

Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations

Table of contents

Abstract

Executive summary

1. Introduction

- 1.1 Scope of this advice.
- 1.2 Objectives of protection in emergency exposure situations.
- 1.3 Description of emergency exposure situations
 - 1.3.1 Emergency exposure situations and existing exposure situations.
 - 1.3.2 Phases of an emergency for the purpose of these recommendations.
 - 1.3.3 Types of emergency exposure situations
 - 1.3.4 Dose quantities.
 - 1.3.5 Dose concepts.
- 1.4 Applying the Commission's System to emergency exposure situations.
 - 1.4.1 Justification.
 - 1.4.2 Optimisation and the role of reference levels.

2. Planning for Emergency exposure situations

- 2.1 The planning process.
 - 2.1.1 Situations for which to prepare response plans.
 - 2.1.2 Protective measures to avoid severe deterministic injury.
 - 2.1.3 Engagement with stakeholders (Who to involve).
 - 2.1.4 Representative Person (Who to protect).
 - 2.1.5 Setting reference levels.
 - 2.1.6 Role of intervention levels.
- 2.2 Components of an emergency response plan.
 - 2.2.1 Strategies and individual protection measures.
 - 2.2.2 Temporal and geographical issues
- 2.3 Developing an emergency response plan.
 - 2.3.1 Evaluation of emergency exposure situations.
 - 2.3.2 Justification of protection measures
 - 2.3.3 Optimisation based on reference levels.
 - 2.3.4 Detailed optimisation.
 - 2.3.5 Triggers.
- 2.4 Supporting measures.
 - 2.4.1 Environmental monitoring.
 - 2.4.2 Personal monitoring.
 - 2.4.3 Communication with the public.

2.4.4 Protection of emergency workers.

3. Implementing protection strategies
 - 3.1 Tuning protection strategies and reference levels to actual conditions.
 - 3.2 Termination of protective measures.
 - 3.3 Protection of emergency workers.
4. Transition to rehabilitation

References

- Annexes:
- A. Assessment of the contributions of different exposure pathway to the residual dose.
 - B. Characteristics of individual protective measures.
 - C. Specific guidance for the termination of protective measures.

Glossary of terms: to be developed

Preface

On 31st October to 3rd November 2006, the Main Commission of the International Commission on Radiological Protection (ICRP) approved the formation of a new Task Group, reporting to Committee 4, to develop guidance on the implementation of the new ICRP recommendations on the principle of the optimisation of radiological protection in various states of emergency preparedness and response. As stated in the terms of reference, the objective of the TG is to develop a report on the application of the Commission's recommendations for the protection of populations in the emergency phase of a nuclear accident or a radiological emergency. It was tasked, in particular, to provide guidance on:

- The setting of the reference levels in both planning and implementation of emergency response,
- How reference levels assist emergency response management,
- How Optimisation can be applied in identifying protective measures at the planning stage,
- The management of changing protective measures with time,
- The interface with the rehabilitation phase.

Particular attention has been given to the interface with the rehabilitation phase following a nuclear accident or a radiological emergency through a close co-ordination with the Task Group developing recommendations on this aspect.

The report of the TG takes into account recent developments, views, and experiences in emergency management. Ongoing work and efforts performed by international organisations, eg. the revision of the International Basic Safety Standards, is also considered. The guidance offered by the TG is generic, providing a basic framework that can be tailored for specific circumstances. The TG expects that detailed implementation of the Commission's recommendations is a matter for the relevant national authorities.

The guidance in this report builds upon the concept of optimisation of protection below reference levels as recommended previously by ICRP.

The membership of the Task Group was as follows:

W. Weiss (Chairman)
J. Fairbent
M. Morrey
O. Pavlovsky
D. Queniart.

The corresponding members of this Task Group were:

E Buglova
T. Lazo
I. Robinson.

The Task Group would like to thank those organisations and staff that made facilities and support available for its meetings. These include the Federal Office for Radiation Protection in Germany

Version 6

and the Nuclear Energy Agency from the OECD.

The report was adopted by the Commission at its meeting in XX on YY 2008.

Executive summary

Basic principles

(a) The Commission's new recommendations re-state its principles of *justification* and *optimisation* as applying to emergency exposure situations. This means that the level of protection should be the best under the prevailing circumstances, maximising the margin of benefit over harm. In order to avoid grossly inequitable outcomes of this optimisation procedure, the process should be constrained, to the extent practicable, by restrictions on the overall doses or risks received by individuals as a result of the emergency.

(b) The *reference level* represents the level of dose or risk, above which it is generally judged to be inappropriate to plan to allow exposures to occur. Therefore, any planned protective strategies should, at least, aim to reduce exposures below this level, with optimisation achieving still lower exposures. Protection against all exposures, above or below the reference level, should be optimised. In the context of developing response plans for emergency exposure situations, the Commission recommends that national authorities set reference levels between, typically, 20 mSv and 100 mSv effective dose (acute or annual, as applicable to the emergency exposure situation under consideration). Reference levels lower than 20 mSv may be appropriate for the response to events involving low projected exposures. There may also be situations where it is not possible to plan to keep all doses below the appropriate reference level, eg extreme malicious events or low probability/high-consequence accidents in which extremely high acute doses can be received within minutes or hours. For these situations it is not possible to plan to avoid such exposures entirely. Therefore, the Commission advises that measures should be taken to reduce the probability of their occurrence, and response plans be developed that can mitigate the health consequences where practicable.

(c) The Commission now considers that a more complete protection is offered by simultaneously considering *all* exposure pathways and *all* relevant protection options when deciding on the optimum course of action to be taken. While each individual protection measure must itself be justified in the context of the overall protection strategy, in addition, the full protective strategy must be justified, resulting in more good than harm. This new approach may represent a relative increase in operational complexity, but it also provides a significant amount of increased flexibility in designing the optimum protection to address an emergency exposure situation by focusing on the combined effects of all individual protective measures included in the protection strategy rather than on any single protective measure. Moreover, the new approach provides a framework that supports a consideration of how individual protective measures affect one another, and it helps focus resource allocation to where the strongest overall benefits can be achieved. It also recognises that the dose someone has already received during an emergency should be taken into consideration when determining what constitutes optimum protection in the later response.

(d) In order to optimise an overall planned response strategy, it is necessary to identify the dominant exposure pathways, the timescales over which components of the dose will be received, and the potential effectiveness of individual protective options. Knowledge of the dominant exposure pathways will guide decisions on the allocation of resources: resources allocated to protective measures should be commensurate with the expected benefits, of which *averted dose* is an

important component. Knowledge of the timescales over which exposures will be received informs decisions about the lead times available to organise the implementation of protective measures once an emergency exposure situation has been recognised. Where urgent action is required to reduce exposures or specific legislation would facilitate efficient management of the response (eg management of contaminated wastes). Furthermore it is important to use easily identifiable ‘triggers’ as the basis for decisions to implement urgent protection measures, in order to ensure they are completed within the necessary timescales.

(e) The Commission recognises that there is a qualitative difference between the risks of stochastic health effects and the risks of an individual receiving exposures that would result in severe deterministic injury. By ‘severe deterministic injury’ the Commission means injuries that are directly attributable to the radiation exposure, that are irreversible in nature and that severely impair the quality of life of that individual, for example, lung morbidity and early death. The Commission recommends that every practicable effort should be made to avoid the occurrence of severe deterministic injuries in the event of an emergency exposure situation. This means that it will be justified to expend significant resources, both at the planning stage and during the response, if this is required, in order to reduce expected exposures to below the thresholds for these effects. Furthermore, where prompt medical intervention has the potential to avert such injury, the Commission recommends that procedures and measures be included in the emergency response plan that enable those individuals who might have received such high exposures to be promptly identified.

Planning for emergency exposure situations

(f) The Commission recommends that plans are prepared for all types of possible emergency exposure situation: nuclear accidents (occurring within the country and abroad), transport accidents, accidents involving sources from industry and in hospitals, malicious uses of radioactive materials, and other events, such as a potential satellite crash. The level of detail within the plans will depend on the level of threat posed, and the degree to which the circumstances of the emergency can be determined in advance. However, even outline generic plans should indicate the responsibilities of different agencies, methods for communication and organisation between them during the response, and a framework for guiding decision making. More detailed plans should contain a description of the overall strategy, and provide triggers for initiating those aspects of the response that need to be implemented promptly. These triggers should be readily observable circumstances or measurable quantities, to facilitate prompt decision making. It is for the relevant national authorities to determine the detail of response planning that is appropriate for different situations.

(g) It is essential that all aspects of the plan are agreed by all relevant stakeholders, otherwise it will be more difficult to implement them during the response. 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. Such an engagement will assist the emergency plans in being focussed, not only on the protection of those most at risk in the early and intermediate phases, but also on the progression to populations resuming ‘normal’ lifestyles.

(h) In the event of an emergency exposure situation it is likely that potential exposure rates will vary in space and time, and that the doses received by individuals will vary, both as a result

of the variations in exposure rates and as a result of differences in their physiological characteristics and their behaviours. These population groups should be characterised by representative persons, as described in the Commission's advice on the representative person [ICRP 2006]. In accordance with the Commission's advice on the representative person, it is important that the dose estimates made reflect those likely to be received by the groups most at risk, but that they are not grossly pessimistic.

(i) The Commission's band of reference levels is expressed in terms of effective dose. For many emergency plans, this is an appropriate quantity in which to express the reference level. However, there are situations for which effective dose is not an appropriate quantity in which to express reference levels. Such situations include: where the type or scale of emergency may result in doses in excess of 100mSv effective dose (where the assumption of linearity in its derivation may no longer hold); where parts of the response need to focus on individuals at risk of incurring severe deterministic injury; where the resulting exposures are very strongly dominated by irradiation of a single organ for which very specific protective measures are optimum (eg releases dominated by radioiodine). For these situations, the Commission advises that consideration be given to specifying (or providing supplementary) reference levels in terms of organ dose.

(j) In its previous advice [ICRP 63, ICRP 96] the Commission recommended the use of *intervention levels* of averted dose, for assisting decisions on whether/when to include certain protective measures in an overall response strategy. The Commission still considers these to be useful tools, for use as part of the development of an optimised protection strategy. This report provides detailed guidance on how this could be achieved.

(k) In order to develop an emergency plan, it is first necessary to evaluate the projected doses for the situations being considered. The purpose of estimating projected doses and their likely spatial and temporal distributions is three-fold: first to identify the scale of health consequences that might occur if no protective measures were taken (and in particular whether there is a risk of severe deterministic injury), and from this to determine the broad scale of resource it is appropriate to assign to a protective strategy; second, to identify the broad geographical and temporal distribution of the various likely response phases; and third, where, in terms of protection, resources are likely to be most effectively spent. Where it is judged appropriate to develop a detailed emergency response plan, it is important first to identify whether specific provisions are required to protect those at risk of severe deterministic injury. If so, this part of the plan should be given priority for focus and resources, and should be separately justified and optimised.

(l) For detailed planning to protect against exposures resulting in stochastic risk, it is useful to begin the development of an overall protection strategy by identifying all protective measures that are likely to be justified, even if they only avert a relatively small component of the dose. Once all protective measures that are likely to be individually justified have been identified, each action should be examined, both for its potential to avert a significant proportion of the projected dose and for consequences that might interact with those of other protective measures, in such a way as to render their combined implementation either significantly more strongly justified, or unjustified. From this initial scoping review, a broad outline protective strategy can be identified.

(m) Having identified protective measures that are likely to be included in the strategy, it is necessary to evaluate the total residual doses (ie those to different reference individuals) that

would result from implementation of this strategy. The first step is to scope the residual doses, in order to compare them with the appropriate reference level. If the total residual dose is likely to be below the reference level, then detailed optimisation of the response strategy can be undertaken. If not, changes to the protective measures or their implementation need to be considered and the process of comparison of the reference level with the total residual dose repeated.

(n) Some combinations of protective measures can be considered to be largely independent of each other, for example commercial food restrictions and the evacuation of close in populations. These types of protective measures can readily be optimised separately and the relevant intervention levels used as a direct guide.

(o) The resources required to implement protective measures are not the only factors that might interact within an overall protection strategy. Other such factors include individual and social disruption, anxiety and reassurance, and indirect economic consequences. It is important to review the proposed overall protection strategy with representatives of all potential stakeholders to ensure the plan is optimised with respect to these factors, as well as with respect to dose and the resources required. This wider review of the strategy may well indicate a role for additional measures, which, in isolation, do not appear optimum (or even justified).

(p) Once the protection strategy has been optimised, *triggers* for initiating the different parts of an emergency response plan for the early phase should be developed. Triggers may be expressed in terms of any observable circumstances or directly measurable quantities, such as plant conditions, dose rates, 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 protective measures within the plan) was developed. It may not be appropriate to specify triggers for initiating later phase protective measures in the plan, since these should generally take account of the specifics of the evolving emergency situation. For later phase protective measures, it may be helpful to include in the response plan an agreed framework for developing triggers in 'real time'. Whilst specification of the triggers themselves in the emergency plan may not be appropriate, it may be helpful to include an agreed framework for developing triggers in 'real time'. The inclusion of such a framework is likely to result in wider acceptance of the 'real time' triggers when they are developed.

Implementing protection strategies

(q) In the context of the ICRP's system of radiological protection, there is one fundamental difference between prospectively planning to address the consequences of a radiological emergency exposure situation, and managing consequences that are in the process of occurring or that have already occurred. In the context of planning, optimisation is performed using the appropriate reference level as the upper bound, eliminating any protection solutions that result in individual residual doses exceeding the reference level. Protection for all those exposed is optimised, and total predicted residual exposures resulting from the application of the protection strategy should be below the reference level. However, the inherently unpredictable nature of emergency exposure situations, their tendency to evolve rapidly, and the wide possible range of emergency conditions (i.e. weather conditions, geographic location, population habits, etc.) could result in situations that do not match the assumptions that were used to develop optimised protection strategies. This may mean that some actual exposures exceed the pre-selected reference level. As

such, in the context of managing the consequences of an emergency that is in the process of occurring or that has already occurred, the predefined reference level is used as a benchmark against which to judge the results of implementing an optimised protection strategy, and for guiding the development and implementation of further protective measures if necessary.

(r) Once an emergency exposure situation has occurred, it is likely that many stakeholders will be very interested in providing input to discussions regarding protective measures. Should the emergency exposure situation have an early phase requiring urgent protective measures, the “reflex” use of pre-planned protection strategies, implemented on the basis of the triggers defined in the emergency plan, will be necessary with no or very little stakeholder involvement beyond the emergency response authorities and those responsible for the site, facility or source that is causing the emergency exposure situation. Inappropriate involvement of stakeholders or excessive review of the detailed effectiveness of such ‘reflex’ protective actions is likely to reduce their effectiveness by delaying their implementation, and so should be avoided. As the emergency exposure situation progresses, however, it will become increasingly beneficial to the overall protection of the population to involve stakeholders in discussions leading to protection decisions. It is therefore important that part of emergency planning should be the development and implementation of processes and procedures to inform and involve stakeholders once the most urgent protective actions have been implemented.

(s) In many cases emergency planning will broadly fit a large range of possible situations, such that the early and urgent implementation of a planned protection strategy should come close to providing the optimum protection, with divergence most likely being on the conservative side. However, there might still be some need to operationally adjust planned protection strategies, justifying new protection measures or significant changes to plans. The need to consider making such modifications might increase as the emergency exposure situation progresses, and the order of magnitude of changes from plans might depend on the nature of the emergency exposure situation that occurs.

(t) If, in application, protection measures do not achieve their planned total residual dose objectives, or worse, result in exposures exceeding reference levels defined at the planning stage, a reassessment of the situation is warranted to understand why plans and results so significantly differ. New protective measures could then, if appropriate, be selected and applied or existing options extended in time and/or space.

(u) As an emergency exposure situation progresses, and understanding of the exact circumstances increases, decisions will increasingly be based on actual circumstances rather than on pre-planned responses, assumptions and models. There will also be an increased need to plan future protection strategies in greater detail than included in the emergency plan.

(v) The decision to terminate individual protective measures will need to appropriately reflect the prevailing circumstances of the emergency exposure situation being addressed. For the termination of early phase protective measures, guidance should have been developed and included within the emergency plan. For later phase protective measures, wherever possible, the criteria for terminating the measures should be agreed in advance of implementing them, with relevant stakeholders. In this case, criteria are best expressed in terms of directly observable or measurable quantities, so that achievement of the criteria can be clearly demonstrated. In both planning

and in the event of an emergency, decisions to terminate protective measures should have due regard to the appropriate reference level. In planning, this is an integral part of the optimisation of the protective overall strategy. However, since the actual circumstances of an emergency may deviate from those addressed during planning, it is important to consider the implications for residual dose when taking decisions on terminating protective actions, using the reference level as a benchmark.

Transition to rehabilitation

(w) The Commission advises that it may be appropriate to manage the long term, rehabilitation phase of an emergency as an existing exposure situation. This is because the characteristics of this phase of response are very different from those of earlier phases. The management of emergency exposure situations is characterised by the management of change, ie the need to manage an uncertain, unacceptable and potentially rapidly changing exposure situation into a more stable, tolerable one. The management of existing exposure situations is one of accepting that the exposure situation is different from what would normally be considered acceptable, but recognising that, given the circumstances, and possibly subject to some on-going special measures, the exposure can and will be tolerated, ie that stability has been achieved.

(x) The change from an emergency exposure situation to an existing exposure situation will be based on a decision by the authority responsible for the overall response. This transition may happen any time during an emergency exposure situation, except the early phase. Moreover, this transition may take place at different geographical locations at different times, such that some areas are being managed as an emergency exposure situation, whilst others are managed as an existing exposure situation. The transition may require a transfer of responsibilities to different authorities. This transfer should be undertaken in a coordinated and fully-transparent manner and agreed and understood by all involved parties. The Commission recommends that planning for the transition from emergency exposure situation to an existing exposure situation should be undertaken as part of the overall emergency preparedness, and involve all relevant stakeholders.

