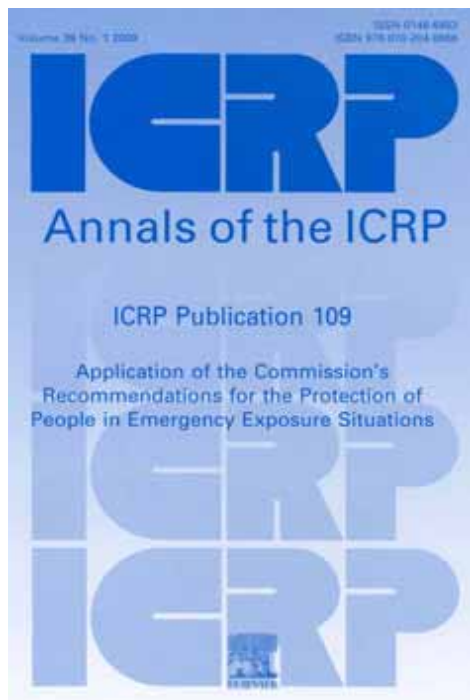


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Federal Office for Radiation Protection
ICRP; Committee 4



**Application of the ICRP
recommendations
for the protection of people in
emergency exposure situations**

4th EURADOS Winter School
Radiological emergencies – Internal exposures
Rome, 3 February 2010



The membership of the Task Group was as follows:

| | | |
|---------------------|--------------|-----------|
| W. Weiss (Chairman) | J. Fairobent | M. Morrey |
| O. Pavlovsky | D. Queniart | |

The corresponding members of this Task Group were:

| | | |
|-----------|---------|-------------|
| E. Buglov | T. Lazo | I. Robinson |
|-----------|---------|-------------|

ICRP publication 109, 2009 discusses the application of the new advice of ICRP (ICRP publication 103), and explains how the previous advice fits into the revised overall system of protection. Where the Commission's advice is unchanged from its previous recommendations, or issues are discussed thoroughly in publications by other international organisations (IAEA BSS, DS 44), appropriate references are given and no detailed discussion is provided.

The report does not cover emergency situations involving unintended exposures of patients; these situations are dealt with separately by the Commission (ICRP, publication 105, 2007).

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WHAT REMAINS UNCHANGED since ICRP 60?

The **OBJECTIVES** of RP in emergency exposure situations:

- * to prevent the occurrence of deterministic health effects among emergency workers, members of off-site assistance services, and in the public
- * to avoid, to the extent practicable, increased individual risks of incurring stochastic health effects.

The **PRICIPLES** of RP: justification and optimisation are to be applied in emergency exposure situations.

The **GUIDANCE LEVELS** for the protection of emergency workers.

Objectives of protection in Emergency Exposure Situations

(ICRP 103, 109, IAEA BSS 2009)

1. to regain control of the situation;
2. to prevent or mitigate consequences at the scene;
- 3. to prevent the occurrence of deterministic health effects in workers and the public;
4. to render first aid and manage the treatment of radiation injuries;
- 5. to reduce, to the extent practicable, the occurrence of stochastic health effects in the population;
6. to prevent, to the extent practicable, the occurrence of adverse non-radiological effects on individuals and among the population;
- 7. to protect, to the extent practicable, the environment and property;
8. to take into account, to the extent practicable, the need for resumption of normal social and economic activity.

International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources

TABLE 1: DOSE LEVELS AT WHICH PROTECTIVE ACTIONS ARE EXPECTED TO BE UNDERTAKEN UNDER ANY CIRCUMSTANCES

| | |
|---|--|
| <p>External brief exposure (< 10 hours) <i>AD</i> Red marrow^(a): 1 Gy <i>AD</i> Foetus: 0.1 Gy <i>AD</i> Tissue^(b): 25 Gy at 0.5 cm <i>AD</i> Skin^(c): 10 Gy to 100 cm²</p> <p>Internal exposure from acute intake ($\Delta = 30$ days^(d)) <i>AD</i>(Δ) Red marrow: 0.2 Gy for radionuclides with $Z \geq 90$; 2 Gy for radionuclides with $Z \leq 89$ <i>AD</i>(Δ) Thyroid: 2 Gy <i>AD</i>(Δ) Lung^(e): 30 Gy <i>AD</i>(Δ) Colon: 20 Gy <i>AD</i>(Δ) Foetus^(f): 0.1 Gy</p> | <p>If the dose is projected, take: - Precautionary urgent protective actions immediately (even under difficult conditions) to keep doses below the generic reference level, public information and warning, urgent decontamination</p> <p>If the dose is received, perform: - Immediate medical examination, consultation and indicated treatment - Contamination control - Immediate decorporation^(g) (if applicable) - Registration for long term medical follow-up - Comprehensive psychological counselling</p> |
|---|--|

