No 02:2024

Nordic Radiation and Nuclear Safety Series

Protective Actions in a Nuclear or Radiological Emergency

Nordic Guidelines

The Radiation Safety Authorities in Denmark, Finland, Iceland, Norway and Sweden

Foreword by Directors General

The Nordic countries – as neighbours and allies – have a long and successful history of cooperation in many areas. The task of the Nordic radiation protection and nuclear safety authorities is to protect people and the environment from harmful effects of ionising radiation. In pursuit of this mission, our organizations closely collaborate on matters related to emergency preparedness and response. The Nordic guidelines are the result of a joint project carried out by the Nordic Emergency Preparedness (NEP) group, providing an update and extension of the so-called Nordic Flag Book issued in 2001 and 2014.

Despite robust safety frameworks and preventive measures, we recognize the need to prepare for unlikely accidents. History has shown that a nuclear emergency in one country usually has an international impact. Therefore, planning for emergencies with cross-border implications requires effective international coordination.

While emergency preparedness and response is a national responsibility, it is firmly rooted in international regulations, conventions and recommendations. The Nordic guidelines harmonize our approach by incorporating the international standards for radiation protection during emergencies. These guidelines provide a starting point for the practical application of consistent public protective actions in our respective countries, enabling an efficient cross-border response.

We believe that these guidelines facilitate international cooperation and further increase our mutual understanding. By planning and responding collectively, we strengthen the resilience of the Nordic region in the face of emergencies.

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Protective Actions in a Nuclear or Radiological Emergency

Nordic Radiation and Nuclear Safety Series, Number 02:2024
Nordic Guidelines, Nordic Emergency Preparedness Group (NEP)

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Stockholm 2024

Cover designer: Inger M. Nergaard
ISBN number: 978-91-527-7462-5
ISSN number: 2000-0456

Preface

During a nuclear[1] or radiological emergency protective actions are implemented to reduce actual or potential exposure to radiation for workers and the public. In these Nordic guidelines, the radiation protection and nuclear safety authorities in the Nordic countries present a common view on how the internationally accepted radiation protection principles should be applied during a nuclear or radiological emergency, within the framework of national regulations. The guidelines build on the previous Nordic guidelines and recommendations published in 2014. Emergency preparedness and response has developed significantly over the last decade, e.g. with the implementation of Council Directive 2013/59/Euratom of 5 December 2013 (EU BSS Directive) as well as new or updated IAEA safety standards. These developments are reflected in the current version of the Nordic guidelines, together with experiences in the Nordic region.

These guidelines are based on the planning methodology for emergency exposure situations using reference levels, dose criteria and operational intervention levels. These concepts, and their application for the public and workers, are briefly described in an introductory chapter. Radiological criteria for protective actions and other response actions are presented based on the temporal sequence of phases of a nuclear or radiological emergency given by the IAEA. The guidelines are therefore divided into three parts: Part A for the urgent response phase, Part B for the early response phase, and Part C for the transition phase.

The main focus of the guidelines is on actions to protect the public in case of a nuclear or radiological emergency. All types of peacetime nuclear or radiological emergencies, irrespective of their cause, are covered. As a nuclear emergency can affect a large geographical area, the planning for responding to a nuclear emergency affecting more than one country in the Nordic region can be seen as the primary scenario for these guidelines. In particular protective actions being implemented across borders. Where appropriate, the guidelines instead refer to national planning and regulations.

The Nordic guidelines provide a common Nordic starting point for the practical application of protective actions for Nordic national authorities responsible for radiation protection in the event of a nuclear or radiological emergency. However, the actual handling of a nuclear or radiological emergency may deviate from the guidelines presented here, depending on the characteristics of a given situation and conditions which may differ between countries.

This publication has been developed by a working group from the Nordic radiation protection and nuclear safety authorities working under the Nordic Emergency Preparedness (NEP) group. It was approved by the Directors General of the Nordic radiation protection and nuclear safety authorities at the Nordic Chefsmöte in 2024.

These guidelines can also be referred to as the "Nordic Flag Book", represented by the Nordic flags on the cover page.

[1] A nuclear emergency refers to an emergency in a nuclear facility

Content

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Introduction

1. Scope

The Nordic guidelines apply for off-site preparedness and response for a nuclear or radiological emergency in peacetime, irrespective of the cause. They represent a common Nordic view on how the internationally accepted radiation protection principles apply in the Nordic countries, within the framework of national regulations.

The Nordic guidelines apply for the preparedness stage and emergency response, up until the transition from, and termination of, a nuclear or radiological emergency.