(y) Existing exposure situations which are created by emergency exposure situations can be characterised as having some sort of residual exposure pathways and lingering contamination above previous background levels, but having social, political, economic and environmental aspects of the situation that are sustainable, and are seen by the affected populations and governments as being their new reality.

(z) 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.

1 Introduction

(1) The Commission has set out general principles for planning intervention in the case of a radiation emergency [ICRP 1991, 1993] and additional relevant guidance [ICRP 2005a, 2005b, 2005c]. More recently, the Commission has published new recommendations relating to its overall system of protection [ICRP 2007]. These new recommendations are intended to complement, rather than replace, the Commission's previous advice. However, the advice contained in these new recommendations has important implications for emergency preparedness and response. This document discusses the application of the new advice, 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 thoroughly discussed in publications by other international organisations appropriate references are provided and no detailed discussion is provided here. The report does not cover situations in the medical field which can and have been subject to overexposures of people; these situations are dealt with separately.

1.1 Scope of this advice

(2) This advice relates to preparedness for, and response to, all radiation emergency situations. The Commission defines radiation emergency exposure situations as: 'situations that may occur during the operation of a planned situation, or from a malicious act, or from any other unexpected situation and require urgent action in order to avoid or reduce undesirable consequences'. The scope of this advice is the process of preparedness for, and response to, emergency exposure situations. It covers the protection of all those at risk of exposure, whether they are directly involved in mitigating actions (here termed emergency 'workers', regardless of whether or not they are routinely exposed to radiation as a result of their normal employment), or are simply in need of protection (here termed 'the public', although they may well be workers in a regulatory sense, in their normal employment).

(3) An emergency exposure situation has some common features with, but is distinct from, an existing exposure situation. The Commission defines an existing exposure situation as 'exposure situations that already exist when a decision on control has to be taken, including prolonged exposure situations after emergencies'. Therefore an emergency exposure situation that includes the release of significant quantities of longer-lived radionuclides, may evolve, in time, into an existing exposure situation. This evolution is discussed in more detail in Sections 1.3.1 and 4. The management of emergency exposure situations and of existing exposure situations have distinct characteristics. Therefore the Commission's detailed advice for these situations is published in two complementary documents.

1.2 Objectives of protection in emergency exposure situations

(4) In the event of a radiation emergency, the first concern is the prevention or reduction of health consequences resulting from exposures to radiation. However, the potential consequences are wider ranging than the risk of radiation health effects. As demonstrated by the accident at the Chernobyl nuclear power station in 1986 [IAEA 1986, NEA 1987, Vargo 2000], the social and economic consequences may well be serious and extend over a prolonged period of time. The goals for response must therefore encompass these wider potential impacts. A number of international bodies [IAEA, 2002] have summarised the practical goals of emergency response to radiation emergency as:

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 prevent, 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 prepare, to the extent practicable, for the resumption of normal social and economic activity.

The Commission agrees with these goals. This document explains how the application of the Commission's advice will contribute to their achievement.

(5) The Commission recognises that there is a qualitative difference between the risks of stochastic health effects and the risks of an individual receiving exposures that would result in a severe deterministic injury. By 'severe deterministic injury' the Commission means injuries that are directly attributable to the radiation exposure, that are irreversible in nature and that severely impair the quality of life of that individual, for example, lung morbidity and early death. The Commission recommends that every practicable effort should be made to avoid the occurrence of severe deterministic injuries in the event of an emergency, and that planning to protect against the occurrence of severe deterministic injury should take priority over that to protect against stochastic risks. This advice is elaborated further in Sections 1.4 and 2.1.2.

(6) The results of an analysis of the lessons from response to the Chernobyl, Goiânia and other emergencies over the past years [IAEA TECDOC-1432, DS-44, GS-G-2.1] conclude that while the nature and extent of past emergencies are dissimilar, the lessons concerning emergency response are very similar, e.g.:

- Non-experts (the public and decision makers) implement protective and other actions.
- The public and decision makers want to know that they and their loved ones are safe, so a rationale based only on cost benefit and averted dose is not helpful in addressing this concern.
- Criteria consistent with established radiation protection principles cannot be effectively developed solely during or after an emergency because the public will likely mistrust officialdom and because it will appear that such criteria are based not on science but political expediency.
- Non-radiological (e.g. economic, social and psychological) consequences may become worse than the radiological consequences due to a lack of pre-established guidance that is understandable to the public and officials.

(7) One of the most important lessons therefore is the need to have prepared an agreed framework within which decisions on the optimum response will be made. Since urgent actions must be taken promptly, it is necessary to determine in advance a set of internally consistent criteria for taking such protective measures, and, based on these criteria, to derive appropriate triggers for initiating the actions. Less urgent protective measures should take account of the actual circumstances of the emergency, and so it will not always be appropriate to define the criteria precisely in advance. For these, the procedure by which such criteria will be established during the emergency should be agreed in advance, in order to facilitate their acceptance by the public during the emergency. Scientifically based recommendations for implementing protective and other measures need to be accompanied by an explanation that enables the decision maker to understand and reasonably consider them, and also to be able to explain them to the public [IAEA TECDOC-1432, NEA 2006.

1.3 Description of emergency exposure situations

1.3.1 Emergency exposure situations and existing exposure situations

(8) Emergency exposure situations are characterised by the need to manage a changing situation back to one of 'normality', or at least one which is both stable and acceptable. They may be managed as a series of distinct phases, each with its own characteristic exposure patterns, decision timescales, and consequent options for protection, but the need to manage a changing situation is a feature of each phase. Emergency exposure situations may be characterised by one or more of the following features: significant uncertainty concerning current and future exposures, rapidly changing rates of potential exposure, potentially very high exposures (i.e. those with the potential to cause severe deterministic health effects), loss of control of the source of the exposure or release. Any or all of these features may continue to dominate how the response is managed for an extended period of time (i.e. months or even years), although, for some types of accidents, the emergency exposure situation may be very short (days or even hours).

(9) At some point in time, the management of an emergency situation may change to one of managing a new 'normality', particularly in situations involving widespread contamination by long-lived radionuclides. Here the purpose is not to manage change, but to facilitate the establishment of the new 'status quo'. Thus an emergency exposure situation may, in time, cease to be managed as an emergency, and be managed according to the Commission's advice on existing exposure situations. Not all emergency exposure situations will evolve into an existing exposure situation, especially if the initiating event or radionuclides released are short-lived, or any environmental contamination is limited in extent. Similarly, not all existing exposure situations will be preceded by an emergency exposure situation. However, for a major accident at a nuclear site or a serious malicious contamination incident, it would be expected that management of the response would move from that required for an emergency exposure situation to that required for an existing exposure situation at some appropriate time following the event. For malicious events, after the emergency phase it is likely that criminal investigation will take priority over radiological considerations. In this case, management of the situation as an existing situation may occur in parallel with the criminal investigation or be delayed until after the investigation is substantially complete.

(10) Existing exposure situations are characterised by the need for a population to continue living in an area with known or assessable levels of exposure. Generally, there is limited uncer-

tainty with regard to current and future potential exposures, rates of exposure are not changing rapidly with time (in the absence of protective measures), exposures are well below the thresholds for deterministic health effects, and the initiating source of exposure or release is under control (i.e. there is no further risk of an additional contribution to the levels of exposure). Radionuclides of importance during this later management regime will be long-lived e.g.: iodine-129, caesium-137, strontium-90 and transuranic radionuclides [ICRP 82]. Whilst there will not be a sharp transition between these two situations, the characteristics at early times in an emergency exposure situation will be quite distinct from those later on in an existing exposure situation. However, the later part of the emergency exposure situation will be more similar to the early part of the existing exposure situation. This is illustrated in Figure 1 below. It is therefore a management decision that determines when the transition from one type of response to the other should take place. Management of the long term rehabilitation of contaminated areas is discussed in the complementary ICRP publication [ref TG report on rehabilitation].

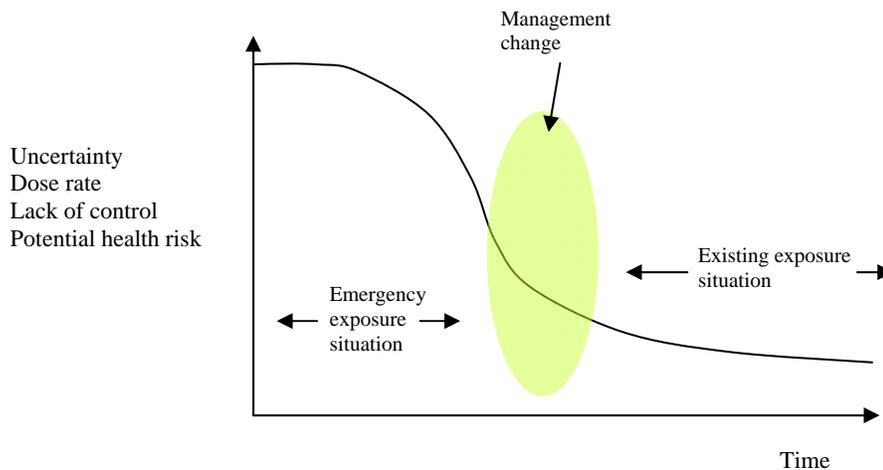


Fig 1: Evolution of an emergency exposure situation with time and the transition between the emergency exposure situation described in this document and the existing exposure situation described in a separate document

1.3.2 Phases of an emergency, for the purposes of these recommendations

(11) In the context of emergency preparedness and response for emergency exposure situations, the Commission defines the following phases of an emergency. The first phase, and in many ways, the most important phase, is the pre-emergency phase. This is the phase during which the planning of an appropriate response is undertaken. An effective response always requires appropriate planning. Therefore, the greater part (i.e. Section 2) of this document deals with the application of the Commission's advice during this phase.

(12) The early phase of an emergency exposure situation starts once it becomes apparent that an exposure or release is happening or is very likely to happen. Depending upon the emergency, it may be possible to distinguish within the early phase a warning period, that is, a period when no exposure or release has actually started, but the strong likelihood of one occurring has been recognised, and a release or exposure period, during which exposures are actually occurring, and the initiating source of the release/exposure is no longer under control. It is during

this phase that many actions need to be taken promptly and so emergency plans need to contain straightforward ‘triggers’ for robust responses, requiring the minimum of discussion or delay. The early phase will normally last a few days to a few weeks, depending on the nature of the event.

(13)The intermediate phase begins when the source of the release or exposure has been brought under control, but there are still decisions to be taken on relatively short term protective measures. During this phase decisions will be required on the termination of early phase protective measures. The implications and need for longer term protective measures will need to be assessed, planned in detail and initiated if required. The intermediate phase may last from days to months, depending on the circumstances of the emergency exposure situation.

(14)For large-scale emergencies involving long-lived radionuclides, the level of contamination may require protective measures to be implemented over timescales of years, for example, long term food restrictions, invasive decontamination measures and relocation. If the purpose of these measures is to continue to reduce potential exposure rates to a level more acceptable for normal living, the management of the response continues to be that appropriate to an emergency exposure situation. This period of management is termed the late phase. The boundary between the intermediate and late phases is unlikely to be defined in terms of changes in the exposure pathways or decision timescales. Rather, the late phase will be recognised by the need to continue to manage the emergency exposure situation for a protracted period of time.

(15)The transition from managing the situation as an emergency exposure situation to an existing exposure situation, if it is required, may take place at some point during the intermediate or late phases. It is not expected that this transition would occur during the early phase, although it might follow it immediately, without any intermediate phase, for small events. The appropriate time for making this transition is a decision that should be taken by the responsible authorities, taking account of the characteristics of the actual situation, as discussed in Section 1.3.1. It should be noted, however, that for some emergency exposure situations affecting large areas, management of the response may need to deal simultaneously with different phases over different geographical areas. Thus, a change to management as an existing exposure situation might not occur for all locations at the same time. In planning for emergency response, it is therefore important to consider issues relevant to each of the phases, since it will not be known in advance exactly when this transition might occur. The application of the Commission’s advice to an emergency exposure situation is discussed in Sections 2 and 3 of this document. Aspects of the transition to an existing exposure situation are discussed in Section 4.

1.3.3 Types of emergency exposure situations

(16)Emergency exposure situations can cover many different types of initiating events and initial locations. Accidents can occur, for example, at regulated nuclear sites, at hospitals using radioactive materials, at industrial sites that use or make radioactive sources or process materials containing naturally occurring radioactive isotopes (NORM industries), or during the transport of radioactive materials, whether for commercial, energy generation or weapons’ use. For these situations, because the use of the radioactive material is regulated, and therefore planned or known about in advance, it is possible to develop emergency response plans tailored for the specific characteristics of the potential accidents. The level of detail required for such plans

will be decided by the relevant national authorities, with response planning for the more likely accidents developed in more detail than those judged more unlikely. Exposures could also be caused maliciously, e.g. through the dispersal of radioactive material in a public place. For these, it is not possible to plan in detail, because the exact mechanism and location of exposure cannot be known in advance. However, this does not preclude the preparation of generic response plans: the inclusion of flexibility and resilience is of paramount importance to enable these generic plans to be adapted to the actual situation that arises. Further guidance on response planning for such events can be found in Publication 96 [ICRP 2005a]. Finally, there are accidents that occur beyond the jurisdiction of the affected regulatory authorities, for example, accidents in other countries, satellite crashes. For these, again, it is not possible to plan in detail, but outline response plans should still be developed.

(17) As indicated in Section 1.3.2, emergency exposure situations can cover many different scales of projected exposures. The Commission's advice covers all such situations, from small events resulting in exposures of only a few mSv or less, through to very large emergencies with the potential for very severe consequences.

1.3.4 Dose quantities

(18) An important pre-requisite for emergency response planning is the understanding of the radiation risks associated with postulated events, with and without the implementation of protective measures. In order to evaluate these risks, it is important to estimate doses using appropriate dose quantities. This section discusses the use of dose quantities in this context.

(19) One priority for emergency response planning is to identify whether there is a risk of individuals receiving severe deterministic injuries. The Commission has provided advice on the thresholds for deterministic effects elsewhere [ref]; relevant national authorities should provide guidance on the appropriate thresholds to adopt for severe deterministic injury in the context of emergency response planning. Doses for comparison with thresholds for severe deterministic injury should be calculated as the RBE-weighted absorbed dose to tissue or organ (RBE-weighted dose, AD_T). This quantity is defined in the Commission's main recommendations [Publication 103].

(20) In order to calculate doses for the purposes of protection against stochastic effects the equivalent dose, H_T , and the effective dose, E , are used [Publication 103]. In general, where effective doses less than 100 mSv are calculated, it will be sufficient to optimise the planned protection strategy using this dosimetric quantity. However, where a planned protective measure protects against a single exposure pathway and/or a small group of radionuclides (eg stable iodine prophylaxis), it can be helpful to evaluate doses and express intervention criteria in terms of the appropriate equivalent dose. Where effective doses in excess of 100 mSv are calculated, consideration should be given to whether there is a need to evaluate equivalent doses or absorbed doses in addition to the effective dose, as the Commission advises that assumption of linearity, fundamental in the derivation of effective dose, becomes progressively less reasonable, as doses exceed 100 mSv.

(21). When calculating effective dose-it should be remembered that its value is not related to an individual but to a reference person, averaged over both sexes and all ages. Whilst such an

averaged quantity is both useful and appropriate in the context of emergency preparedness and response, effective dose should not be used for individual risk assessments in which ‘proof of causality’ is required.

(22) The application of the dosimetric quantities of effective dose, equivalent dose and RBE-weighted absorbed dose in emergency preparedness and response is illustrated in Figure 2 [IAEA TECDOC-1432, DS-44]. In the dose range where mainly stochastic effects have to be considered the effective doses from external exposure are assessed from data measured by dosimeters in terms of operational dose quantities (ambient dose equivalent, $H^*(10)$, for area monitoring and personal dose equivalent, $H_p(10)$ for individual monitoring) and from internal exposure by determining the intake of radionuclides and using appropriate dose coefficients. For estimating deterministic effects at higher doses the RBE-weighted absorbed doses to the organs and tissues need to be assessed.

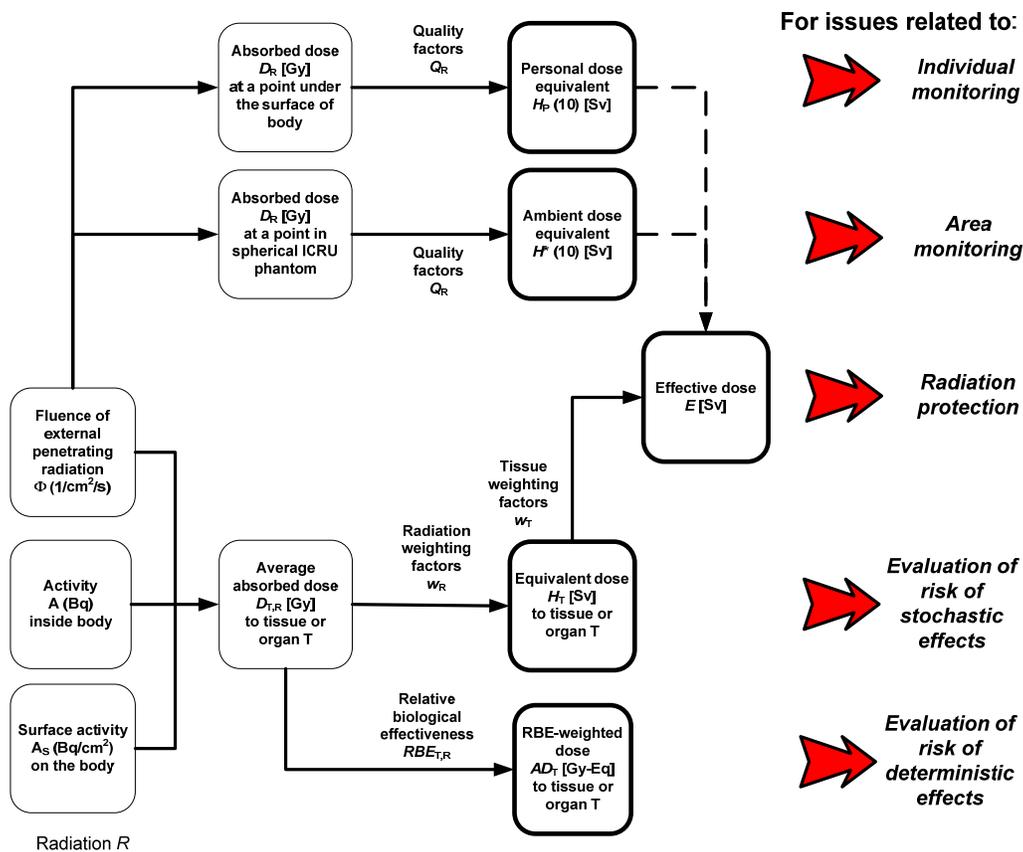


Figure 2: Basic dosimetric quantities and their application.