TABLE 4: GUIDANCE VALUES FOR RESTRICTING EXPOSURE OF EMERGENCY WORKERS

| Tasks | Guidance value ⁱ |
|---|--|
| Life saving actions | Ten times the maximum single-year occupational dose limit $H_p(10)_{ii} < 500$ mSv This value may be exceeded under the circumstances where the benefit to others clearly outweighs the emergency worker's own risk and the emergency worker volunteers to take the action, and understands and accepts this risk. |
| Actions, to prevent severe deterministic health effects and Actions to prevent the development of catastrophic conditions | Ten times the maximum single-year occupational dose limit $H_p(10) < 500$ mSv |
| Actions to avert a large collective dose | Two times the maximum single-year occupational dose limit $H_p(10) < 100$ mSv |

ⁱ These values apply only to exposure from external penetrating radiation. The dose from non-penetrating external radiation and from intake or skin contamination need to be prevented by all possible means. Should this not be feasible, the effective dose and equivalent dose to an organ received shall be limited to minimize the health risk to the individual in line with the risk associated with the guidance values above.

ⁱⁱ $H_p(10)$ is the personal dose equivalent $H_p(d)$ where $d = 10$ mm.

Women who have declared that they are pregnant, or who are nursing an infant, should not have an emergency role that would be expected to lead to doses greater than 1mSv or significant bodily contamination (ICRP 109)

WHAT IS NEW?

Introduction of a **REFERENCE LEVEL** which represents the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur.

Commission recommends that national authorities set (a) reference level(s) between, typically, 20 mSv and 100 mSv effective dose (acute or annual, as applicable).

ALL EXPOSURE PATHWAYS and all relevant protection options have to be considered when deciding on the optimum course of action to be taken.

The full protective **STRATEGY** must be justified, resulting in more good than harm.

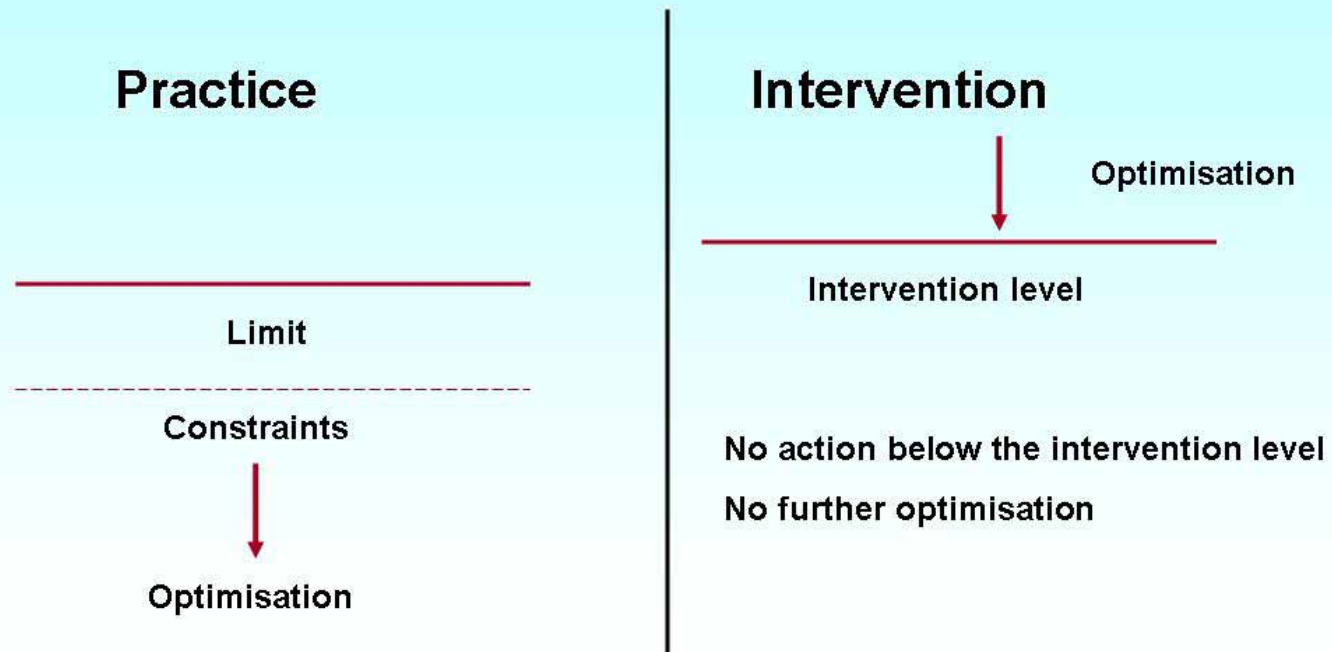
Conceptual set of (effective) doses, for use in the justification and optimisation of emergency plans and decisions:

'projected dose': dose expected to be received in the absence of planned protective measures;

'residual dose': residual dose = projected doses – averted dose; dose expected to be received or measured/assessed following implementation of planned protection strategy; the residual dose is derived in planning as the dose to each of a set of 'representative persons' (ICRP publication 101). The residual dose is the quantity that is compared to the appropriate reference level when selecting and assessing protection strategies.

'averted dose': dose expected to be avoided through the implementation of planned protective actions. In general, averted dose refers to the implementation of individual protective actions, but may, if specified, refer to the dose avoided from the implementation of several protective actions.

PRACTICE AND INTERVENTION (ICRP 60)



Optimisation and Dose Constraints (ICRP 103)

Planned exposure situations

Dose limit

Dose constraint

Optimisation

Existing and emergency exposure situations

Reference level

Optimisation

Framework for setting REFERENCE LEVELS

| BANDS OF PROJECTED DOSE | CHARACTERISTICS AND REQUIREMENTS |
|--|---|
| <p>20 - 100 mSv</p> <p>Organ dose!</p> | <p>Exceptional situations. Benefit on a case-by-case basis. Information, training and individual monitoring of workers, assessment of public doses.</p> |
| <p>1 - 20 mSv</p> | <p>Individual direct or indirect benefit. Information, training and either individual monitoring or assessment.</p> |
| <p>less than 1 mSv</p> | <p>Societal benefit (not individual). No information, training or individual monitoring. Assessment of doses for compliance.</p> |

Effective dose vs. organ dose?

Organ dose calculations were performed for an extensive set of radionuclides which might be relevant for emergency exposure situations. The calculated organ doses corresponding to an effective dose of 100 mSv were compared with the following criteria:

- * the doses expected to result in a cancer incidence of double the spontaneous level (doubling dose).
- * the dose at which severe radiation induced complications can be expected in 5% of the cases within 5 years (tolerance dose).

In no cases was the tolerance dose exceeded but in the following cases the doubling dose was exceeded: Thyroid cancer in individuals exposed as adults to **I-125 or I-131** and for all solid cancer in adults exposed to As-73 as children.

On the basis of these results ICRP concludes that effective dose is indeed valid up to 100 mSv.

IMPORTANT ASPECTS DURING PLANNING

Identify the ***dominant exposure pathways***, the ***times*** over which components of the dose will be received, and the ***potential effectiveness*** of individual protective measures.

The Commission recommends that ***plans*** are prepared for all types of possible emergency exposure situation.

To the extent possible, the overall strategy and its constituent individual protective measures should be worked through and agreed with all those potentially exposed or affected (***stakeholder*** involvement) .

KEY PARAMETER: NUCLIDE VECTOR

Relative contribution of various exposure pathways to the annual effective dose (atmospheric release during the summer period)