The guidelines focus on such protective actions and other response actions where there is a need for cross-border alignment within the Nordic region. This includes actions relevant to implement:

1. at larger distances from a facility (e.g. nuclear power plant), i.e. beyond the emergency planning zones; and
2. in the event of an emergency arising from activities and acts where the location is not known beforehand, such as nuclear powered vessels at sea.

Protective actions and other response actions that may be relevant during a nuclear or radiological emergency in the vicinity of the site, i.e. within the emergency planning zones, are also briefly described with references to national planning.

Guidance on crisis communication, medical response and management of radioactive waste are not within the scope of these guidelines. These topics are important but require different competences. They are therefore better covered in stand-alone guidelines.

2. Phases of a nuclear or radiological emergency

Response to a nuclear or radiological emergency starts by detection of conditions warranting an emergency response, whereby an emergency class is declared. The period of time between the declaration of the emergency until the emergency is terminated can be divided into several phases. The scope of these guidelines is radiation protection during a radiological or nuclear emergency which is covered by the concept of emergency exposure situation from ICRP [1]. IAEA divides the emergency exposure situation into two phases: the emergency response phase and the transition phase. The emergency response phase is in turn divided into an urgent response phase, which may last from hours to days, and an early response phase, which may last from days to weeks [2].

These guidelines comprise three parts covering: A) the urgent response phase, B) the early response phase, and C) the transition phase. The internationally accepted concepts used to describe the temporal sequences of a nuclear or radiological emergency and their relation to the three parts of these guidelines are illustrated in Figure 1.

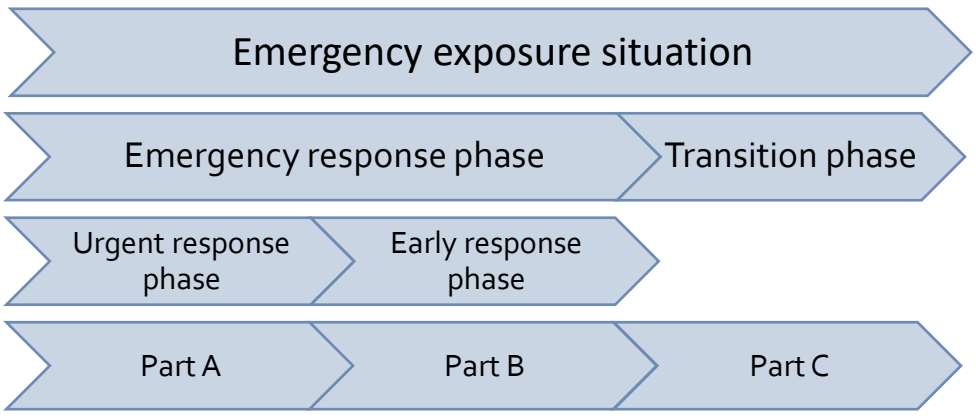

Figure 1. Illustration of phases during a nuclear or radiological emergency and the corresponding parts (A-C) of these guidelines.

3. Protecting the public and workers in emergency exposure situations

The goals for emergency response in a nuclear or radiological emergency are expressed in the IAEA General Safety Requirements, GSR Part 7 [3]. Some of the goals, such as saving lives, are generic and apply to all emergencies, whereas others are specific and only relevant for nuclear and radiological emergencies. In the latter category, the objectives to avoid severe deterministic effects and to reduce the risk of stochastic effects are fundamental goals of radiation protection.

The international system for radiation protection is based on three general principles: justification, optimization of protection and application of dose limits [1]. As dose limits do not apply in emergency exposure situations, ICRP has instead introduced the concept of reference levels, to be used in conjunction with optimization.

This section gives an overview of how the principles are applied in emergency exposure situations in order to reach the goals of emergency response. Emphasis throughout the Nordic guidelines are on common interpretation and application of these principles in the Nordic countries with a focus on cross-border consequences .

3.1. Justification

The ICRP states, "*any decision that alters the radiation exposure situation should do more good than harm"* [1]. Decisions that do more good than harm are thus justified. During a nuclear or radiological emergency, decision makers who may need to decide on emergency actions – i.e. protective actions and other response actions – must therefore ascertain that the benefits of reducing the risk of potential exposures offset the detriments of the associated action before making a decision. In practice, however, the need for timely decision-making requires that, as far as possible, it must be assessed in advance under which conditions a protective action can be considered justified.

As many emergency actions are disruptive to functions of society and individuals' lives, most of the detriments associated with the protective actions are non-radiological. Thus, for justification, all of these detriments, including societal and psychosocial, need to be balanced against the radiological and non-radiological benefits from emergency actions.