1.3.5 Dose concepts

(23) In addition to the use of these dosimetric quantities, it is necessary to define a set of conceptual doses, for use in the justification and optimisation of emergency plans and decisions. These doses are those doses which:

- are expected to be received following implementation of planned protective measures (*‘residual dose’*);

- are expected to be received in the absence of planned protective measures (*'projected dose'*);
- all or part of the planned response are expected to avert (*'averted dose'*).

These doses and their respective roles in emergency planning are discussed below.

Residual dose

(24) The total residual dose is the total effective dose from the emergency exposure situation that is expected to remain after the implementation of the full strategy of protective measures. The total residual dose should be calculated as realistically as possible. Strictly, since emergency plans are developed to protect population groups, not specific individuals, the residual dose is derived as the dose to each of a set of 'representative person. Guidance on characterising the 'representative person is provided in Publication 101 [ICRP 2006]. In principle, those populations potentially exposed during the emergency should be divided into groups which are relatively homogeneous with respect to exposure and risk from that exposure, and representative persons characterised for each group. This is discussed further in Section 2.1.4.

(25) The calculation of total residual dose is important for emergency planning, because it is necessary to explore whether or not this dose is both radiologically and socially acceptable, given the circumstances. In particular, it is fundamental to the Commission's approach to emergency planning, and supports the achievement of goals 3, 5, 6, 7 and 8, as listed in Section 1.2. The total residual dose may be calculated over the period of time that a protective measure is active (in order to determine the dose averted by the action for comparison with appropriate intervention levels, see Section 2.1.5), or it may be calculated, taking account of the effectiveness of planned protective measures, for a year (or the duration of exposures, whichever is shorter) for comparison with the appropriate reference level (see next paragraph) . Where the implementation of additional protective measures is being considered during the actual response, the residual dose calculated for comparison with the reference level should include doses already received and committed, as well as those expected to be received in the future (see Section 3).

(26) The Commission has recommended that a process of constrained optimisation be used to determine what total residual dose(s) will be acceptable in particular circumstances. The level of dose that acts as a constraint on the optimisation process is termed a 'reference level'. In the context of developing response plans for emergency exposure situations, the Commission recommends that national authorities set reference levels between, typically, 20 mSv and 100 mSv effective dose (acute or annual). Reference levels that exceed 100 mSv will only rarely be acceptable. Such exceptions include circumstances of extreme benefit (e.g. life saving), and circumstances where the probability of the exposure occurring is extremely low and the detrimental consequences of ensuring doses will not exceed this level are extremely high. Reference levels lower than 20 mSv may be appropriate for the response to events involving low projected exposures, i.e. exposures below 20 mSv. There may also be situations where it is not possible to plan to keep all doses below the appropriate reference level, eg high-consequence emergencies in which extremely high acute doses are received within minutes or hours. For these events the Commission advises that measures should be taken to reduce the probability of their occurrence, and response plans developed that can mitigate the health consequences where practicable. These exceptions are discussed further in Section 2.4. Any plans for an

overall strategy that is not expected to reduce residual doses to below the appropriate reference level require review and revision, in order to identify a more protective outcome. For accidents where the total dose is likely to be received or committed in less than one year, the residual dose calculated and compared with the reference level should be the total dose. For accidents where the total dose is likely to be received or committed in more than one year, the residual dose calculated and compared with the reference level should be the sum of the external dose received over one year plus the committed effective dose received from intakes over the same one year period. With the exception of high-consequence, low probability emergencies, the Commission recommends that if the total residual dose exceeds the appropriate reference level, additional protective measures should be planned to result in residual doses less than the reference level.

(27) The process of constrained optimisation should result in a level of the total residual dose, below the appropriate reference level, that is both radiologically and socially acceptable. This is because the process of optimisation involves wider issues than simply the radiation health risk associated with the dose. The process of optimisation must take account of the perceptions and aspirations of those who will continue living and working in the area, and of those who may visit or purchase goods from it. Doses that are acceptable in the longer term will be influenced by the doses actually received. Therefore it is generally the full one year residual dose (dose received summed with prospective dose for the remainder of the year) that should be optimised. The optimised outcome may also be influenced by other, non-radiological, measures taken to support those affected, for example, compensation schemes, health monitoring, infrastructure and economic support. It is therefore important, in the development of emergency plans, to engage the potentially affected stakeholders and, to the extent possible, explore with them what overall outcome, including residual dose, would be acceptable. This process of constrained optimisation within emergency planning is discussed in more detail in Sections 1.4.2 and 2.

Projected dose

(28) In this context, projected dose is the individual effective (or equivalent) dose that is expected to occur as a result of the emergency exposure situation, should no protective measures be employed. Projected doses should be calculated to representative persons. Generally, these will represent population groups, but, where there is a risk that individuals may be exposed above the thresholds for severe deterministic injuries, the representative persons may be assumed to undertake activities leading to the highest potential exposure. Projected doses may be used in several ways, within emergency planning:

- to give an initial indication of the scale of response planning required, by comparing them with the appropriate reference level(s)
- to determine the dominant exposure pathways and the likely time evolution of doses, for informing the emergency planning process with respect to the type and urgency of protection measures required
- to compare with threshold doses for severe deterministic injuries.

In each case, it is important that any assumptions made in the calculation of projected dose should be consistent with the assumptions underlying the comparison level(s).

The use of projected doses in emergency response planning is discussed further in Section 2.3.1.

Averted Dose

(29) The concept of averted dose is an important component of the optimisation of emergency planning, since it is one measure of the benefit gained from implementing a protective option. The averted dose is the dose to the appropriate representative person (usually expressed as effective dose or equivalent dose) that is expected to be averted by the implementation of a protective measure or combination of protective measures.

(30) Overall response strategies are made up from a set of individual protective measures (such as evacuation, milk restrictions etc). Where a number of different protective measures are relevant, optimisation of the overall strategy as a single process is likely to be complex. To assist emergency planners, the Commission has published guidance on the setting of intervention levels of averted dose (ILs) for individual protective options [ICRP 1993, 2005]. These are intended to assist in the optimisation of the component protective measures of an emergency response plan. The use of ILs in emergency planning is discussed further in Section 2.1.5.

1.4 Applying the Commission's System to emergency exposure situations

(31) The Commission's new recommendations re-state its principles of justification and optimisation, and the requirement to protect against severe deterministic injury, as applying to emergency exposure situations. The relevant text is repeated below.

- **The principle of justification:** Any decision that alters the radiation exposure situation should do more good than harm.

This means that [in taking action] one should achieve sufficient individual or societal benefit to offset the detriment it causes.

- **The principle of optimisation of protection:** the likelihood of incurring exposures, the number of people exposed, and the magnitude of their individual doses should all be kept as low as reasonably achievable, taking into account economic and societal factors.

This means that the level of protection should be the best under the prevailing circumstances, maximising the margin of benefit over harm. In order to avoid severely inequitable outcomes of this optimisation procedure, there should be restrictions on the doses or risks to individuals from a particular source (...[in the context of emergency exposure situations]...reference levels).

- **The requirement to protect against severe deterministic injury:** situations in which the dose threshold for severe deterministic effects in relevant organs or tissues could be exceeded should always require action.

The principles of justification and optimisation are discussed in more detail in the following subsections. Protection against severe deterministic injuries is discussed in Section 2.1.2.

1.4.1 Justification

(32) Protection strategies are made up of a series of specific protective measures designed to address, as appropriate, all pathways to which affected populations may be exposed. This concept represents an evolution from the previous ICRP recommendations which suggested that the individual and independent justification and optimisation of protective measures was sufficient. The Commission now considers that a more complete protection is offered by simultaneously considering all exposure pathways and all relevant protective measures when deciding on

the optimum course of action to be taken. In more concrete terms, this means that the overall “benefit” and “harm” of a suite of protective measures must be assessed when judging the justification of their application – it will be justified to implement a protective strategy when it results in more benefit than harm. In many cases, the summation of benefit and harm from a series of justified individual protective measures will also result in a net benefit. However, in some cases, particularly for large-scale accidents, the addition of many protective measures, each with a positive net-benefit but each resulting in significant social disruption, could result in the collective benefit of the protection strategy being negative. Thus, while each individual protective measure must itself be justified, in addition, the full protective strategy must be justified, resulting in more good than harm.

(33) The level of resources allocated to the quantification of the factors relevant to the justification process will depend on how readily it can be demonstrated that the benefits outweigh or do not outweigh the harm. The detail of the process of justification, in itself not a simple task, will vary, depending on a number of factors. Two of the most important factors are the nature of the likely health effects, should an emergency exposure situation occur, and the extent to which the harms can be deferred until the occurrence of the exposure situation (i.e. whether the planned response can largely rely on ‘paper’ planning and training, or whether specialised equipment, for example alarm systems, must be purchased and/or installed in advance). The Commission also recognises that the practicability of implementing a protective measure is relevant to determining whether that action should be included in the overall protection strategy.

(34) Where the emergency exposure situation may result in severe deterministic injuries, then the Commission recommends that it will be justified to expend significant resources, both at the planning stage and during the response, if this is required in order to reduce expected exposures to below the thresholds for these effects.

1.4.2 Optimisation and the role of reference levels

(35) As with justification, when optimising protection strategies, it is necessary to consider all aspects and protection measures to reduce residual dose, questioning whether “...the best has been done in the prevailing circumstances, and if all that is reasonable has been done to reduce doses.” [ICRP 2007, paragraph 217]. While this new approach does represent a relative increase in operational complexity, it also provides a significant amount of increased flexibility in designing the “best” protection to address an emergency exposure situation. This is partly because it enables the influence of one protective measure upon another to be taken into account, and partly because it provides for resources to be focussed towards those measures that are expected to achieve the most net benefit overall, rather than implying the need to focus equal attention on each single protective measure. As with justification of a protection strategy, the sum of the benefits and harms from all individual, optimised protective measures may not, itself, be positive. Again, this is because the combination of effects of many individual protective measures each involving large social disruptions may be too socially disruptive overall. Similarly, an overall optimised strategy may include within it protective measures which, if considered in isolation would not appear optimised, but when taken together with others within the strategy become optimised.

(36) The Commission has introduced the concept of constrained optimisation below reference levels in order to ensure that the response, as well as being optimised, also avoids an unacceptable inequity in the resulting distribution of expected harms and benefits between population groups. The reference levels define a level of dose above which it is generally unacceptable to plan to allow exposures to occur. The exceptions are extreme malicious incidents and some high consequence, low probability emergencies (cf. 2.3.4). The level of dose applies to that estimated for representative persons of identified population groups. Since the circumstances relating to different types of emergency exposure situations and to different population groups (e.g. on-site, off-site, different age groups and vulnerabilities) may be very different, national authorities may wish to define sets of reference levels appropriate to these different circumstances. In developing emergency plans, the potential exposures of different population groups should be considered, and an appropriate set of representative persons identified. Note that the protection of those involved in implementing urgent protective actions (here termed ‘workers’, see Section 1.1) is also subject to optimisation below an appropriate reference level, with the exception of life saving actions and measures undertaken to bring the source of the release under control. Further guidance on the protection of workers is provided in Section 2.4.4.

(37) Application of the Commission’s reference level during planning is illustrated in Figure 3a. In this Figure, the residual dose outcomes of three protective strategies are compared. The residual doses represented may be considered in two ways. First, consider the optimisation of protection for a specific population group. The residual doses to the representative person appropriate for this group, as a result of each strategy, may be estimated, together with the uncertainty associated with this estimate. In Figure 3a, the ‘best estimate’ dose is represented by the blocked bar, and the uncertainty is indicated by the vertical lines. For this population group, the best estimate residual dose is below the reference level for strategies A and B, but above the reference level for C. In this case, Strategy C would not be acceptable, but Strategies A and B would warrant further consideration.

(38) In emergency planning, it is necessary to optimise protection both with respect to specific population groups and with respect to the overall response. This latter consideration is also illustrated by Figure 3a. In this case, the blocked bars represent the mean of the residual doses to the representative persons of all population groups considered in the plan. The vertical lines represent the spread of doses to the representative persons. In this case, only Strategy B is acceptable, as both Strategies A and C result in doses to the representative persons that exceed the reference level.

(39) Whilst the general intent of the Commission’s advice is that no residual doses should be planned to exceed the reference level, there may be circumstances in which this is either not practicable or not possible. In particular, where an emergency results from a malicious act, or where an accident occurs that results in very high exposures being received during or shortly after the initiating event, it is not practicable to plan to prevent all doses above the reference level. However, it is important that any exclusion of particular situations or population groups from the general requirement to plan to keep doses below the reference level is explicitly justified and agreed by the appropriate national authorities.

(40) In order to optimise an overall planned response strategy, it is necessary to identify the dominant exposure pathways, the timescales over which components of the dose will be re-

ceived, and the potential effectiveness of individual protective measures. Knowledge of the dominant exposure pathways will guide decisions on the allocation of resources: resources allocated to protective measures should be commensurate with the expected benefits, of which averted dose is an important component. Knowledge of the timescales over which exposures will be received informs decisions about the lead times available to organise protective options once an emergency exposure situation has been recognised. Where urgent action is required to reduce exposures, it may be necessary to commit resources in advance of the emergency, and to use easily identifiable ‘triggers’ as the basis for decisions to implement the options, in order to ensure they are completed within the necessary timescales. The effectiveness of individual protective measures can be complex to evaluate, since it includes, not only dose-effectiveness, but also wider social and economic consequences.

(41) The optimisation of the effectiveness of the overall strategy is an iterative process, involving all stakeholders, in which the proposed component protective measures are optimised and then their contribution to the overall strategy assessed and optimised. For planning, this optimisation needs to be robust for a range of circumstances, as the detailed circumstances of the emergency cannot be known in advance. However, once the early phase measures have been implemented, a more detailed iterative optimisation can be implemented, taking into account the exact circumstances and the actual stakeholders. Thus the process of constrained optimisation is iterative with respect to individual measures and the overall strategy, with respect to time, and with respect to stakeholders. At each stage, comparison of the total residual dose expected from the overall strategy should be compared with the appropriate reference level(s) to ensure the outcome is not just optimised, but equitable.

(42) Figure 3b illustrates the application of the reference level once an emergency situation has occurred. Regular review of the expected residual doses as both the emergency situation and the response develop, and a consequent re-optimisation of the response, may well result in a progressive lowering of the expected residual doses over time. Review of the expected residual doses may also demonstrate that the doses to some population groups will exceed the reference level. In this case, any re-optimisation of the response strategy should first focus on these population groups, in order to explore whether it is optimum to reduce their doses. It should be noted, however, that a fully optimised response may still result in a distribution of doses, where some are above the reference level, as indicated by the second bar in Figure 3b.

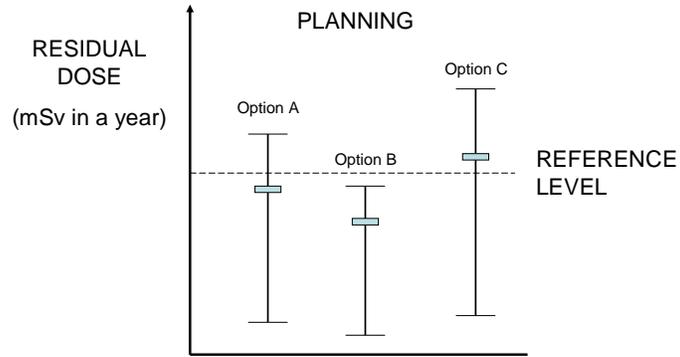


Fig. 3a: Example of the application of dose reference levels in planning (see text).

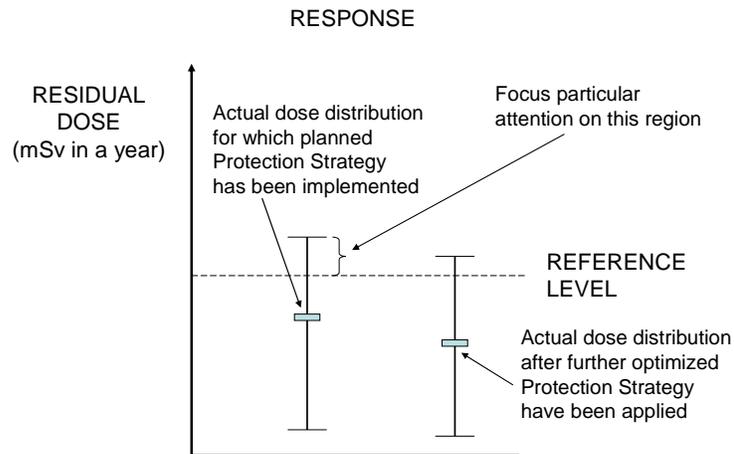


Fig. 3b: Actual dose distribution after implementing the planned protection strategy (left) and optimization (right)

2 Planning for emergency exposure situations

2.1 The planning process

2.1.1 Situations for which to prepare response plans

(43) The importance of planning emergency response can never be over-emphasised. No emergency response can be effective without prior planning. This planning needs to involve identification of the range of different types of accidents for which a response may be required, engagement with stakeholders, selection of appropriate individual protective measures and development of the overall protection strategy, agreement of the areas of responsibility of different agencies and how they will interact and communicate, deployment of the necessary equipment for monitoring, supporting the implementation of protective measures, and communicating with those at risk, training, and exercising of the plans. Emergency preparedness can therefore be seen as wider than simply an activity, it is a culture that needs to be fully integrated within society.