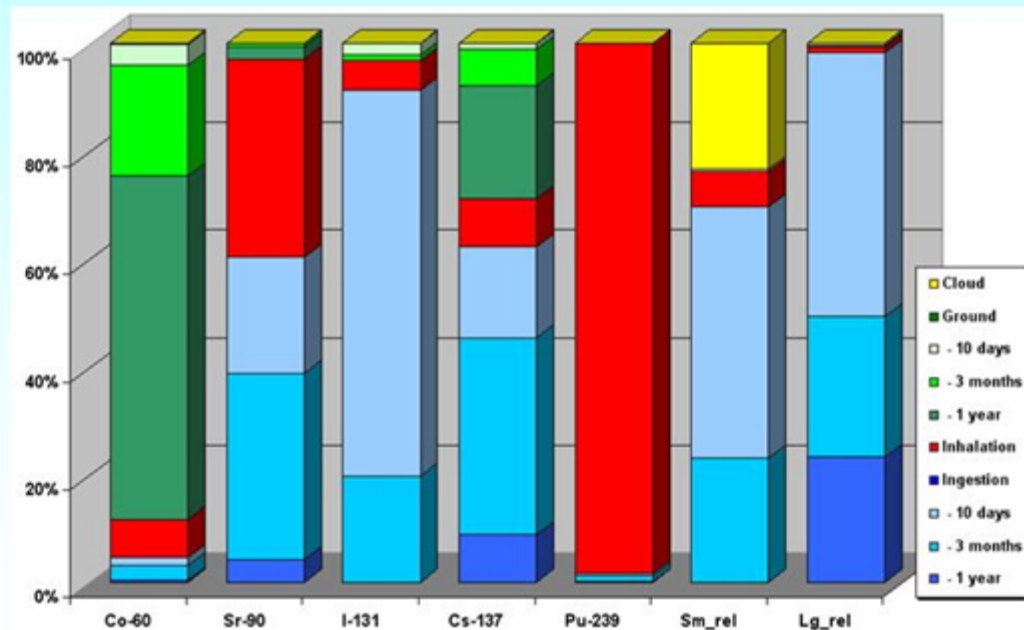


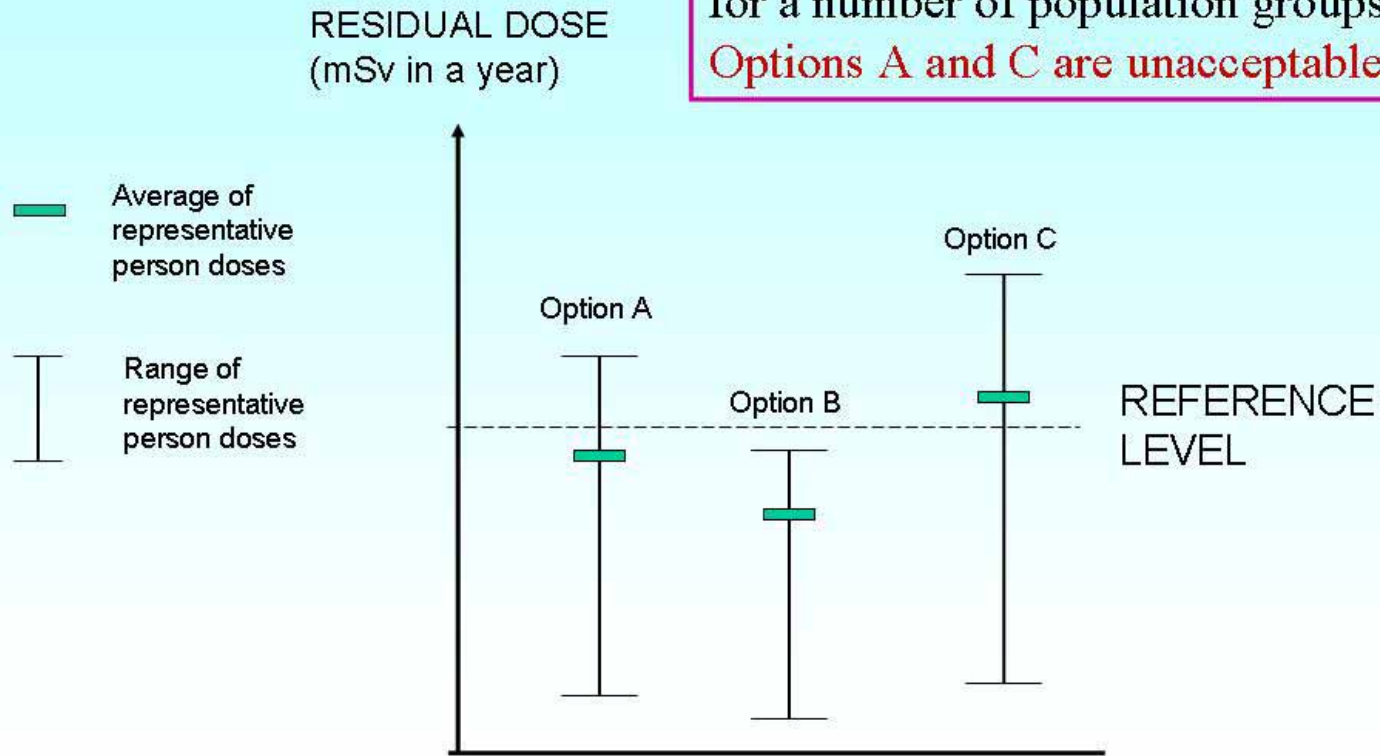
Table 2. Protective actions for averting exposures via various pathways

