cornerstone of the system to control exposures in both normal operations or in case of failure of security measures (emergency and post-accident situations)

- ICRP Publications (103, 109, 111) propose ranges of values to select proper dose constraints and reference levels for the practical implementation of ALARA

Proposal for the European ALARA Network

- To review the practical implementation of the ALARA principle for the safety and security of radioactive sources:
  - Use of dose constraints and reference levels
  - Optimization of protection strategies within national preparedness plans
  - Good practices, lessons from incidents and accidents…
  - Experience with stakeholder engagement
- To develop programmes for the information, education and training of security workers and first responders
- To identify the radiation protection culture elements characterizing the security and safety of radioactive sources