(44) The Commission recommends that plans are prepared for all types of possible emergency exposure situation: nuclear accidents (occurring within the country and abroad), transport accidents, accidents involving sources from industry and in hospitals, malicious uses of radioactive materials, and other events, such as a potential satellite crash. The level of detail within the plans will depend on the level of threat posed¹, and the degree to which the circumstances of the emergency can be determined in advance. However, even outline generic plans should indicate the responsibilities of different agencies, methods for communication and organisation between them during the response, and a framework for guiding decision making. More detailed plans should contain a description of the overall protection strategy, and provide triggers for initiating those aspects of the response that need to be implemented promptly. These triggers should be readily observable circumstances or measurable quantities, to facilitate prompt decision making.

(45) Detailed response plans are likely to place most emphasis on the initial response as this is when there is least time for developing the response in real time and when uncertainties concerning the overall situation, current exposures and the likely evolution of exposures will be greatest. However, any actions (or inactions) taken during the early phase will impact on what can be, or needs to be, done later on. In addition, the particular characteristics of these later phases, particularly, for example, with regard to the need for widespread monitoring, may mean that unless the response strategy is adequately addressed during planning, it may not be possible to respond effectively in the event. Finally, as outlined in Section 1.2, the optimum protection strategy for emergency exposure situations must be holistic, addressing a wide range of issues over a range of timescales. For this reason, the Commission's reference level for emergency exposure situations refers to the total residual dose received/committed over one year. Optimising the planned strategy to aim for the maximum residual doses to be below this level requires consideration of the response across all phases (or at least the early and intermediate phases for large events). An emergency response plan should therefore address the response

¹ the assessed level of threat will involve consideration of both the probability of occurrence of the event and the consequences, should it occur.

during all phases. For the early phase, the planned response would be set out in detail with triggers to help guide decisions on implementation. For the intermediate and late phases, it is likely that, rather than a specific response being planned, an outline strategy would be indicated, together with a framework for developing the specific response at the time of the accident, taking account of the actual circumstances. Whilst the form of the planning for the later phases would be different, it is important that this planning is undertaken in such a way as to provide confidence that total residual doses over a whole year will not exceed the reference level.

(46) Even after an emergency exposure situation has occurred, there will be a need to plan subsequent actions, particularly as time advances and the urgent need to act dissipates and finally disappears. As such, there will continually be a need to reflect relevant experience in selecting and implementing protective measures. The emergency plan will have identified a set of protective measures, and planned their implementation to a level of detail that reduces with time – ie much detail for the early phase, and less detail for the intermediate and late phases.

2.1.2 **Protective measures to avoid severe deterministic injury**

(47) In its previous recommendations (Publication 60), ICRP advised that ‘...at some level of dose, approaching that which would cause severe deterministic effects, some kind of intervention would become almost mandatory’. This concept was elaborated in Publication 63: ‘The first concern in the event of a radiological emergency is to keep the exposure to individuals from all pathways below the thresholds for severe deterministic health effects. In fact, when deciding on the implementation of protective actions, the decision maker should first determine whether the protective action is justified from the point of view of those individuals who are most at risk.’ In advising emergency planners to optimise the planned response across different response phases and exposure pathways, it is not the intention of ICRP to override this important principle.

(48) In the event of an emergency it is possible that some individuals may be exposed to radiation doses that are so high that, without prompt medical treatment, they will cause severe, irreversible injury to their health. The Commission calls these severe deterministic injuries, to distinguish them from deterministic tissue reactions which either may be reversible or may have only a minor impact on the individual’s health. The Commission continues to advise that practicable protection measures should always be planned to protect those individuals who would be at risk of suffering severe deterministic injury in the event of an emergency exposure situations. The following paragraphs provide additional advice on a framework for achieving this.

(49) In developing this framework, the Commission recognises that there is a qualitative difference between planning protection for accidents and planning protection for malicious acts. Accidents occur when unplanned events disrupt planned exposure situations. It is therefore possible to design additional safety precautions into a planned activity, that would mitigate the doses received in the event of an accident. This is clearly not possible in the case of malicious acts, as such acts are planned deliberately to circumvent any protective measures that might be in place. The Commission therefore recommends that the framework for protection in the case of accidents comprises two steps, one prior to any accident and one in the event of an accident.

The recommended framework for protection in the case of malicious acts may contain a ‘prior’ step, for specific locations or activities judged to be at particular risk, but will generally focus on the response phase only.

(50) For accidents, the Commission recommends that postulated accidents should be examined to determine whether or not they may result in exposures that could cause severe deterministic injuries. If such exposures are considered possible, then all protective options that could be implemented in advance to reduce these exposures, should the accident occur, should be considered.

Such options will be dependent on the particular circumstances and might include:

- engineering (e.g. additional shielding, containment, filtration, interlocks, alarm systems, separation distances of stored fissile material)
- procedures (e.g. restrictions on those who may enter a particular area, requirement for using personal protective equipment)
- training (e.g. recognition of alarms and response to them, suitable qualification and experience to operate plant and equipment)

The Commission recommends that all options are presumed justified, and therefore implemented, unless a specific case can be made to demonstrate the contrary. Reasons for an option being considered unjustified may include:

- disruption of normal activities to an unreasonable extent
- the placing of an unreasonable economic burden on the operation
- the introduction of a greater health risk by their implementation than they are designed to protect against
- that another protective option exists which provides the same or better protection.

However, it is important that every option is explicitly considered, so that maximum practicable protection is provided.

(51) The second step is the preparation of a response plan that provides specific protection for those at risk of severe deterministic injury in the event that the accident occurs. The protection of those at high risk should take priority over the protection of others, in terms of both resources and focus. Therefore, this part of the overall response should be separate from the protection of those at risk of lower exposures. Nothing in the emergency plan developed for protecting those at lower risk should compromise the protection of those who are at risk of receiving exposures that could result in severe deterministic injury. The response plan for those at risk of severe deterministic injury should not only include specific measures aimed at reducing exposures, but should include procedures for rapidly identifying those most likely to be at high risk, so that they can receive detailed assessment and prompt medical attention. One way of achieving this might be for those in a particular high risk area to muster separately to others, so that they can be accorded appropriate priority.

(52) As indicated above, in the case of planning protection against malicious acts, it may not be possible to implement protection in advance of the incident. However, for specific ‘high risk’ locations and activities, the Commission recommends that practicable options are considered for implementation, in order to reduce the exposures that might result from such acts. Response planning for malicious acts should develop procedures that enable the potential for exposures sufficient to cause severe deterministic injury to be rapidly assessed. Where this poten-

tial is judged to exist, the emergency plan should also provide procedures for identifying those who might have been exposed at such levels, guidance on exposure assessment and appropriate treatments, and, practical plans for enabling the individuals to receive treatment on the necessary timescales.

2.1.3 Engagement with stakeholders (who to involve)

(53) It is essential that all aspects of the plan are agreed by all relevant stakeholders. Otherwise it will not be possible to implement them effectively during the response. To the extent possible, the overall strategy and its constituent individual protective measures should have been worked through and agreed with all those potentially exposed or affected, so that time and resources do not need to be expended during the emergency exposure situation itself in persuading people that this is the optimum response. Where evaluation of the later phases indicates that there may be significant societal and economic adjustments required in order for populations to live in areas that were contaminated, it is important that those populations are engaged in exploring the implications of, and reasons for, this in advance of any accident occurring. Such engagement will assist the emergency plans in being focussed, not only on the protection of those most at risk in the early and intermediate phases, but also on the progression to populations resuming 'normal' lifestyles (where 'normal' may be rather different from the 'normality' that existed before the emergency).

(54) Stakeholders are not limited to those groups affected in the country where the emergency occurs: for large-scale emergencies, there may be international consequences. These may result from: international trade, and concerns that produce / trade items might be contaminated; the perceived need for protective measures in other countries and therefore the need to harmonise the response across country borders; the need for authorities to ensure the safety of their nationals in the affected country and to deal appropriately with people from the affected country crossing their borders. It is therefore important to engage internationally in order to ensure effective communication and a co-ordinated response in the event of a large-scale emergency.

(55) A further need for stakeholder engagement centres around the issue of contaminated waste. In any emergency exposure situation involving anything more than the most limited contamination of the environment, it is likely that very large volumes of contaminated waste will be generated, e.g. Goiania [IAEA 1988]. Managing and disposing of this waste will pose significant problems both socially and practically, and may even require changes to legislation. Where agriculture is affected the problem of large volumes is compounded with the waste rapidly becoming a health hazard and the production of some food wastes (e.g. milk) not being easily terminated. Engagement with representatives of local communities, producers and regulators in advance of an emergency can provide an opportunity for solutions to be developed in outline, and any legislative changes required to be identified in advance.

2.1.4 Representative persons (who to protect)

(56) In the event of an emergency exposure situation, it is likely that potential exposure rates will vary in space and time, and that the doses received by individuals will vary, both as a result of the variations in exposure rates and as a result of differences in their physiological characteristics and their behaviours. In order to ensure that the optimum response strategy is developed, it is important to consider the range of doses and other consequences for individuals that

may occur, both in the absence of protective measures, and following implementation of the protection strategy.

(57) The Commission advises that this is achieved by identifying a set of different population groups who, by their locations, characteristics and behaviours, appropriately represent the full distribution of doses and risks. These population groups should be characterised by representative persons, as described in the Commission's advice on representative persons [ICRP 2006]. It would be expected that, where children are likely to be present in an affected area, the consequences and protective strategy for this age group would be explicitly considered. In accordance with the Commission's advice on the representative person, it is important that the dose estimates made reflect the those likely to be received by the groups most at risk, eg pregnant women and children, but that they are not grossly pessimistic.

2.1.5 Setting reference levels

(58) The Commission has recommended an upper value for the reference level for emergency exposure situations (of 100 mSv, acute or in one year). It has already been discussed that for some high consequence, low probability accidents, and also for some malicious incidents, it may not be possible to plan measures that would reduce exposures to all population groups to below the Commission's upper reference level. For some other emergencies, a reference level set at 100 mSv may be inappropriately high. Part of the role of those authorities responsible for requiring emergency planning should therefore be to determine the appropriate value of reference level to apply to each type of emergency plan (and/or, as appropriate, for different population groups likely to be exposed by the event). Emergency planners should prepare their response plans in accordance with the required reference level for that situation, and only use the 100 mSv value recommended by the Commission if the relevant authority indicates that this is the most appropriate value.

(59) The selection of a reference level should fit the type of emergency exposure situation and the protection strategy to which it will be applied. For example, in a large-scale nuclear reactor accident the protection strategy will be an evolving set of protective measures aimed at addressing the particular circumstances of populations affected in different ways and to different levels, at different times and in different places. Because of the lasting nature of the situation and the exposure circumstances, the pre-selected reference level against which to assess the optimisation of protection should be expressed as mSv in a year. The optimisation process may thus need to take into account exposures of different phases simultaneously in assessing whether the optimum protection is being afforded to individuals under various emergency circumstances. The total residual doses to be compared with the pre-selected reference level is that assessed and/or estimated for the exposed populations for the year following the accident.

(60) However, in an accident involving no long term environmental contamination, the pre-selected reference level against which to assess the effectiveness of the protection strategy is the dose received as a result of the accident.

(61) The type of reference level that is selected should thus be tailored to meet the type of accident scenario under consideration. Ideally, regulatory authorities and operators will assess all credible risks, and authorities will be able to pre-select appropriate reference levels for the various accident scenarios that they judge to be relevant.

(62) The Commission's band of reference levels is expressed in terms of effective dose. For many emergency plans, this is an appropriate quantity in which to express the reference level. Where the nature and scale of doses are such that effective dose is an appropriate quantity for indicating the level of risk incurred, national authorities should not set reference levels in excess of the Commission's recommended upper value. However, there are situations for which effective dose is not an appropriate quantity in which to express reference levels. Such situations include: where the type or scale of emergency may result in doses in excess of 100mSv effective dose (where the assumption of linearity in its derivation may no longer hold); where parts of the response need to focus on individuals at risk of incurring severe deterministic injury; where the resulting exposures are very strongly dominated by irradiation of a single organ for which very specific protective measures are optimum (eg releases dominated by radioiodine). For these situations, the Commission advises that consideration be given to specifying (or providing supplementary) reference levels in terms of equivalent or absorbed dose. In such circumstances, this reference level should always be set such that doses just below this level would not be expected to cause severe deterministic health effect.

2.1.6 Role of intervention levels

(63) In its previous advice [ICRP 1993, ICRP 2005a] the Commission recommended the use of intervention levels of averted dose, for assisting decisions on whether/when to include certain protective measures in an overall response strategy. The Commission still considers these to be useful tools, for use as part of the development of an optimised response strategy.

(64) A protection strategy will comprise a number of distinct components, where the difference between components may be the type of protective measure considered, or it may be the criteria used to trigger its introduction or the phase in which its use is planned. If the only guidance available to the emergency planners was the designated reference level, then identifying the combination of component protective measures that formed the optimum planned response could be a very difficult exercise. Moreover, it might result in emergency plans for one situation appearing very different from those for a different, but similar situation. It is important that emergency plans are developed within a common framework: this provides stability for planners and reassurance for those being protected.

(65) Intervention levels provide information on the likely levels of averted dose that would justify the introduction of a protective measure (i.e. the level of averted dose at which the expected net benefits of the protective measure outweigh the expected net harms). Intervention levels are inevitably developed using a process that combines the selection of representative parameters for quantifying some consequences with qualitative judgements. Intervention levels can be very useful tools for aiding consideration of whether and how to include particular protective measures within an emergency response plan. However, intervention levels can only be indicative: in an actual emergency exposure situation, the parameters relevant to the situation may be different, and / or the judgements may not be fully representative. Furthermore, the Commission's intervention levels were developed for protective measures applied in isolation: when several actions are combined within an overall protection strategy, the balance of harms and benefits contributed by individual measures is likely to be different (e.g. because resources required for one action can be shared between implementing two actions as would be the case

if stable iodine tablets were distributed at evacuation centres). It is therefore not appropriate to treat the Commission's intervention levels as 'absolute' criteria that prescribe when each protective measure should be included within a plan.

(66) The role of intervention levels within emergency planning has not changed with the introduction of the Commission's latest advice. However, the need for planners to consider the optimisation of the plan over all response phases and protective measures serves to highlight the role of intervention levels as useful inputs as opposed to absolute criteria for developing the plan. In particular, in circumstances for which it appears that no single protective measure on its own is sufficient to reduce residual doses to below the reference level, it may be necessary to combine several protective measures, one or more of which would appear unjustified by simple comparison with its intervention level, to achieve this outcome. In this case, the intervention level would act as a prompt to consider the introduction of that measure more carefully, to determine whether or not an alternative measure or manner of introduction might increase the expected benefits or decrease the expected harms.

The Commission therefore continues to recommend use of intervention levels in planning, provided they are applied flexibly, as an aid to developing an optimised overall protection strategy.

2.2 Components of an emergency response plan

(67) An emergency response plan will contain a wide range of information and guidance, including much information, such as contact details, duties and responsibilities, reference to legislation, amounts of equipment/resource required etc, that is beyond the scope of this document. A discussion of these practical and technical issues can be found in publications from other bodies, such as the NEA and IAEA [NEA 2000, IAEA 2002, IAEA 2003,]. In these documents only those aspects of emergency response planning relevant to the application of the Commission's advice are discussed.

2.2.1 Strategies and individual protective measures

(68) There are different protective measures which could be applied in a radiation emergency for the protection of people. These protective measures could be applied promptly (urgent protective measures) or be prolonged over weeks, months or years (longer term protective measures). Urgent protective measures are those protective measures that, in the event of an emergency, must be taken promptly (normally within hours) in order to be effective, and for which the effectiveness will be markedly reduced if there is a delay. The most commonly considered urgent protective measures in a nuclear or radiological emergency are evacuation, decontamination of individuals, sheltering, respiratory protection, iodine prophylaxis, and restriction of the consumption of foodstuffs that have the potential to give significant exposures to people (eg green vegetables grown in the open and milk from animals grazing outdoors). Longer term protective measures (and food restrictions to protect against longer term exposures) include measures such as relocation, agricultural protective measures and some decontamination measures. The Commission has previously published detailed guidance on most of these protective measures [ICRP 1993]; further discussion of individual protective measures in this document is therefore restricted to new aspects of the Commission's advice.

(69) During an emergency there are also other measures that are likely to be taken to manage exposures. These include public warning, information, advice and basic counselling, comprehensive psychological counselling, medical management and long-term follow up. More details on some of protective measures are provided in Annex B.

2.2.2 Temporal and geographical issues

(70) The characteristics of potential exposures and therefore the requirements for protective response will vary both spatially and in time. In order to be manageable, emergency plans will sub-divide the area at risk into appropriate sub-areas, based on a number of factors such as: distance from the initiating source; demographic, economic and land use factors, response phase (early, intermediate, late). This approach enables the broad issues for each sub-area to be treated appropriately within the plan. However, in reality, there will be few, if any, sharp boundaries to delineate the implementation of protective measures. Whilst such sub-divisions assist practical implementation, if they are managed in too rigidly or with too narrow a focus, they can also introduce additional problems.