| Route of exposure | Protective action |
|---|--|
| External irradiation from the source, plume and/or radionuclides deposited on the ground Inhalation or ingestion of radionuclides in the plume and/or resuspended radionuclides External contamination of individuals | Control of access |
| External irradiation from the source, plume and/or radionuclides deposited in the ground | Shielding |
| External contamination | Protective clothing |
| External irradiation from the source, plume and/or radionuclides deposited on the ground Inhalation of radionuclides in the plume External contamination of individuals | Sheltering |
| External irradiation from the source, plume and/or radionuclides deposited on the ground Inhalation or ingestion of radionuclides in the plume and/or resuspended radionuclides External contamination of individuals | Evacuation |
| Inhalation of radioiodine in the plume | Stable iodine administration |
| External contamination | Decontamination of individuals and clothing Intervention in food chain and water supply |
| Ingestion of radionuclides | (a) Restrictions on food and water —banning consumption —processing of food/water |
| Ingestion of radionuclides | (b) Decreasing radionuclide incorporation into the food chain —alternative fodder —binders —deep ploughing and other changes in agricultural practice —temporary fixation of contamination in ground (e.g. spraying) |
| Inhalation of resuspended radionuclides | Relocation |
| External irradiation from radionuclides deposited on the ground Inhalation and ingestion of resuspended radionuclides | Relocation |
| Inadvertent ingestion | Decontamination of materials and controls on use of contaminated materials |
| External irradiation Inhalation of resuspended radionuclides | Decontamination of ground and other surfaces |

ICRP 2E:4-C

Individual protective actions (ICRP 63) which could be considered **within a comprehensive protection strategy**

The application of dose reference levels in **planning** protective actions for a number of population groups:
Options A and C are unacceptable



Application of the new advise during emergency response



WHAT TO DO IF AN ACCIDENT OCCURS?