The following dose intervals can be used as guidance in determining if public protective actions or other response actions are justified during a nuclear or radiological emergency. If the projected effective dose is expected to be:

- above 100 mSv it is almost always justified to take emergency actions;
- above 10 mSv it is usually appropriate to take emergency actions; and
- between 1 and 10 mSv it may be appropriate to take emergency actions.

3.2. Optimization

Whereas justification produces a set of possible protective actions and other response actions, optimization is a tool to select an emergency action or a set of actions that will result in the best total result for a given situation. The ICRP defines optimization of protection as "*a process to keep the likelihood of incurring exposures, the number of people exposed, and the magnitude of individual doses as low as reasonably achievable, taking economic and societal factors into account*" [1]. In other words, optimization is a process for identifying the best possible protection for a given situation, which does not necessarily mean the solution with the lowest dose.

Reference levels during planning

The primary tool used in the optimization process at the preparedness stage for an emergency exposure situation is the concept of reference levels. The ICRP states "*…the reference levels represent the level of dose…, above which it is judged inappropriate to plan to allow exposures to occur…*" [1]. Reference levels are the basis of emergency response planning, formulating the overall aims in terms of doses that should not be exceeded during the emergency exposure situation. The reference levels refer to the total residual dose resulting from the emergency, either acute or, in case of protracted exposure, on an annual basis.

At the preparedness stage, the protection strategy and emergency arrangements for a certain scenario should therefore enable annual residual doses to be kept below the reference level for members of the public. When

evaluating a plan at the preparedness stage, the concept of representative person[2] is used. A plan leading to annual residual doses for a representative person in excess of the chosen reference level should not be adopted and a new or modified plan should be developed.

Reference levels are determined on a national level by each Nordic country. The recommendations from ICRP present a range for the reference levels for emergency exposure situations for the public of 20 – 100 mSv annual effective dose. The general reference level for the public in emergency exposure situations used in the Nordic countries is 20 mSv effective dose during the first year, with one exception:

- For emergencies arising from some events[3] at a Swedish nuclear power plant, the reference level for the public is 100 mSv effective dose during the first year.

Unless otherwise stated, the recommendations regarding emergency actions for the public in these guidelines are based on the reference level of 20 mSv effective dose during the first year for emergency exposure situations.

Reference levels during response

Once an emergency has occurred, the reference level has another function, as expressed by the ICRP: "*The reference level may then assume a different function as a benchmark against which protection options can be judged retrospectively.*" [1]

However, the ICRP stresses that the reference level should not be considered as a limit: "*The doses to be compared with the … reference level are usually prospective doses, i.e. doses that may be received in the future, as it is only those doses that can be influenced by a decision on protective actions. They* [the dose constraint or reference level] *are not intended as a form of retrospective dose limit.*" [1]

The doses received by the population affected by a nuclear or radiological emergency may include doses above the reference level, depending on the success of the implemented protection strategy. The practical benefit of reference levels during an emergency exposure situation as a benchmark is limited, as there will be no practical way of assessing the actual doses received early on. Rather, the reference levels have a role during emergency response in that they can aid in choosing the appropriate course of action for a particular scenario, if different options exist.

3.3. Dose criteria

A dose criterion is a value of radiation dose to an unprotected person which, when exceeded or likely to be exceeded during a specified period of time, in most circumstances will justify a particular protective action or other response action[4]. Dose criteria may be used as a support in emergency response planning and as a starting point for taking protective actions during emergency response. These guidelines therefore sets out dose criteria expressed as projected dose during a given period of time for the protective actions covered by the guidelines. The dose criteria may be expressed as effective dose, absorbed dose or equivalent dose to an organ or tissue. The dose criteria are not calculated but rather selected so that the reference level will not be exceeded.

Doses to be compared to the dose criteria are calculated using projected doses to a hypothetical individual that belongs to a more highly exposed population group without having extreme habits. Such an individual is referred to as a representative person [4]. For emergency preparedness and response purposes, a 1-year old child is usually a conservative choice as representative person. The prospective dose that the representative person would receive when staying outdoors without protection is then compared to the dose criteria. A protective action should be considered at latest when the dose criterion is exceeded or is anticipated to be exceeded. In a nuclear or radiological emergency, this means that if protective actions are taken when the dose criteria for each

[2] The concept of representative person is described below in the section on dose criteria.
[3] For postulated events deemed as so unlikely that they do not need to be taken into account when designing mitigation systems at Swedish nuclear power plants.
[4] Dose criteria is thus related to *generic criteria* used by IAEA [3]. While generic criteria express that protective actions should be taken dose criteria express that a specific protective or other response action should be taken.

protective action are anticipated to be exceeded, the residual doses should remain below the reference level once all protective actions have been implemented.