(71) The Commission's recommendation of a reference level that applies in all areas and for all response phases is intended to assist in the development of plans with a balanced focus. The need to consider the combined effect of individual protective measures within the overall protection strategy has been discussed in Section 2.1.5. Other aspects that need to be considered when optimising an overall strategy are: the impact of actions (or inactions) taken in one response phase on the protective requirements for other phases; and, the potential need to manage different areas in different response phases simultaneously (e.g. one area with heavy contamination may require management appropriate to the early phase, whilst another area with much lower contamination may have moved into intermediate phase management). These issues are discussed below.

2.2.2.1 Influence of actions in one phase on actions in another phase

(72) Actions taken in the early phase tend to scope the impact and severity of the accident in the minds of the public. If the authorities appear competent and 'protective' in their response to the accident, the public will tend both to trust these authorities to handle the more difficult intermediate and late phases appropriately, and to define the spatial extent of the hazard in terms of the spatial extent of the protective measures implemented. If the authorities appear to be indecisive or failing in their responsibility to protect people, then the public may tend not to trust the actions of these authorities during the intermediate and late phases and may also assume that the extent of the hazard exceeds the boundaries of the protective measure implemented. The Commission recognises that the area of public trust of authorities is extremely complex and that the summary suggested here is an oversimplification: considerably more research is needed in this area to provide a basis on which specific causal influences can be identified. However, what is clear is that the public perception of how the early phase is handled by the authorities will have an impact on the extent to which the public react to, and, in particular, cooperate with, the actions of the authorities in later phases. It is therefore important that emergency plans address the likely influence that proposed early phase protective measures and the choice of 'triggers' for these protective measures may have on public perception of both the authorities and the extent /scale of the hazard.

(73) The termination of protective measures is one area where the potential interaction of early phase protective measures and intermediate phase protective measures is particularly obvious. Withdrawing all early protective measures and then, some time later, initiating intermediate protective measures such as decontamination, might, purely from consideration of future doses and dose rates, seem the optimum course of action. However, such an approach is likely to be very confusing to the public, and may even imply that the authorities had wrongly believed the hazard had gone, only to discover later that it had not. It may also not be optimum from a practical and 'cost' viewpoint. For example, extending evacuation by a couple of weeks whilst decontamination is carried out may actually not increase the monetary costs of the combined protective measures substantially, as the decontamination may be carried out more efficiently in the absence of people living in the area.

(74) The disposal of wastes arising from decontamination, food restrictions and other protective measures (e.g. domestic and commercial refuse left outside in an area that was evacuated) is another example of the need for response planning to consider the wider temporal consequences of actions. A decision to prevent the consumption of fresh milk is straightforward to make and to implement, but the consequence is a rapid build up of large volumes organic liquid waste that are difficult to dispose of safely, from a biological perspective, regardless of the radiation hazard posed. An optimised overall response strategy should include the identification and prior agreement of appropriate disposal routes and temporary storage sites.

(75) The Commission therefore advises that effective emergency planning should consider the interactions between protective measures, not only during each phase, but also between phases. It may be that one way of ensuring that these interactions are adequately addressed is for the planned response to identify the need for a team to be set up in the early phase whose responsibility is primarily to consider what might be required in later phases and how early phase decisions might impact on this.

2.2.2.2 Co-existent response phases

(76) The spatial variation of potential exposures inevitably results in some areas having much higher potential exposures than others. In the case of a release of radionuclides to the environment, it is likely that areas close to the source will experience higher levels of contamination than those further away (although in the case of a release via a tall stack or significant plume rise and heavy rain at some distance, such as occurred following the Chernobyl accident, areas of high deposition may occur far from the site of release). For large releases, particularly, it is likely that appropriate reassurance monitoring will enable areas with low contamination to move to the intermediate or even the late phase form of response management, whilst the more highly contaminated areas will remain subject to the protective measures and management approach planned for the early phase. One consequence of this is that, depending on the plan and the overall emergency response management approach of the country, different authorities may be responsible for management of the different areas. Whilst management of the response in different phases simultaneously may not be problematic in principle, people living and working near the boundaries of such areas, or even living in one such area and working in another, may require particular care and involvement in the decision process. Unless the possibility for this situation arising has been foreseen in the emergency plan, serious practical and social problems may result.

2.3 Developing an emergency response plan

2.3.1 Evaluation of emergency exposure situations

(77) In order to develop an emergency plan, it is necessary to evaluate the projected doses for the situation being considered. For example, in the case of a severe accident with a radioactive source or in a nuclear reactor resulting in an accidental atmospheric release, it is likely that projected doses will be characterised by an initial, relatively high dose rate, inhalation component, from inhalation of short-lived, beta/gamma emitters during dispersion of the plume. This is likely to be followed by a phase lasting days or weeks when iodine-131 dominates the exposures, through external irradiation from contamination deposited in the environment and from direct contamination on crops and in milk. In the longer term, external radiation from radioactive isotopes of caesium and ruthenium is likely to become dominant, together with longer term contamination of foodstuffs with these radionuclides. Overall, during the first year, following the accident, if no protective measures are taken, the largest component of the projected dose is likely to be received from contaminated foods, followed by external irradiation from contamination in the environment, with the smallest components originating from inhalation of radionuclides during dispersion of the plume or of resuspended radionuclides and external irradiation from the plume. Only for the very largest accident scenarios are projected doses received over timescales of fractions of a second up to 1 or 2 days likely to exceed 100 mSv. However, there is a wider range of postulated accidents which may result in projected doses in excess of 100 mSv committed from intakes over the first year, together with external doses received over that period.

(78) Examples for the relative contribution of different pathways (cloud shine, inhalation, ground shine, ingestion) to the total projected dose are given in Fig. 4 for an atmospheric release of five radionuclides (^{60}Co , ^{90}Sr , ^{131}I , ^{137}Cs and ^{239}Pu) and for two NPP release scenarios with a variety of different radionuclides. Details are given in Annex A.

(79) By contrast, the spread of contamination experienced in London following the poisoning of Mr Litvenenko in November 2006 [HPA, 2008] resulted in actual or potential acute intakes of an alpha emitting radionuclide, via inhalation of re-suspended particles or ingestion, but no risk from external irradiation nor contamination of foodstuffs (except secondary contamination spread from contamination on hands or contaminated utensils).

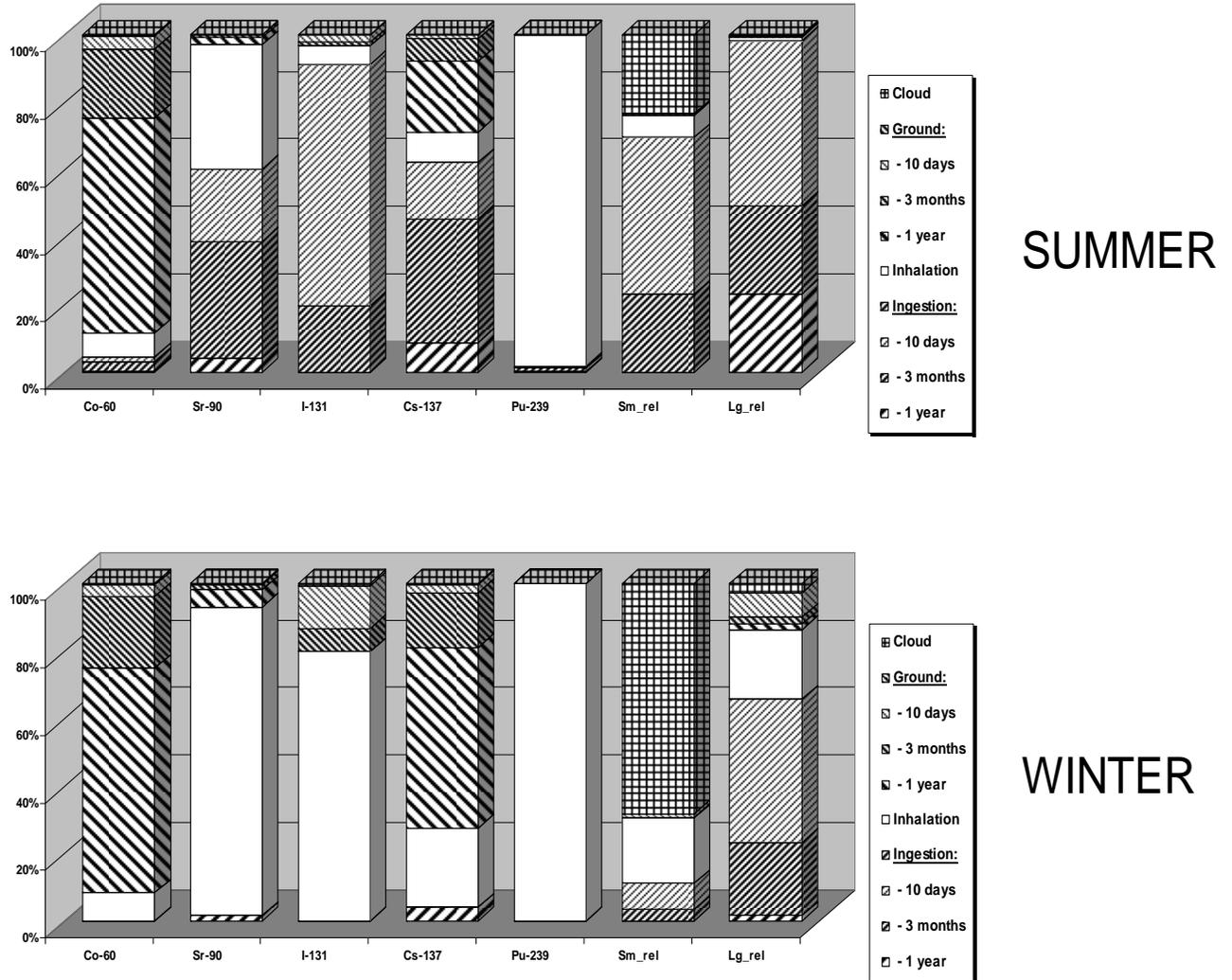


Fig. 4: Examples for the relative contribution of different pathways to the total dose

(80) The above examples illustrate how different the circumstances of different emergency exposure situations can be. However, the circumstances from the perspective of different roles within an emergency exposure situation can also be very different. For example, the situation of a trained radiation worker saving the life of a colleague, injured during a nuclear accident, is very different from that of a child in school at the time a contaminated plume passes overhead. Not only are the projected doses for these people likely to be very different, but what is considered an unacceptable level of the total residual dose would also be very different.

(81) The purpose of estimating projected doses and their likely spatial and temporal distributions is three-fold: first to identify the scale of health consequences that might occur if no protective measures are taken, and, therefore, to determine the broad scale of resource it is appropriate to assign to a protective strategy; second, to identify the broad geographical and temporal

distribution of the various likely response phases; and third, where, in terms of protection, resources are likely to be most effectively spent. In respect of the second aim, an example could be that an area within a few kilometres of the source of release is judged to remain in the early phase for a few weeks, whilst an area further area is expected to move to the intermediate phase after about one week, and an area beyond that is judged to move rapidly from the early phase to the late phase over only a few days. Identifying these broad trends helps both to highlight the evolving response management issues that need to be addressed and to provide initial guidance on the sorts of protective measures that might be appropriate for the plan. Some types of protective measure are clearly more suited to a particular phase, for example, sheltering is unlikely to be appropriate in the intermediate or late phases. In respect of the third aim, it is likely that protective measures aimed at reducing the dose from the exposure pathway(s) that would otherwise dominate the projected dose will have the potential to avert the most dose. It is therefore reasonable to allocate resources to the evaluation of such protective measures. In the context of accidental particulate releases from nuclear reactors, as has been seen above, it is likely that ingestion doses will dominate the projected doses over the first year, and so it is protective measures on the food chain that are likely to have the potential to avert most dose.

2.3.2 Justification of protective measures

(82) As discussed in Section 1.4.1, it is the overall protective strategy that requires justification. However, whilst individual justification of the component protective measures will not guarantee that the overall strategy is justified, it is useful to begin the development of an overall strategy by identifying all protective measures that are likely to be justified, even if they only avert a relatively small component of the dose. The development of an overall strategy that aims to reduce residual doses to just below the reference level will not necessarily result in an optimised response. If justified protective measures can be implemented to reduce the residual doses still further, then application of the Commission's advice on optimisation requires these actions to be considered for inclusion in the overall plan.

(83) Once all protective measures that are likely to be individually justified have been identified, each action should be examined for consequences that might interact with those of other protective measures, in such a way as to render their combined implementation either significantly more strongly justified, or unjustified. The former combinations will merit particular consideration when optimising the strategy, the latter should normally be omitted, but might still be retained if they constitute the only actions that can potentially prevent severe deterministic effects or reduce residual doses to below the appropriate reference level.

2.3.3 Optimisation based on reference levels

(84) Development of an emergency plan requires optimisation of the expected residual dose, to all relevant population groups, below the appropriate reference level. It is not sufficient simply to plan to achieve doses just below the reference level; it is necessary to demonstrate that the planned protection has been optimised below that level.

(85) Having identified protective measures that are likely to be justified and, in particular, those that have the potential to avert a significant proportion of the projected dose, it is necessary to evaluate the residual doses (ie those to different reference individuals) that would result from implementation of these actions. The first step is to scope the residual doses, in order to compare them with the appropriate reference level. If the total residual dose is likely to be be-

low the reference level, then detailed optimisation of the response strategy can be undertaken. If, however, the total residual dose is expected to be above the reference level, then further protective measures need to be considered, in order to reduce the residual dose to below the reference level

(86) This process of scoping the total residual doses and comparing them with the reference level should be iterated until the residual doses are expected to be below the reference level. Once this has been achieved, detailed optimisation of the strategy can be undertaken.

2.3.4 Detailed optimisation

(87) Clearly, the timing and manner of implementation of individual protective measures and how they are combined into a strategy will influence the overall net benefit achieved by the response strategy. It is therefore important to optimise the broad strategy. In this context, the Commission's previous advice on individual protective measures and their optimisation is relevant [ICRP 1993, ICRP 2006].

(88) In principle, the process of applying constrained optimisation to the planning of strategies of protective measures is the same as that for individual protective measures, that is, all the consequences, harmful and positive, expected to result from the imposition of different strategies are evaluated and balanced, and the one with the greatest net benefit, which also results in a residual dose below the dose constraint, is selected. The problem with this process in practice is that there are so many permutations of strategies that could be considered, that the process could quickly become complex. It is therefore advisable to adopt a more pragmatic approach, in which individual protective measures are optimised separately, and then, issues associated with their application in combination identified and explored, as discussed below. As noted in Section 1.4.2, a strategy composed of individually optimised protective measures will not necessarily itself be optimised, whilst an optimised strategy may contain actions implemented in a way that, taken in isolation, would not be optimum.

(89) Some combinations of protective measures can be considered to be largely independent of each other, for example commercial food restrictions and the evacuation of close in populations. The actions and resources required to implement these protective measures are very different (buses and evacuation centres for evacuation, food monitoring equipment and facilities for disposing of or processing foods in the case of food restrictions), and the impacts (other than doses averted) resulting from implementing these protective measures are likely to be sustained by different population groups (those evacuated, voluntary groups providing food and bedding, bus drivers for evacuation; farmers, food manufacturers agencies responsible for monitoring food production and disposing of wastes in the case of food restrictions). These types of protective measures can readily be optimised separately and the relevant intervention levels used as a direct guide. However, the intervention levels should be applied flexibly, since it may be better to widen the area of application of a protective measure to take account of local geographic and demographic factors, for example, encompassing a whole community even if the expected averted dose for some parts of that community will be below the relevant intervention level.

(90) With other combinations the protective measures are more closely linked, with actions required to implement one being relevant for implementing the other. For example, if stable io-

dine prophylaxis and evacuation are implemented together, then stable iodine tablets can be administered at the evacuation centres, thereby reducing the resources that would be required for tablet distribution in the absence of evacuation. In this case there is the potential for significant interaction between the harms (including resources required) and benefits of the options, and so the process of detailed optimisation is less straight forward. In this case, single measure intervention levels need to be applied more flexibly, taking into account both the enhanced benefits of combining actions and, as above, the need to develop a plan that reflects the characteristics of the surrounding area, such as geographic and demographic areas.

(91) The resources required to implement protective measures are not the only factors that might interact within an overall protective strategy. Other such factors include individual and social disruption, anxiety and reassurance, and indirect economic consequences. It is important to review the proposed overall protective strategy with representatives of all potential stakeholders to ensure the plan is optimised with respect to these factors, as well as with respect to dose and the resources required. This wider review of the protection strategy may well indicate a role for additional actions, which, in isolation, do not appear optimum (or even justified). Alternatively, it may indicate that the optimum strategy should modify or omit other actions, even though they appeared justified and optimised when only dose and direct resource requirements were considered.

(92) The level of detail of optimisation of the response plan should be commensurate with the needs of the situation. This is a matter for national authorities to decide. In general, events with the potential to result in widespread, high levels of contamination and events that are relatively likely to occur require more detailed planning than very low probability events or events whose consequences are expected to be limited.

(93) At stages during the detailed optimisation of the strategy, the expected residual doses should be compared with the reference level, to ensure that the outcome of the optimisation remains below it. Development of the plan is therefore an iterative process, with the degree of iteration depending on the level of detailed optimisation considered appropriate both to the significance of the emergency exposure situation and to the need to provide for flexibility of response on the day.

(94) Once the response strategy has been optimised, triggers for initiating the different parts of that plan should be developed, as discussed in the next sub-section.

2.3.5 Triggers

(95) Doses are not readily measurable quantities. Since most protective measures taken in the early phase need to be taken promptly, any delay in decision making would be counter-productive. Therefore, protective strategies should include early phase triggers (which may include default operational intervention levels (OILs)², emergency action levels (EALs)³, and observables/indicators of on-scene conditions, as described by [IAEA 2002]) that can be used immediately and directly to initiate appropriate protective measures. Triggers may be expressed

² The operational intervention level (OIL) is a calculated level, measured by instruments in the field or determined by laboratory analysis; see *Glossary*

³ The emergency action level (EAL) is a specific, predetermined, observable criterion used to detect, recognize and determine the emergency class of an event in a facility; see *Glossary*

in terms of any observable circumstances or directly measurable quantities, such as plant conditions, dose rates, wind direction. Triggers may be related to dose considerations, but are more likely to be quantities that indicate that the situation has occurred for which the plan (or a group of actions within the plan) was developed. Similarly, triggers may be identified which indicate that the event is outside the range of scenarios considered when the plan was developed, thus warning decision makers that the scale of protective measures may need to be escalated from those set out in the plan (in particular, the areas over which early phase protective measures are introduced may need to be significantly enlarged). Once the occurrence of a trigger has been identified, decision makers can advise that the appropriate part of the protection strategy should be immediately implemented, without further delay or discussion.