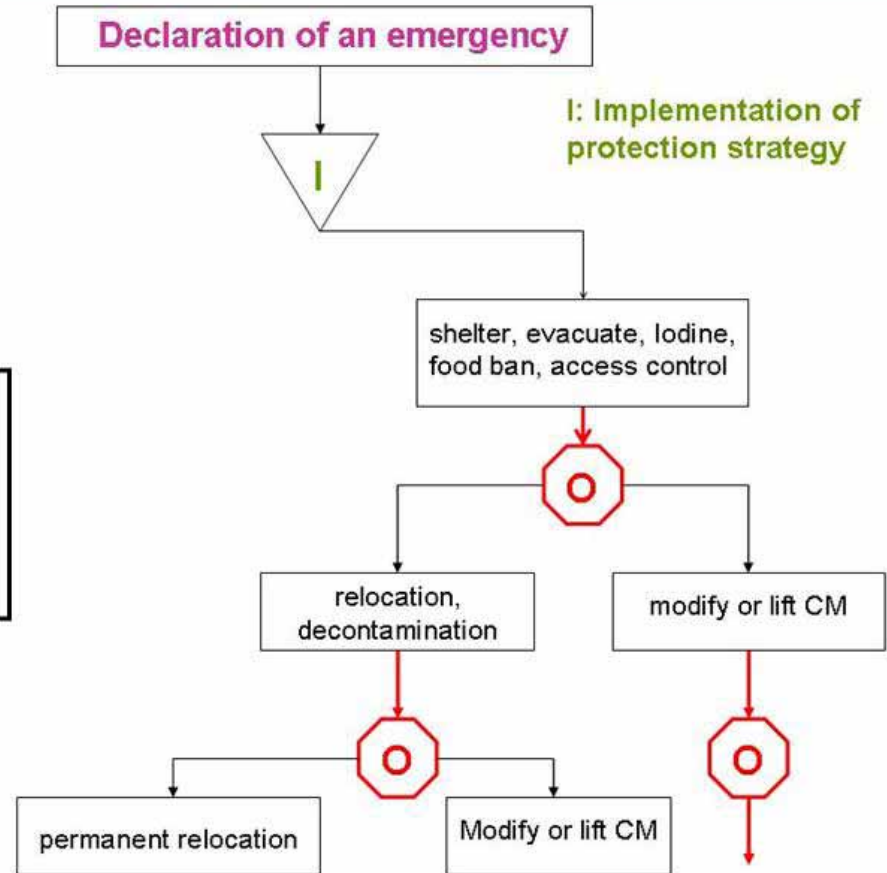
Implementing Protection Strategies

Once the protection strategy has been optimised, **triggers** for initiating the emergency response plan shall be developed. Triggers are expressed in terms of any observable circumstances or directly **measurable quantities**, such as **dose rates, reactor core temperatures, wind direction**. They may be related to dose considerations, but are more likely to be related to key indicators that the situation has occurred for which the plan (or a group of actions within the plan) was developed.

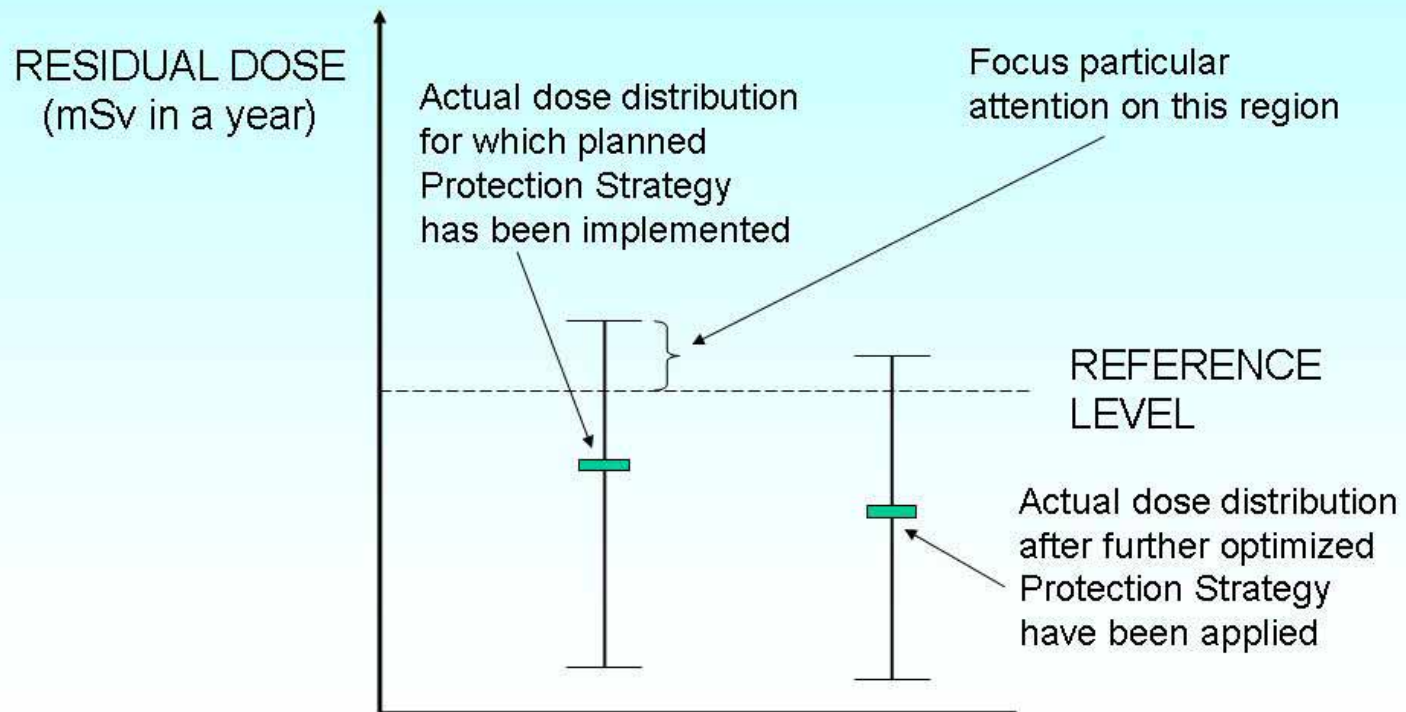
The predefined reference level is used as a **benchmark** against which the results of implementing an optimised protection strategy are assessed, and for guiding the development and implementation of further protective measures if necessary.