3.4. Operational intervention levels

To support the dose criteria, operational intervention levels (OILs) expressed in measurable quantities (e.g. dose rate, concentration, etc.) can be set at the preparedness stage for protective actions. The starting point during response is that when the operational intervention level for a particular protective action is exceeded or expected to be exceeded, the emergency action should be taken. Use of operational intervention levels can thus facilitate the management of the nuclear or radiological emergency response as it makes it easy to relate to a single protective action.

Operational intervention levels may be needed to implement protective actions in a timely manner. However, operational intervention levels do not necessarily ensure that the residual doses will remain below the chosen reference level as they only consider one exposure pathway. Furthermore, operational intervention levels may need to be revised during an emergency depending on the scenario to correctly correspond to the dose criteria, for instance due to radioactive decay.

Most dose criteria are expressed in effective dose, which means that e.g. the age of the representative person is considered when comparing projected doses with the dose criteria. Since effective dose cannot be measured directly, it is estimated using the operational quantity ambient dose equivalent, H*(10). This estimate is considered conservative, also for estimating effective doses to 1-year old children. When deriving OILs expressed in ambient dose equivalent rate such underlying assumptions should be considered to avoid excess conservativeness.

With these limitations in mind, operational intervention levels may be used in planning and during response to support the implementation of protective actions, as illustrated in Figure 2. These guidelines focus on dose criteria for protective actions, but also provide guidance on operational intervention levels, where appropriate.

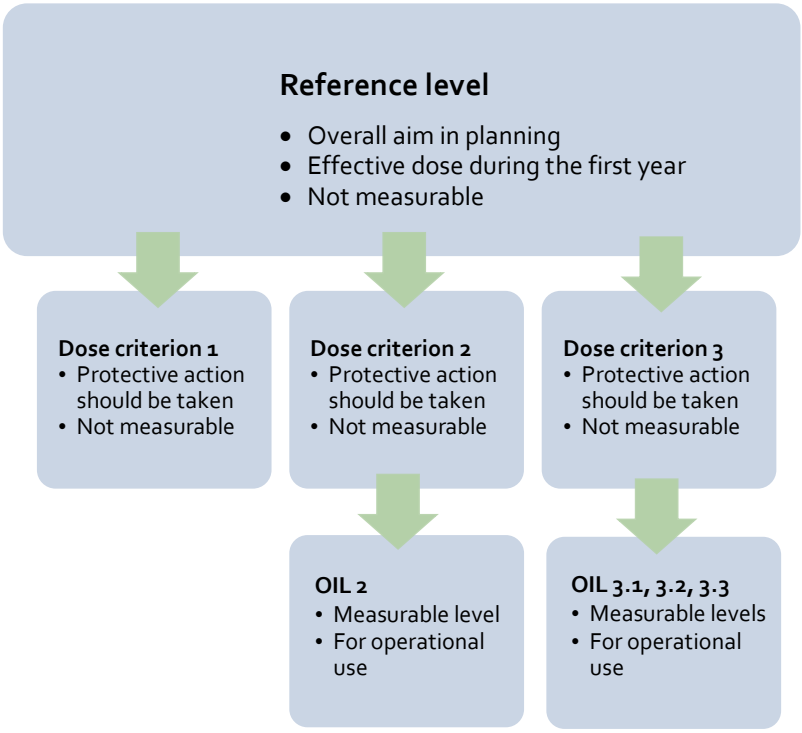

***Figure 2**. Illustration of planning methodology for emergency exposure situations using reference level(s), dose criteria and operational intervention levels. In order to keep doses below the reference level, a given protective action should be taken if the corresponding dose criterion is exceeded, or is anticipated to be exceeded, or if any of the corresponding OILs are exceeded. Adapted from [5].*

3.5. Protection strategy

Requirement 5 of GSR Part 7 states: "*Governments shall ensure that protection strategies are developed, justified and optimized at the preparedness stage for taking protective actions and other response actions effectively in a nuclear or radiological emergency.*" [3].

In order to achieve the goals of emergency response, protection strategies should be developed at the preparedness stage based on the hazards identified and the potential consequences of an emergency. Justification and optimization of a pre-defined set of emergency actions to be implemented in the urgent response phase is a vital part of the protection strategy. Selection of dose criteria and, where appropriate, derivation of operational intervention levels is also important for effective implementation of the protection strategy.