(96) In order to ensure widespread compliance with protective measures implemented on the basis of triggers, both with respect to those implementing the actions as well as those affected by them, it is important that all relevant stakeholders (or their representatives) are involved at the preparedness stage in determining what the appropriate triggers should be. Unless this is achieved, the implementation of prompt actions on the day may be delayed whilst different groups demand further information to assure themselves that this is indeed the best course of action.

(97) Once an emergency is occurring, the types of information likely to be available to the decision maker change with time, eg from assessments of plant conditions and limited dose rate measurements to widespread and detailed information based on a substantive monitoring programme. Early phase triggers should be specified in terms of circumstances and quantities that it is reasonably expected will be promptly available to the decision makers in the phase of an emergency exposure situation.

(98) In some emergency exposure situations, it may become apparent that protective measures are required that were not envisaged within the plan, or for which the triggers identified were not sufficiently protective. In this case, decision makers should first implement all those urgent actions indicated by the triggers, but may then take additional actions not indicated by the planned triggers. In other words, the triggers should be used to facilitate prompt decision making, but not to prevent necessary flexibility to respond appropriately to the exact circumstances of the emergency. This is discussed further in Section 3.

(99) Triggers may also be helpful for deciding on and delineating the extent of protective measures in the intermediate and late phases. It will not generally be useful to specify these triggers in the planning phase, as they will need to be related to the exact circumstances of the emergency. For example, once the radionuclide composition of environmental contamination is understood, a dose rate criterion could be applied to delineate where temporary relocation would be advised. Whilst specification of the triggers themselves in the emergency plan may not be appropriate, it may be helpful to include an agreed framework for developing triggers in 'real time'. The inclusion of such a framework is likely to result in wider acceptance of the 'real time' triggers when they are developed.

2.4 Supporting measures

2.4.1 Environmental Monitoring

(100) In support of decision making, the key roles of environmental monitoring are to:

- identify the extent and level of contamination;
- identify whether trigger levels, as specified in the emergency plan, may be exceeded;
- indicate that circumstances are sufficiently different from those planned for that much larger, or very different response is required;
- provide the basis for more accurate estimation of residual doses – both those already received to date and those expected to be received in the future, for comparison with the reference level specified in the emergency plan.

(101) In order to appropriately design, implement and manage protection in an emergency exposure situation, it is essential that any assessments of the quantities and nature of radioactive material involved are supported by environmental monitoring data. Actual measurements of various types may be used to update dose calculations that have been estimated based on release assumptions, and will help to define the extent of radiological effects. Knowledge of actual environmental contamination will also support decisions with regard to where various protective measures should be considered, thus providing an idea of the order-of-magnitude of the resources necessary to appropriately respond. Environmental monitoring data is one of the key tools for the optimisation of protection.

(102) In the face of a broad spectrum of possibilities, environmental monitoring resources should be focused to support the decision-making process regarding the optimisation of protection. Decision-making needs for optimisation of protection will depend upon many parameters, such as the type of facility or situation for which protection is being considered or implemented, the exact nature of the emergency being considered or addressed, the time-frame with respect to any actual or potential environmental release for the actions being considered or implemented, the geographic and demographic nature of the various locations affected by the emergency, as well as the nature of the decision being made.

(103) One approach to planning to effectively address the decision-maker's needs is to consider a series of simple questions: "WHY" (for what purpose) should emergency monitoring be performed; "WHAT" (in terms of physical quantities to be measured) parameters should be monitored; "WHEN" (with respect to the time-phases of an accident) should each parameter be monitored; and "WHERE" (with respect to the accident site) should specific parameters be measured. These four questions form a simple framework which can be used to define emergency monitoring needs and priorities (NEA 2000).

- The first key element of an emergency monitoring strategy addresses the reasons **WHY** emergency monitoring is performed. This can include many different reasons, for example to allow early detection of the onset of an emergency, to develop an estimate of the source term, to guide the implementation of urgent protective actions, to identify the trajectory and extent of contamination, or to implement agricultural measures and food restrictions.
- The second axis of an emergency monitoring strategy concerns **WHAT** actual measurements should be made. The types of measurements made can include meteorological data, ambient dose and dose rate, airborne radionuclide concentration, environmental deposition, food and water contamination levels, individual dose assessments, or surface contamination levels on objects such as buildings, roads or merchandise

- The third axis of an emergency monitoring strategy concerns **WHEN** measurements should be made. While the temporal nature of the Early, Intermediate and Late phases of an emergency exposure situation (see section 1.3.2) are theoretical and artificial in nature, such a designation is useful for planning purposes and for guiding the nature and priority, and thus resource allocation, that will be necessary for data collection
- The fourth axis of an emergency monitoring strategy concerns **WHERE** measurements should be made. Different geographic areas may be defined corresponding approximately to the zones in which different types of decisions will be necessary, for example urgent protective planning zone(s), food and agricultural restriction zone(s), and any areas further from the release site. Such areas can be pre-designated for fixed installations, but where this is not possible (e.g. for mobile sources or malicious incidents) they may be planned but only precisely defined at the time to address the circumstances actually at hand. Such pre-planned designation of the physical areas to be considered will assist in defining the types of measurements that will be needed.

(104) Within these four axes of an emergency monitoring strategy, several different types of measurements may be needed, depending on the nature of the emergency exposure situation being considered, and a variety of data collection techniques, including monitoring instruments and sample collection for processing and assay, may be needed. There is much international guidance available to assist in the detailed design of monitoring capabilities [NEA 1998, NEA 2000, IAEA-TECDOC-1092].

As a complement to physical monitoring capabilities, it will be important to be able to model environmental contamination and the spread of gaseous and liquid effluents. In the early phases of an accident, models will most likely provide the most significant quantities of data available for decision making. While model estimates and projections will, in general, be very uncertain and will most likely not represent the degree of inhomogeneity that will actually be found, they will be key tools for decision making in designing environmental monitoring capabilities, and for responding to accidents, particularly in the early phase.

2.4.2 Individual Monitoring

(105) Appropriate monitoring of individuals during an emergency response can fulfil a number of distinct functions. In situations where individuals may have received whole body doses in excess of 1Gy (eg in a criticality incident), the prompt identification of those individuals and their exposures (eg from dose meters they are required to wear routinely) can enable them to receive early medical treatment. Where it is expected that individuals have not received high doses, individual monitoring can provide confirmation and reassurance. In the event of a release containing radioiodine, measurement of thyroid burdens can be used to provide information on the effectiveness of the protective measures. Finally an appropriate monitoring programme of selected individuals can be used to underpin retrospective assessment of the impact of the event and also an on-going health surveillance programme (see next section).

2.4.2 Health surveillance

(106) There are different reasons to perform long-term medical follow-up (health surveillance) of affected people, such as to provide advanced medical care for affected people; to decrease public concern with regard to their health status, and to obtain new scientific knowledge for enhancing radiation protection. Each of the reasons could form the basis for medical

follow-up. However, for medical care of the affected population, the reason for establishing a registry and providing medical follow-up is: early detection, and hence effective treatment of cancer that may be induced by radiation.

(107) Long term medical follow-up has both potential benefits and risks. Early recognition of the cancer represents a net benefit both to the individual and to society. However, potential penalties both to the patient and to the medical care system should be also considered. Potential risk for the patient includes performing invasive and potentially harmful procedures (e.g., fine needle biopsy of thyroid), ultrasound detection of clinically insignificant nodules (leading to false positive results), and the psychological pressure of regular examination, which influences the quality of life. The potential risks to the consequences for the medical care system, e.g. overload in terms of both personnel and equipment, need to be identified and appropriate cost- and risk-benefit analyses should be undertaken (including not only morbidity and mortality associated with surgery, but also the need for long-term patient compliance and the necessity for life-long medication, e.g. replacement hormone therapy after removal of the thyroid gland). This should be of special consideration for countries with limited resources allocated for long-term medical follow-up of people with very low risk of radiation-induced cancer [IAEA DS-44].

2.4.3 Communication with the Public

(108) In an emergency exposure situation it will be essential to communicate with the public. This will of course focus on those members of the public who have or could be directly affected, but should also include information for those not directly affected as they may come into contact with products or individuals from directly affected areas

(109) At the planning stage, it will be important to dialogue with as many possibly affected stakeholders as possible so as to appropriately identify the most effective protection strategy. Once an emergency exposure situation has occurred, there may be a need to direct members of the public with regard to urgent protective measures that need to be taken. As an emergency exposure situation progresses, and the need for urgent decisions dissipates, the decision-making process will inevitably shift away from giving direction toward furnishing an appropriate dialogue process with affected stakeholders so that the optimum protection strategy can be identified and implemented, and such that feedback of experience can help to improve the implementation of such protective measures. In this way, decision makers, and those responsible for planning and implementing protection strategies, can make their choices most optimally, with an understanding of stakeholder concerns and views as well as of relevant radiological protection science.

(110) For communicating with stakeholders in all phases of an emergency exposure situation processes and procedures will need to be identified and made ready to implement if necessary. Training of RP professionals in aspects of public communication will be necessary.

2.4.3 Stakeholder involvement in planning

(111) In planning for an emergency exposure situation it will be essential to appropriately involve stakeholders in the development of protection strategies, and to effectively communicate with the public. This will of course focus on those members of the public who have or could be

directly affected, but should also include information for those not directly affected as they may come into contact with products or individuals from directly affected areas.

(112) The Commission wishes to emphasise that this does not simply indicate the furnishing of information regarding an emergency exposure situation. While early in an emergency exposure situation there may certainly be need to direct members of the public regarding the application of specific, urgent protective measures, there will also be a need to discuss options with the public at the planning stage and at the stage of implementing non-urgent protective measures. By involving stakeholders, decision makers and those responsible for planning and implementing protection strategies can make their choices most optimally, appropriately incorporating stakeholders' concerns and views, as well as of relevant radiological protection science.

(113) To accomplish this, it will be essential that the needed plans, procedures and infrastructures are put in place before an emergency exposure situation occurs, and that those members of the public likely to be affected are aware of the plans and the reasons for different messages being provided. Appropriate training of RP professionals in stakeholder involvement is an essential part of this.

(114) In planning it will be essential to identify any urgent protective measures and their communications mechanisms, however it will be increasingly difficult to explicitly define the types of decisions and dialogues that will be necessary as any given emergency exposure situation progresses. None-the-less, processes and procedures for communicating with stakeholders in all phases of an Emergency exposure situation will need to be identified and planned (see section 3.1).

2.4.4 Protection of emergency workers [ICRP 1991 b and 2005 a, revised BSS]

(115) Traditionally, emergency workers are assumed to be those individuals who can be identified in advance as possibly being involved in response to a radiation emergency. However, emergency workers could also include any individual responding to a radiation emergency at a location or time that could not be foreseen. This would include police, rescue personnel, fire fighters and medical personnel.

(116) Previously [Publication 63, Annex A], the Commission advised that the exposures of emergency workers should be managed by grouping them into 3 categories:

- those engaged in urgent action at the site of the accident;
- those implementing early protective actions and taking action to protect the public;
- those implementing recovery operations.

The Commission's advice with respect to the first and third categories is unchanged. With respect to workers in category 2, the Commission now recommends that the protection of these workers should be explicitly optimised below an appropriate reference level of dose. This is a small change from the advice in Publication 63, where the focus was on planning exposures so that they did not exceed those 'permitted in normal conditions'. Whereas, in 1991, the Commission cited optimisation as an aspiration, it now judges that an emergency preparedness culture has developed sufficiently to recommend that optimisation of the exposures always be undertaken.

(117) The Commission's advice, as set out in Publication 63, regarding the appropriate provision of training and information to emergency workers, and, for those in category 1, ensuring they are undertaking the risks voluntarily, remains unchanged. Furthermore, the Commission now explicitly recommends that women who have declared that they are pregnant, or who are nursing an infant, should not be employed as first responders undertaking life-saving or other urgent actions.

(118) The IAEA has provided practical guidance for planning the protection of emergency workers, which is consistent with the Commission's advice [revised BSS].

3 Implementing protection strategies

(119) In the context of the ICRP's system of radiological protection, there is at least one fundamental difference between prospectively planning to address the consequences of a radiological emergency exposure situation, and managing consequences that are in the process of occurring or that have already occurred. In the context of planning, optimisation is performed using the appropriate reference level as the upper bound to optimisation, eliminating any protection solutions that result in individual residual doses exceeding the reference level. Protection for all those exposed is optimised, and residual exposures resulting from the application of the protection strategy are below the reference level. However, the inherently unpredictable nature of emergency exposure situations, their tendency to rapidly evolve, and the wide possible range of emergency conditions (i.e. weather conditions, geographic location, population habits, etc.) could result in situations that do not match the assumptions that were used to develop optimised protection strategies such that some actual exposures may well exceed the pre-selected reference level. As such, in the context of managing the consequences of an emergency that is in the process of occurring or that has already occurred, the predefined reference level is used as a benchmark against which to judge the results of implementing an planned protection strategy, and for guiding the development and implementation of further protective measures if necessary (see Fig. 3b).

(120) When reviewing the effectiveness of an on-going response or taking decisions on the implementation or variation of protective measures, it is important to compare the total residual dose with the reference level, ie the sum of doses already received with those expected to be received in the future. A comparison that neglects the component of dose already received, may result in the implementation of individual protective measures that appear optimum in themselves, but an overall response that is not appropriately optimised.

3.1 Tuning protection strategies to actual conditions

(121) In planning and preparing for emergency response, a full suite of emergency scenarios will be assessed, and plans, procedures and processes put in place and made ready for implementation should an emergency exposure situation actually occur. However, it is likely that should an emergency exposure situation occur it will not exactly match the assumptions that were made in planning. Divergence from initial assumptions will most likely increase as an emergency exposure situation progresses in time. However, in most cases emergency planning will broadly fit a large range of possible situations, such that the early and urgent implementation of a planned protection strategy should come close to providing the optimum protection, with divergence most likely being on the conservative side. However, there will still be some need to operationally adjust planned protection strategies, justifying any new actions or significant changes to plans. The need to consider making such modifications will increase as the emergency exposure situation progresses, and the order of magnitude of changes from plans will depend on the nature of the emergency exposure situation that occurs (i.e. large and complex or small and straight-forward). It is important, however, that minor modifications to the planned actions are avoided, particularly during the early phase where uncertainties are greatest, as this is likely to, at best, introduce confusion for very little expected benefit, and at worst, actually result in reduced protection.

(122) Ideally, all relevant stakeholders will be involved in planning protection strategies, although in practice it can be difficult to interest relevant stakeholders in such planning exercises. On the contrary, once an emergency exposure situation has occurred, it is likely that many stakeholders will be very interested in providing input to discussions regarding protective measures. Should the emergency exposure situation have an early phase requiring urgent protective measures, the “reflex” use of pre-planned protection strategies will be necessary with no or very little stakeholder involvement beyond the emergency response authorities and those responsible for the site, facility or source that is causing the emergency exposure situation. As the early phase progresses, however, stakeholders will become increasingly interested and available to participate in discussions leading to protection decisions, such that part of emergency planning should be the development and implementation of processes and procedures to inform and involve stakeholders.

Tuning protection strategies in the early phase

(123) The early phase of an emergency exposure situation can be characterised as taking pre-planned actions as best possible to manage any emergency consequences. Here, the focus is not on “forward-looking” planning, such that reference levels will be of limited, if any use. The focus of protection strategy decisions will be on adapting pre-made plans to best fit the actual situation.

(124) In the early, uncertain phase of an emergency exposure situation, the objective of a protective strategy should be to avoid severe deterministic effects and to keep the risk of stochastic effects as low as reasonably achievable. To accomplish this, there may well be the need to act very quickly and without much concrete knowledge of releases or exposures. Such “reflex” protective measures will, of necessity, follow pre-planned scenarios using pre-planned procedures and processes. Many considerations will have already been taken into account with regard to the justification and optimisation of such pre-planned actions. The plan should be developed such that revision of the most urgent protective options would not be required under almost any circumstances. However, reassessment of the planned response in the light of actual conditions may be necessary after these most urgent measures have been implemented, so that actions best apply to the situation at hand. Reassessment of planned early phase response will involve as much specific information concerning the nature of the emergency exposure situation and its possible effects as possible, and any significant deviations from planning assumptions (i.e. extreme weather conditions, unexpected geographic location of the release site, temporary changes in population density due to unexpected circumstances such as large sporting or political events, etc.). In general, any modifications that are made to the planned response will be to extend the extent of protective measures in time and space.

Tuning protection strategies in the intermediate and late phases

(125) As an emergency exposure situation progresses, and understanding of the exact circumstances increases, decisions will increasingly be based on actual circumstances rather than on pre-planned responses, assumptions and models. As understanding increases, and the need to act becomes less urgent, there will also be an increased need plan future protection strategies in greater detail than included in the plan, and thus to involve the relevant stakeholders in decision framing and decision making processes when judging the justification of protective strategies, and when optimising their application. For this future planning, to deal

appropriately with the situation at hand, a pre-determined reference level will be a useful tool. The endpoint of optimisation processes will be at least partially characterised by residual dose, which will have to be agreed upon by government (e.g. at the local, regional and national level; and among relevant ministries) and by the relevant stakeholders (e.g. affected populations, affected businesses, etc.), and can be compared against pre-determined reference level when judging the appropriateness of the protection strategy.