EXAMPLE for the IMPLEMENTATION of a PROTECTION STRATEGY

↓ verification
O: Optimisation

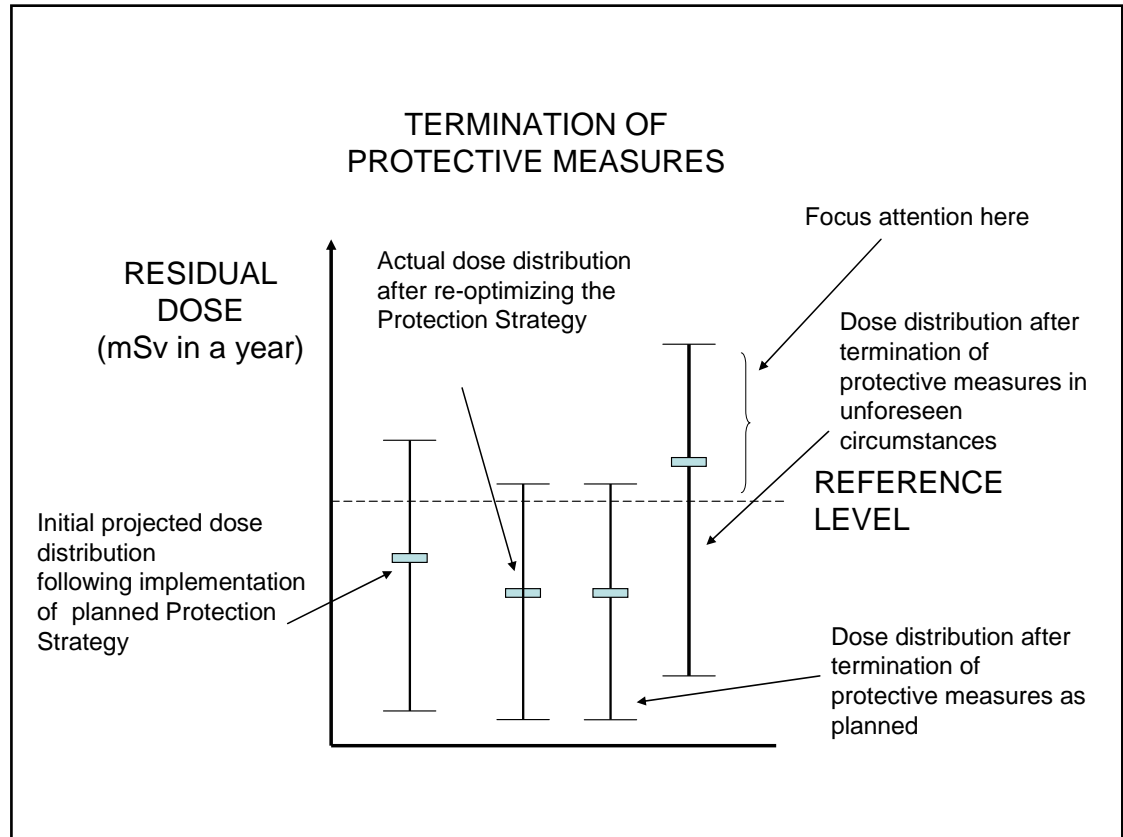


Optimisation during RESPONSE



Termination of protective measures

The decision to **terminate** protective measures will need to appropriately reflect the prevailing circumstances of the emergency exposure situation. The reference level will be an important input when deciding whether or not to terminate protective measures.



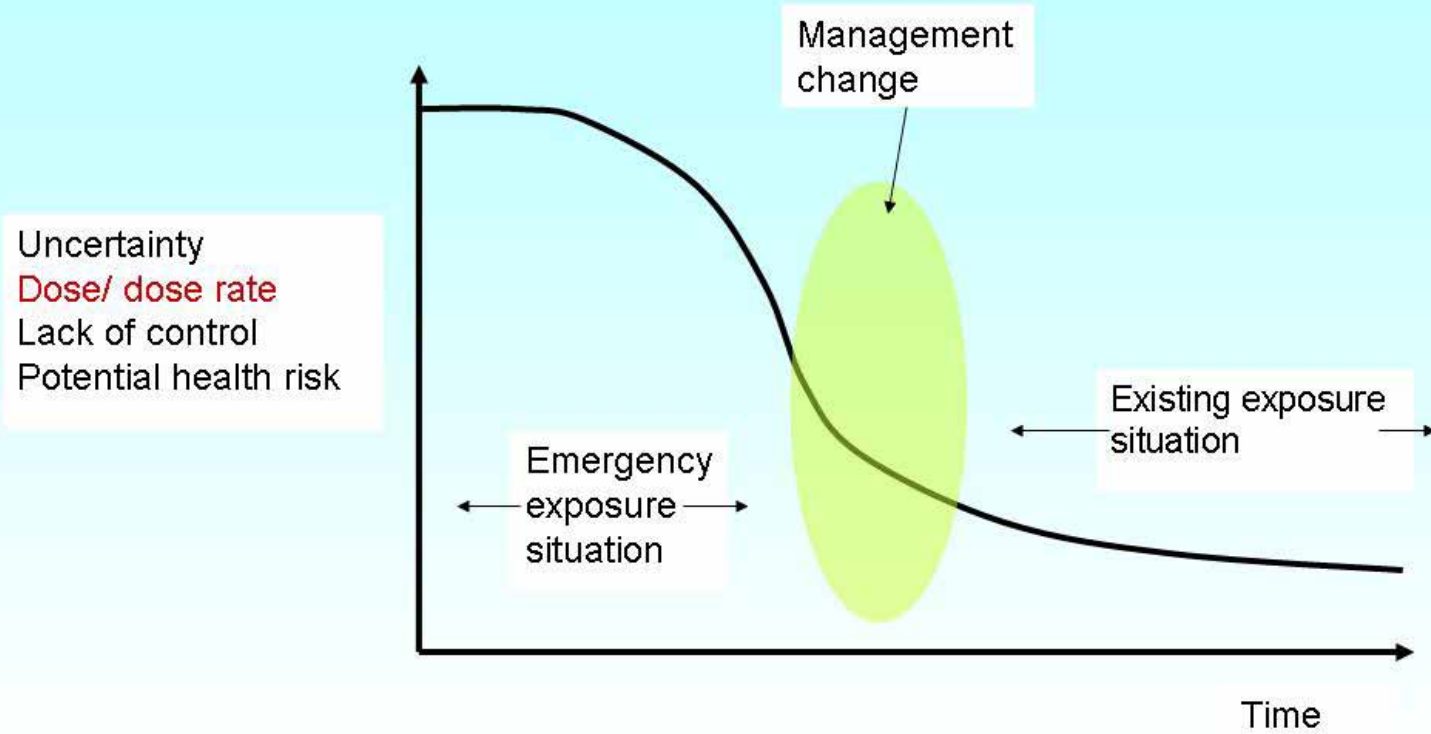
Checklist for terminating the advice to **shelter**

| Issue | Comments/Considerations |
|-------------------|---|
| Duration | Unlikely to be practicable for more than a day. |
| Release status | Partial lifting (eg re-uniting of families) or phased evacuation may be considered before formal advice is given that the release has been terminated. |
| Contamination | Detailed monitoring in the sheltered area is likely to be a priority. Ensure that measurements are 'published' for access by media and public. |
| Information | Withdrawal of advice to shelter will probably be carried out without significant interaction with stakeholders because of the short timescales involved. |
| Health | Detailed information for all those affected is required for subsequent dose estimation and decisions on health follow-up programmes. |
| Stakeholders | Those affected should have already been given the opportunity to contribute to the development of a strategy for withdrawing sheltering. They may need a mechanism to provide an input into decisions on the recovery strategy, should one be required. |
| Order of priority | Decisions on withdrawing sheltering will normally be accorded the highest priority. |

TRANSITION to REHABILITATION

There are ***no pre-determined temporal or geographic boundaries*** that delineate the transition from an emergency exposure situation to an existing exposure situation. In general, a reference level of the magnitude used in emergency exposure situations will not be acceptable as a long-term benchmark, as these exposure levels are generally ***unsustainable from social and political standpoints***.

As such, governments and/or regulatory authorities will, at some point, identify a new reference level, typically between 1 and 20 mSv in a year, which can be used to judge optimisation of protection strategies in the longer term, i.e. for existing exposure situations.



ICRP will provide advise on the

“Application of the Commission's system to the Protection of People Living in Long Term Contaminated Territories after a Nuclear Accident or a Radiation Emergency“

in ICRP publication 111 (2010)