(126) If, in application, protection options do not achieve their planned residual dose objectives, or worse, result in exposures exceeding Reference Levels fixed at the planning stage, then a reassessment of the situation is warranted to understand why plans and results so significantly differed. New protection options could then, if appropriate, be selected and applied.

Stakeholder involvement in the implementation of protection strategies

(127) Once an Emergency exposure situation has occurred, there may be a need to direct members of the public with regard to following the planned, urgent protective measures that need to be taken. As an Emergency exposure situation progresses, and the need for urgent decisions dissipates, the decision-making process will inevitably shift away from giving direction toward furnishing an appropriate dialogue process with affected stakeholders so that the optimum protection strategy can be identified and implemented, and such that feedback of experience can help to improve the implementation of such protective measures.

(128) While it may be difficult to secure the active involvement of all stakeholders in the planning of emergency response strategies, in general, once an event has occurred, many stakeholders will want to be actively involved in decisions regarding the development and implementation of protection strategies. To appropriately incorporate stakeholder input into decisional processes, it is essential that structures, processes and procedures, and perhaps legislation and regulation, are appropriately tuned to allow and encourage such participation.

(129) The active participation of stakeholders will, in general, bring relevant local knowledge, experience and values to decision-making processes such that resulting, detailed protection strategies are more likely to be well focused, understood and supported. To effectively involve stakeholders, however, will require that the relevant staff from government bodies dealing with the emergency exposure situation are appropriately trained in the social and interpersonal aspects of stakeholder involvement, bringing their technical knowledge to the service of the broader decisional process. Because such processes can be long and detailed in nature, mechanisms for appropriate financial support for stakeholder participation may be needed. In the long term, however, as the emergency exposure situation becomes increasingly managed as an existing exposure situation, ongoing stakeholder involvement should become self-standing and independent.

Feedback of experience

(130) Once protective measures start to be implemented, it is important to review their actual performance against the outcomes expected when the plan was developed. This feedback of actual outcomes and experience should be used to inform the further implementation of protective options and decisions on modifications to the later phases of the emergency plan.

3.2 Termination of protective measures

(131) The decision to terminate protective measures will need to appropriately reflect the prevailing circumstances of the emergency exposure situation being addressed. Many different aspects must be taken into account when reaching such decisions. Terminating a protective measure may result in the affected population receiving a ‘step change’ increase in dose rate, for example, if access restriction to a contaminated area were terminated. However, planned protective strategies should consider the impact that termination of protective measures will have on the total residual dose. In general, optimisation of the overall strategy during the planning phase and reactive ‘re-optimisation’ of the strategy throughout the emergency response will mean that the impact of termination of protective measures on the total residual dose will have been factored into decisions. Therefore, in general, it would not be expected that the total residual dose will change significantly as a result of the termination of protective measures. However, there may be unforeseen circumstances that require termination of protective measures at a time or in a manner that was not planned for. In this case the resulting exposures following termination of the measures may be higher than planned, and may even exceed the reference level. As with decisions on the initiation of protective measures, whilst the requirement for optimisation of the overall protective strategy remains valid, the focus for decision makers should then be on implementing further practicable protective measures to reduce the exposures of those population groups receiving doses in excess of the reference level. These points are illustrated in Figure 3c.

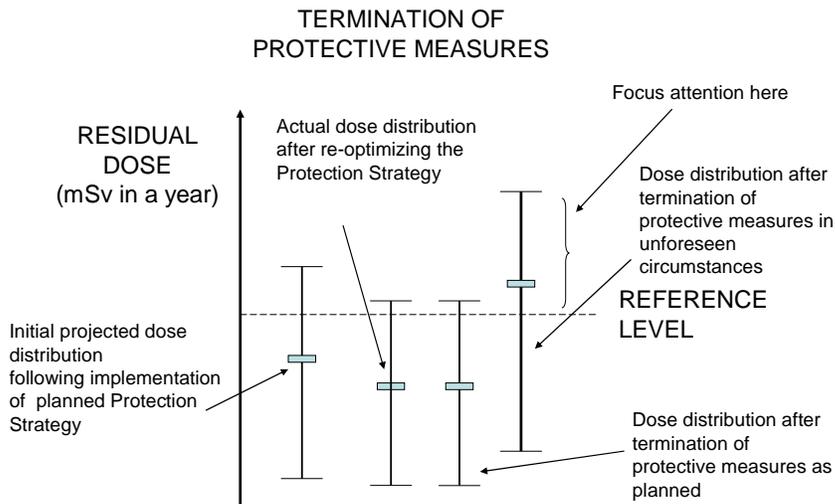


Fig. 3c: Actual dose distribution after applying the planned protection strategy and optimization (left) followed by the termination of a protective measure (right)

(132) In general, protective measures will be terminated because they have achieved their desired effect (i.e. the use of prophylactic iodine has prevented thyroid uptake of radioactive iodine and radio-iodine is no longer available for uptake), because their continued application will cause more harm than good (i.e. prolonged sheltering becomes too disruptive), or because there is an agreement reached that the optimum state has been reached (i.e. the decontamination of contaminated roads and roofs has removed sufficient amounts of radioactive ma-

terial). There will be some urgency to terminate those protective measures that will at some point cause more harm than good. This is particularly true of some early, urgent protective measures such as sheltering and evacuation. Most protective measures, however, will not need such urgent decisions or cause such obvious pressure to terminate. As such, it will be important to assess the potential benefits and harms that termination of a protective measure may cause, and how this will affect the overall objectives of the protection strategy. A summary of issues which require consideration and evaluation before such decisions are taken is given in Annex C.

(133) It is important to involve, wherever possible, relevant stakeholders in discussions regarding termination of protective measures. While it will be difficult, if not impossible to discuss decisions with sheltered populations, it will be essential to discuss decisions to return to evacuated areas with those who have been evacuated and the termination of protective measures implemented during the intermediate and late phases.

(134) The types of information that will be needed for these decisions will, of course, vary from situation to situation, however in general it will be important to have sufficient technical data on hand to judge the effects of termination. For example, the decision to allow evacuated populations to return to their homes and offices, i.e. the termination of temporary relocation, should only be taken when the exposures that would result from such returning can be appropriately assessed, and this will most likely require an adequate understanding of contamination conditions. As noted above, for protective measures implemented in the early phase whose effects are short-natured, it will be essential to consider how their termination will affect the overall protection strategy and its optimisation.

Terminating intermediate and late phase protective measures

(135) Decisions regarding the termination of later protective measures will usually be based on having achieved an optimum level of protection. These decisions will, in general, not be urgent in nature, and will, in general, be based on radiological protection input and social and political judgement. In these cases, the involvement of relevant stakeholders is essential, and processes and procedures should be established to assure that such involvement can take place efficiently.

(136) One important aspect of the involvement of stakeholders is that, when agreeing on the detailed implementation of a protective measure in the intermediate and late phases, directly measurable outcomes should also be agreed (e.g. residual contamination levels, dose rates). This will help ensure that when the action has been completed, it can readily be demonstrated that it has achieved the intended level of protection.

4. Transition to rehabilitation

(137) The Commission recommends that the management of long-term exposures resulting from an emergency exposure situation, through remedial actions and other measures, should be treated as an existing exposure situation. The change from an emergency exposure situation to an existing exposure situation will be based on a decision by the authority responsible for the overall response. The decision may include considerations of the fact that different geographic areas may undergo this transition at different times. The transition may require a transfer of responsibilities to different authorities. This transfer should be undertaken in a coordinated and fully-transparent manner and agreed and understood by all involved parties. The Commission recommends that planning for the transition from emergency exposure situation to an existing exposure situation should be undertaken as part of the overall emergency preparedness, and involve all relevant stakeholders.

(138) Existing exposure situations which are created by emergency exposure situations can be characterised as having some sort of residual exposure pathways and lingering contamination above previous background levels, but having social, political, economic and environmental aspects of the situation that are sustainable, and are seen by the affected populations and governments as being their new reality. This is not to say that conditions are “normal”, that is as they were before the emergency exposure situation occurred. Rather, the new context does not significantly hinder a “normal” way of life, in spite of the fact that new behaviour may be necessary.

(139) There are no pre-determined temporal or geographic boundaries that delineate the transition to an existing exposure situation. However, during the planning for an emergency exposure situation, governments and/or regulatory authorities will have chosen a reference level, typically between 20 and 100 mSv in a year, to be applied for emergency exposure situations. During implementation of the response, this reference level will be used as a benchmark against which to judge the optimisation of the protection strategy that is applied. In general, a reference level of this magnitude will not be acceptable as a long-term benchmark, as exposures caused by emergency exposure situations at these levels are generally unsustainable from social and political standpoints.

(140) Where the emergency response continues into the intermediate and late phases of an emergency exposure situation, it is possible that national authorities may choose to constrain optimisation of the response according to progressively lower reference levels. Whilst not strictly necessary, since optimisation below the reference level is always required, the explicit reduction of the reference level can simplify the optimisation process. Such a reduction may also be helpful in conveying a message of reassurance to the public that the response is effective. A schematic presentation of this development is given in the left hand part of Fig. 5.

(141) Whether the emergency response enters the intermediate and late phases, or is within the early phase only, there will come a time when the prospective annual dose is not expected to continue reducing significantly, even with the application of further practicable protective measures. At this time governments and/or regulatory authorities may, identify a new reference level, typically between 1 and 20 mSv in a year, which can be used to judge optimisa-

tion of protection strategies in the long term, i.e. for existing exposure situations. Again, in general a single reference level will be selected to be applied to the new existing exposure situation, however because of geographic and behavioural inhomogeneities of contamination and exposure pathways, the reference level used for the emergency exposure situation may apply in some areas or circumstances, while at the same time the reference level for the new existing exposure situation may apply to other areas or circumstances. A schematic presentation of this development is given in the right hand side of Fig. 5.

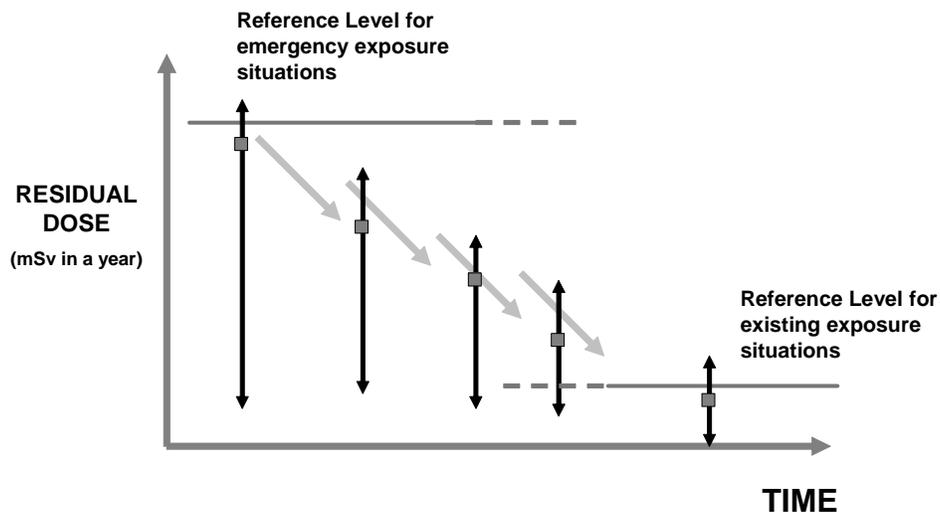


Fig 5: Transition from an emergency exposure situation where protective measures are optimised with respect to a pre defined reference level which is used as a benchmark to an existing exposure situation for which another reference level has to be defined.

(142) It can then be said that an emergency exposure situation becomes an existing exposure situation once the government and/or regulatory authority has decided, presumably based on extensive discussions with affected stakeholders, that the new reference level is appropriate as a benchmark for judging the optimisation of protection strategies for a given geographic area or exposure circumstance. Typically, these reference levels have been selected at the lower level of the 1 to 20 mSv in a year range. Application of the Commission's system of radiological protection to existing exposure situations resulting from emergency exposure situations is discussed in detail in another Commission recommendation.

References

- IAEA 1988. The radiological Accident in Goiania. STI/PUB/815, IEAE, Vienna, 1988
- IAEA, 1996. International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, Safety Series No. 115. IAEA, Vienna (1996).
- IAEA, 2002, Preparedness and Response for a nuclear or radiological emergency, Safety Requirements, Safety Standards Series No. GS-R-2. IAEA, Vienna (2002).
- IAEA. Safety Guide GS-G-2.1
- IAEA. draft Safety Guide DS-44
- IAEA. Development of an extended framework for emergency response criteria. IAEA TEC-DOC-1432, IAEA, Vienna (2005)
- IAEA. One decade after Chernobyl: Summing up the consequences of the accident. IAEA/WHO/EC International Conference, IAEA, Vienna (1996)
- IAEA. Method for developing arrangements for response to a nuclear or radiological emergency. EPR-Method, IAEA, Vienna (2003)
- ICRP, 1991a. 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Ann. ICRP.
- ICRP, 1991b. Principles for intervention for protection of the public in a radiological emergency. ICRP Publication 63, Ann. ICRP.
- ICRP, 2005a. Protecting people against radiation exposure in the event of a radiological attack. ICRP Publication 96. Ann. ICRP 35(1).
- ICRP, 2005b. Prevention of high-dose-rate brachytherapy accidents. ICRP Publication 97. Ann. ICRP 35(2).
- ICRP, 2005c. Radiation safety aspects of brachytherapy for prostate cancer using permanently implanted sources. ICRP Publication 98. Ann. ICRP 35(3).
- ICRP 2006. Assessing Dose of the Representative Person for the Purpose of Radiation Protection of the Public, ICRP Publication 101, Ann. ICRP 36 (2)
- NEA 1987 The Radiological Impact of the Chernobyl Accident in OECD Countries
- NEA 1995 INEX 1 - An International Nuclear Emergency Exercise
- NEA 2000 Monitoring and Data Management Strategies for Nuclear Emergencies
- NEA 2001 Experience from International Emergency Exercises. The INEX 2 Series
- NEA 2006 Stakeholders and Radiological Protection: Lessons from Chernobyl 20 Years After
- United Nations. Sources and Effects of Ionizing Radiation. Volume I: Sources; Volume II: Effects. United Nations Scientific Committee on the Effects of Atomic Radiation, 2000 Report to the General Assembly, with scientific annexes. United Nations sales publication E.00.IX.3 and E.00.IX.4. United Nations, New York, 2000.
- Vargo 2000 The Chernobyl Accident: A Comprehensive Risk Assessment', ed. George Vargo. Batelle Press 2000

Annex A

Assessment of the contributions of different exposure pathway to the projected dose

(A1) Assessments of the contributions of different exposure pathway to the projected dose can be based on numerical calculations using state of the art radioecological models, which are readily available as part of decision support systems. The calculations require definition of a large number of input parameters. The most important ones are the characteristics of a release (total activity, nuclide vector, release height and duration), the characteristics of the release site (urban/rural, flat terrain/complex topography), the time of year of a release (summer/winter), the meteorological conditions (wind strength and direction, atmospheric stability), the distance between a release and the area where people need protection, the human dietary and consumption rates, etc.

(A2) The TG has performed a variety of calculations of this kind using standardised input parameters for all calculations in order to demonstrate the application of the new system. Unit source terms for some key radionuclides as well as complex source terms with a multitude of radionuclides which are typically used in risk assessment studies for NPPs have been used for this purpose.

(A3) The following Tables show the results for the radionuclides Co-60, Sr-90, I-131, Cs-137, Pu-239, as well as for “small release” (Sm_rel; nuclide vector which is characterised by the following cumulative fractions of the core inventory: Kr-Xe: 0.9, I: 2E-3, Cs: 3E-7, Te: 4E-6, Sr: 2E-7, Ru: 6E-10, La: 6E-8) and a “large release” (Lg_rel; nuclide vector which is characterised by the following cumulative fractions of the core inventory: Kr-Xe: 1, I_{org}: 7E-3, I₂-Br: 4E-1, Cs-Rb: 2.9E-1, Te-Sb: 1.9E-1, Ba-Sr: 32.E-2, Ru: 1.7E-2, La: 2.6E-3). It is evident from the results of the two tables that there are major differences in the contributions of the pathways considered (ingestion, inhalation, cloudshine, groundshine) to the total dose, which for the purpose of this presentation is normalised (100%). The main parameters are the radionuclides, the time of year, and the integration time after a release. For example, the main contribution of inhalation to the total dose is 100% in the case of Pu-239 (“winter”) whereas it is only 1% for a “large release (“summer”). The relative contributions to the normalised yearly dose change with time: for I-131 for example, ingestion would contribute about 72% to the total annual dose during the first 10 days after release and another 20% by the end of 3 months. Of course, the absolute values of the annual dose would be markedly different for unit releases of the radionuclides in the Tables. These differences have to be considered in an appropriate fashion in defining reference levels and in developing protection strategies in the planning state.

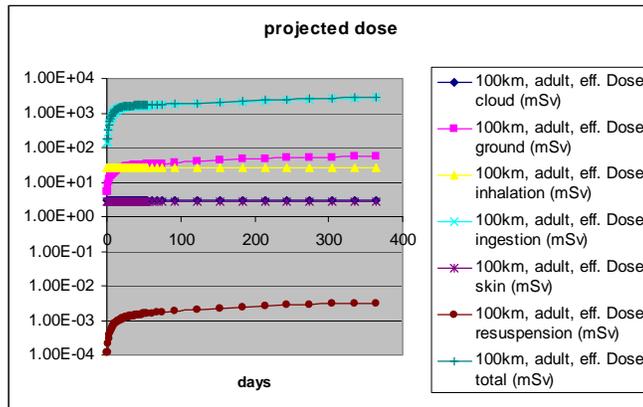
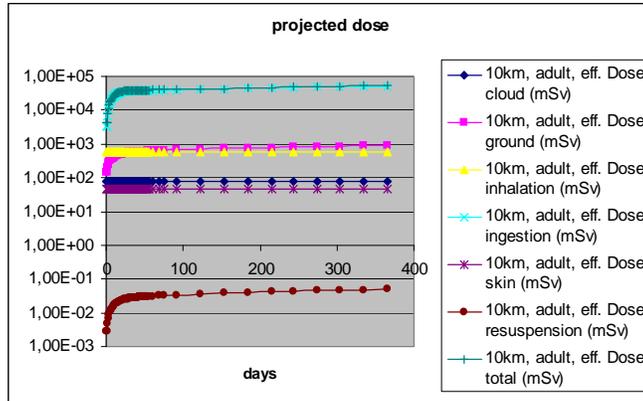
(A4) Characteristics in “summer” (release 1st July)

Pathway	Co-60	Sr-90	I-131	Cs-137	Pu-239	Sm_rel	Lg_rel
Ingestion:							
- 1 year	0,26	4,23	0,00	8,79	0,08	0,00	23,28
- 3 months	2,81	34,54	19,69	36,54	1,01	22,96	25,93
- 10 days	1,47	21,43	71,55	16,85	0,52	46,58	49,03
Inhalation	7,12	36,85	5,39	8,95	98,38	6,59	1,05
Ground:							
- 1 year	63,72	2,14	0,00	21,00	0,00	0,00	0,09
- 3 months	20,43	0,69	1,10	6,73	0,00	0,08	0,11
- 10 days	3,83	0,13	2,21	1,02	0,00	0,38	0,37
Cloud	0,37	0,00	0,04	0,11	0,00	23,39	0,14
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00

(A5) Characteristics in “winter” (release 1st December)

Pathway	Co-60	Sr-90	I-131	Cs-137	Pu-239	Sm_rel	Lg_rel
Ingestion:							
- 1 year	0,02	1,61	0,00	3,95	0,00	0,00	1,48
- 3 months	0,00	0,00	0,00	0,00	0,00	3,37	21,78
- 10 days	0,00	0,00	0,00	0,00	0,00	7,74	42,46
Inhalation	8,18	91,41	79,82	23,43	100,00	19,25	20,57
Ground:							
- 1 year	66,70	5,17	0,01	53,56	0,00	0,00	1,70
- 3 months	21,35	1,57	6,82	16,27	0,00	0,25	2,06
- 10 days	3,33	0,24	12,77	2,50	0,00	1,11	7,21
Cloud	0,42	0,00	0,59	0,28	0,00	68,28	2,75
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00

(A6) The results presented in the Tables represent the conditions in the vicinity of a release. As a result of various processes (dilution due to atmospheric mixing and deposition on ground surfaces) the dose resulting from an airborne release will decrease with increasing distance between the point of release and the area for which protective measures have to be planned. Therefore, it is important to include this into the considerations during planning. Fig A1 demonstrates this effect for distances of 10 km (top) and 100 km (bottom).



Literature

Ehrhardt, J. (1997) The RODOS System: Decision for Off-Site Emergency Management in Europe. Radiat. Prot. Dosim 73(1-4), 35-40

Ehrhardt, J. and Weiss, A. (2000) RODOS: Decision Support for Off-Site Nuclear Emergency Management in Europe. EUR 19144 EN, Luxembourg, European Community.

Annex B:

Characteristics of individual protective measures

Iodine Prophylaxis,

(B1) Iodine prophylaxis ('thyroid blocking' or 'iodine blockade') is the administration of a compound of stable iodine (usually potassium iodide) to prevent or reduce the uptake of radioactive isotopes of iodine by the thyroid in the event of an accident involving radioactive iodine. Stable iodine is only of benefit in protecting the thyroid against radioactive iodine (reactor emergencies resulting in the release of radioactive iodine, laboratory emergencies, malicious events involving radioiodine).

(B2) Thyroid blocking prevents dose to the gland in case of exposure by inhalation and ingestion of radioiodines. But as there is another measure that prevents radioiodine intake directly (restriction of potentially contaminated food consumption), thyroid blocking is considered to be primarily used for reduction of doses that result from inhalation. Iodine prophylaxis should only be used to reduce the uptake of ingested radioiodine if it is impossible to provide supplies of uncontaminated food, especially for children and particularly in relation to milk; even if this is the case, iodine prophylaxis is intended for relatively short periods of time, since efforts should be made to provide supplies of uncontaminated food as soon as possible.

As iodine prophylaxis is intended primarily as a protective measure against inhalation, it is therefore primarily a short term measure (up to a few days).

(B3) To obtain the maximum reduction of the radiation dose to the thyroid, stable iodine should be administered before any intake of radioiodine; otherwise, as soon as practicable thereafter. If stable iodine is administered orally within the six hours preceding the intake of radioactive iodine, the protection provided is almost complete; if stable iodine is administered at the time of radioiodine inhalation, the effectiveness of thyroid blocking is about 90%. The effectiveness of the measure decreases with delay, but the uptake of radioiodine can be reduced to about half if blocking is carried out within a few hours of inhalation.

Sheltering

(B4) Sheltering is the use of the structure of a building to reduce exposure from an airborne plume and/or deposited materials. Solidly constructed buildings can attenuate radiation from radioactive materials deposited on the ground and reduce exposure to airborne plumes. Buildings constructed of wood or metal are not generally suitable for use as protective shelters against external radiation, and buildings that cannot be made substantially airtight are not effective in protecting against any exposures.

(B5) Sheltering is not recommended for longer than around 2 days. Sheltering is easy to implement but in most cases cannot be carried out for long periods. In addition sheltering can be used as a preparation for an evacuation. The people in an area of potential risk can be instructed to "go inside" and listen to their radios for further instruction while preparations for evacuation are being made. However, for very severe reactor accidents sheltering in a typical home may not be sufficient to prevent deterministic health effects close to the facility. Sheltering is not a long

term protective measure, therefore monitoring must be performed promptly anywhere sheltering is used, to locate and evacuate people from areas of high risk.

Evacuation

(B6) Evacuation represents the rapid, temporary removal of people from an area to avoid or reduce short term radiation exposure in an emergency exposure situation. It is most effective in terms of avoiding radiation exposure if it can be taken as a precautionary measure before there can be any significant release of radioactive material.

(B7) Generally evacuation is not recommended for a period of longer than a few weeks.

Individual decontamination and medical intervention.

(B8) Individual decontamination is the complete or partial removal of *contamination* from a person by a deliberate physical, chemical or biological process.

(B9) Urgent individual decontamination may be advised to reduce exposures to external radiation from contamination on skin or inadvertent ingestion of such contamination. This measure may be particularly useful for protecting emergency workers. It is unlikely that individual decontamination will be required outside the area in which evacuation has been advised.

Preventative agricultural actions

(B10) Protective measures related to food can reduce or prevent doses from ingestion and include: a ban on the consumption of locally grown food in the affected area; the protection of local food and water supplies by, for example, covering open wells and sheltering animals and animal feed; and the long term sampling and control of locally grown food and feed. Control of milk is very important, because it is a significant part of the diet of children in many countries, as well as concentrating important radionuclides, such as radioiodine.

(B11) If appropriate, emergency plans should provide for considering the need for restriction of food consumption. Where they are needed the population should be instructed not to drink milk from cows or goats that have been grazing on potentially contaminated pasture. In addition, they should be instructed not to eat fresh vegetables, fruit or other food that may have been outside during the release and thereby contaminated. Drinking water is typically not a major concern during the early phase response unless it comes directly from collected rain water. However, water supplies should be regularly monitored during the response, in case of a gradual build up of contamination owing to run-off into the water catchment area. If implemented, food and water restrictions should continue until sampling determines that food or milk is not contaminated beyond established levels.

Annex C.

Specific Guidance for the termination of protective measures

(C1) Although some protective measures may remain in effect for long periods, almost all protective measures will eventually need to be terminated. Some protective measures, particularly some of those that are implemented during the early phase of an emergency exposure situation, will because of their nature (e.g. sheltering and use of stable iodine) be implemented for rather short periods (e.g. a on-off prophylactic of stable iodine or sheltering implemented for few hours to a few days). Other measures, for example food interdictions, may last for longer periods of time. However, there are substantial risks associated with precipitate decisions to terminate protective measures, before all the specific circumstances of the situation have been evaluated. For example, if protective measures are terminated too soon, the situation may worsen unexpectedly, resulting in further exposures. The need for evaluation of the specific circumstances of the emergency and potential future exposures, before taking decisions on lifting protective measures, means that it is difficult (or even potentially dangerous) to try to plan specific numerical guidance on this in advance. Therefore, the Commission has developed a framework to assist the taking of such decisions in real time.

(C2) The key problem for the decision makers is to balance the need to terminate unnecessary restrictions on people's lives with the need to ensure that the termination of protective measures does not expose them to unintended risks. This balance may vary between different population groups, and will be associated with considerable uncertainty. It may therefore be appropriate to treat population groups differently. Moreover, protective measures may be terminated at different times in different locations, as the required information on which to base the decision becomes available.

(C3) It may be appropriate to terminate protective measures for some groups of people, whilst continuing to recommend they be left in place for other groups. This may be required because of local 'hotspots' or due to the inhomogeneity of the detailed monitoring. Whilst there may be clear radiological justification for this approach to lift protective measures, the potential for increased anxiety and misunderstanding of the revised advice needs to be recognised and addressed.

(C4) Owing both to the passage of time and the possibility of scaling down the response, it is important for the decision makers to consider whether to replace existing protective measures with alternative ones. A prime example of this is sheltering. Sheltering can not be maintained for a long period of time. From a radiological protection perspective, the protection afforded by sheltering will decrease with time, as radionuclides increasingly penetrate from the outside into the building. People require access to food, medicines, exercise and the contact with other people. Therefore, at some point it will be necessary to discontinue sheltering, regardless of whether the release has stopped or not. At this point in time the decision maker has to consider whether to terminate the advice to shelter altogether or whether to replace it with alternative advice, such as evacuation.

(C5) Whilst every accident will have specific characteristics that influence decisions made on how and when protective measures would be withdrawn, it is possible to provide general guidance on issues that require consideration and evaluation before such decisions are taken. The following sections provide this guidance for the termination of protective measures implemented in the early phase, and the termination of those implemented in the intermediate and late phases.

Guidance on the termination of protective measures implemented in the early phase

(C6) The prime protective measures likely to be considered in the early phase are the administration of stable iodine, and advice to shelter or evacuate, and advice to avoid foods that might have become contaminated, until a measurement programme can provide the information necessary to give more detailed advice regarding food protective measures. The factors that require consideration for the termination of these protective measures differ between termination during the early phase, and termination after the early phase is over.

(C7) There will be no requirement to consider the termination of evacuation or early phase food advice until after the release has stopped. In the case of stable iodine, the decision is whether to advise a second administration of stable iodine, in the event of a release lasting more than one day, rather than whether to terminate this protective measure. In this situation, the Commission advises that, if the population would otherwise require a second administration, then every effort should be made to evacuate the population, until the cessation of the release. Sheltering, however, is different. It may well be necessary to terminate sheltering during the early phase, either because it is not possible to maintain the measure for an extended period of time, or because it is decided that the population should be evacuated. In these situations, it is particularly important to determine how both exposures and public anxiety and confidence will be impacted by the decision. Such decisions should be based on an informed understanding of the needs and concerns of the people affected, ideally, through dialogue with potentially affected population groups prior to any accident occurring. Such dialogue will assist in managing the expectations of those affected, so that sheltering followed by evacuation is expected. It will also inform decisions concerning how long sheltering can be maintained by different population groups, and whether specific support measures, such as the provision of emergency supplies, and re-uniting of families are practical alternatives to the early termination of sheltering.

(C8) Once the early phase has finished, there may well be very strong pressure to terminate all protective measures. However, it is important to fully evaluate the options and their likely consequences and to avoid making precipitate decisions. Decisions to withdraw sheltering, evacuation and food advice will need to reflect the prevailing circumstances of the emergency situation being addressed. Premature decisions to withdraw protective measures, before all the specific circumstances of the situation have been evaluated may result in further exposures, if the situation worsens unexpectedly. In general, protective measures implemented in the early phase will be withdrawn because they have achieved their desired effect, or their continued application will cause more harm than good (e.g. sheltering for an extended period becomes too disruptive). Many different aspects must be taken into account when reaching such decisions and as with all decisions regarding protective measure termination, it is important to involve, wherever possible, relevant stakeholders in discussions. While it will be difficult, if not impossible to discuss decisions with sheltered populations, it will be essential to discuss decisions to return to evacuated areas with those who have been evacuated. Non-radiological (e.g. economic, social and psychological) consequences may become worse than the radiological consequences if there is a lack of pre-established guidance that is understandable to the public and officials. In Tables C1 a-C1 d below the key issues that should be considered are summarised.

(C9) One key difference between protective measures implemented in the early phase and those implemented in the intermediate and late phases is that the former are likely to have been implemented on the basis of only limited information concerning the actual situation and its impact. By the time when no further release is judged likely, additional information will have been

gathered. This may well demonstrate the initial actions to have been an over-response, in which case there will be a strong incentive for those responsible for managing the response to reduce the extent and severity of protective measures as promptly as possible. However, even for these situations, it is important to ensure that the issues in Tables C1a-C1d are explored, to avoid the possibility of unexpected problems subsequently emerging.

Table C1 a 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	Ideally, establish a dialogue with sheltered population before any decision to lift the advice to shelter.
Health	Detailed information for all those affected is required for subsequent dose estimation and decisions on health follow-up programmes.
Stakeholders	Those affected need a mechanism to provide an input into decisions on the recovery strategy.
Order of priority	Decisions on continuing sheltering will normally be accorded the highest priority.

TABLE C1 b Checklist for terminating the advice to evacuate*

Issue	Comments/Considerations
Duration	Prolonged evacuation requires the provision of acceptable living conditions; many evacuation centres cannot provide such conditions. Supervised visits to the evacuated area in order to retrieve personal belongings or deal with animals left behind may reduce pressure for an early lifting of evacuation.
Release status	If a release occurs, the need to delay decisions on lifting of evacuation until a formal statement can be given that the release has definitely been terminated, means that emergency plans should assume that evacuation will last from several days up to perhaps a week.
Contamination	Priority should be given to monitoring those areas in which it is expected that withdrawal of evacuation can take place. Measurement results should be 'published' for access by the media and the public.
Information	It is important to establish a mechanism for direct information and dialogue with the evacuees prior to their return to the area.
Health	Detailed information for all those affected is required for subsequent dose estimation and decisions on health follow-up programmes.
Stakeholders	Those affected need a mechanism to provide input into decisions on the recovery strategy.
Order of priority	Low priority.

* It is important to distinguish between the admission of closely supervised people into an evacuated area in order to monitor, retrieve items, undertake maintenance activities or provide security, and the provision of advice to an evacuated population to return home. This table provides a checklist for consideration before full withdrawal of evacuation.

Table C1 c Checklist for deciding that further doses of stable iodine shall not be administered

Issue	Comments/Considerations
Duration	One dose of stable iodine will provide protection for around 24 hours. Normally, evacuation would be preferred to administration of a second dose. Where the potential for prolonged releases indicate that multiple administrations to a sheltering population may be required, the emergency plan should address how this will be achieved.
Release status	Multiple administrations shall not be considered unless a release is actually detected more than 24 hours after the first administration, and evacuation is not practicable.
Contamination	Ideally, stable iodine prophylaxis should not be used to provide protection against food contamination. Wherever practicable, food restrictions should be implemented to provide protection against intake by ingestion.
Information	Stable iodine prophylaxis should be combined with either sheltering or evacuation, and has the same associated needs for information provision.
Health	The thyroids of infants born shortly before or shortly after the accident should be individually monitored, if either the child or the mother received stable iodine. Details of all those who received stable iodine should be recorded, in case of subsequent health problems.
Stakeholders	Those affected need a mechanism to provide input into decisions on the recovery strategy.
Order of priority	The multiple administration of stable iodine is only relevant to a sheltering population, which would normally be afforded the highest priority.

Table C1 d Checklist for terminating early phase advice to avoid foods that might have been contaminated

Issue	Comments/Considerations
Duration	The precautionary measure of avoiding potentially contaminated foods, can generally be maintained for up to a few days. After this time the economic costs and, for some people, dietary needs, may start to become a major issue, and so the precautionary advice must either be terminated or legally enforced on the basis of a measurement programme.
Release status	It is not possible to advise termination until after the release has been terminated.
Contamination	Priority should be given to monitoring those areas in which it is expected that termination of the food advice can take place. Measurement results should be 'published' for access by the media and the public.

Guidance on the termination of protective measures implemented in the intermediate and late phases

There is an important difference between protective measures initiated in the early phase, and those implemented in the intermediate and late phases. The prime aim of early phase measures is to protect people from relatively high, short term exposures. Decisions on their implementation are likely to be taken in a context of significant uncertainty. In the intermediate and late phases, however, the situation will be much better characterised, whilst the protective measures put in place may well need to continue for weeks or months. These differences mean that, for intermediate and late phase measures, it is both possible and desirable to establish the criteria for terminating those measures in advance of initiating them. These ‘termination’ criteria should be defined in terms of directly measurable or observable quantities, so that it is clear when they have been met. The criteria should also be discussed and agreed with stakeholders, so that the termination of the relevant protective measures is accepted. For some measures, e.g. relocation, the criteria may be expressed in terms of the residual dose rates in the areas to be returned to, for others, such as decontamination, they are more likely to be expressed as the maximum level of residual contamination that will be accepted on the surface subject to a particular decontamination technique.

Protective measures implemented in the intermediate and late phases do not need to be initiated as urgently as those in the early phase. This means that more time is available for dialogue with those who will be affected in order to implement the measures in a way that is truly optimum for stakeholders. Whilst it may not be possible to meet the expressed priorities of every individual, the process, in itself, of involving stakeholders in decisions that are affecting their lives, can help to reduce anxieties and frustrations, and contribute towards an efficient transition to management of the situation as an existing exposure situation.