As the emergency evolves into the early response phase and eventually into the transition phase, more time is available to adjust the protection strategy, including the pre-planned emergency actions. With more time available, the range of prevailing circumstances and non-radiological factors that needs to be considered will increase. In these phases, adjustments of the protection strategy will likely be needed and should be part of the justification and optimization during the response.

3.6. Emergency workers

Workers could be identified and designated as emergency workers[5] in advance, for instance in an emergency response plan, but they could also be individuals given tasks during the emergency response by the appropriate response organization. Members of the public who help in the response may be classified either as emergency workers or as helpers[6]. In general, the requirements on protection of emergency workers designated from members of the public, such as helpers, are more extensive than for other emergency workers. The regulations

[5] Defined in EU BSS (COUNCIL DIRECTIVE 2013/59/EURATOM) as: "*any person having a defined role in an emergency and who might be exposed to radiation while taking action in response to the emergency*".
[6] Defined by the IAEA as: "*member of the public who willingly and voluntarily helps in the response to a nuclear or radiological emergency*" [3].

also protect vulnerable groups such as workers under 18 years of age and pregnant women (for protection of the foetus).

In both the EU BSS and IAEA GSR Part 7, there are requirements on justification and optimization of protection of emergency workers. There are also requirements on prior information and training of emergency workers designated in advance, especially information and training pertinent to the radiological hazards, as these are unique for nuclear or radiological emergencies. For helpers or emergency workers not designated in advance, such information or training needs to be given 'just-in-time'. There are also requirements on e.g. monitoring or assessment of individual doses. Furthermore, emergency workers who undertake actions where an effective dose above a certain value[7] might be exceeded must be volunteers.

Justification and optimization of protection

Justification and optimization (e.g. reference levels and their values) are determined on a national level by each Nordic country. In general:

- Emergency occupational exposures shall remain, whenever possible, below the values of the dose limits. If this is not feasible, the reference levels for emergency workers should in general be set below an effective dose of 100 mSv.
- Emergency occupational exposures in excess of 100 mSv are only justified under extreme circumstances. These are actions taken to: save lives, prevent development of serious disasters or prevent severe deterministic health effects.

Optimization of protection of emergency workers will be done using a graded approach that, among other things, will depend on the urgency of the actions to be taken and the information available. Hence, as the situation and the emergency response evolves from the urgent response phase towards the transition phase, the requirements on the protection of emergency workers will be more rigorous up to a point where the requirements are no longer that different from the ones used in a planned exposure situations. Once the emergency is declared terminated, occupational exposure of workers will be handled as a planned exposure situation.

Prior information and training

Emergency workers should have the procedures and equipment enabling them to work in a hazardous environment, e.g. outdoor work during an atmospheric release. However, in many cases the ordinary personal protective equipment and working procedures are sufficient to protect workers from contamination. Experience from past events has also shown that providing radiation protection training and information to emergency workers is essential for an effective emergency response. The risks associated with occupational exposure during an emergency should be understood and managed without introducing unnecessary delays or restrictions in the response.

Nordic context

The regulations for emergency workers differ among the Nordic countries. However, for the emergencies within the scope of these guidelines where emergency workers from different Nordic countries are foreseen to be working together, for example during international or bilateral assistance missions, national differences should not present a problem. This is mainly because doses to personnel, such as monitoring teams, are expected to be low and because the understanding of the situation with regard to possible occupational exposures will be significantly improved by the time international assistance takes place.

[7] In IAEA GSR Part 7 (§ 5.57) this level is 50 mSv effective dose, i.e. identical to the dose limit recommended by IAEA. In EU BSS (Article 53.3) the level is 100 mSv effective dose, i.e. not identical to the EU dose limit 20 mSv effective dose.

4. Factors affecting the choice of protective actions

In addition to actual or potential exposure to radiation, decisions on protective actions should also include the influence of other factors such as: potential adverse effects of the protective action, efficiency, timing, resources, waste management, surroundings, economy, social and ethical aspects, etc. A map of some of the other factors that may be relevant for decision makers to take into account in emergency response planning and, as appropriate, during an emergency is presented in Figure 3.

These factors may influence a decision on protective actions or other response actions. However, it is important to recognize that with limited time for e.g. stakeholder involvement during the urgent and early response phases these factors should already be taken into account at the preparedness stage. Planning and preparation, taking into account other aspects than potential exposure to radiation, would therefore result in a protection strategy that avoids unnecessary harm caused by the implemented emergency actions.

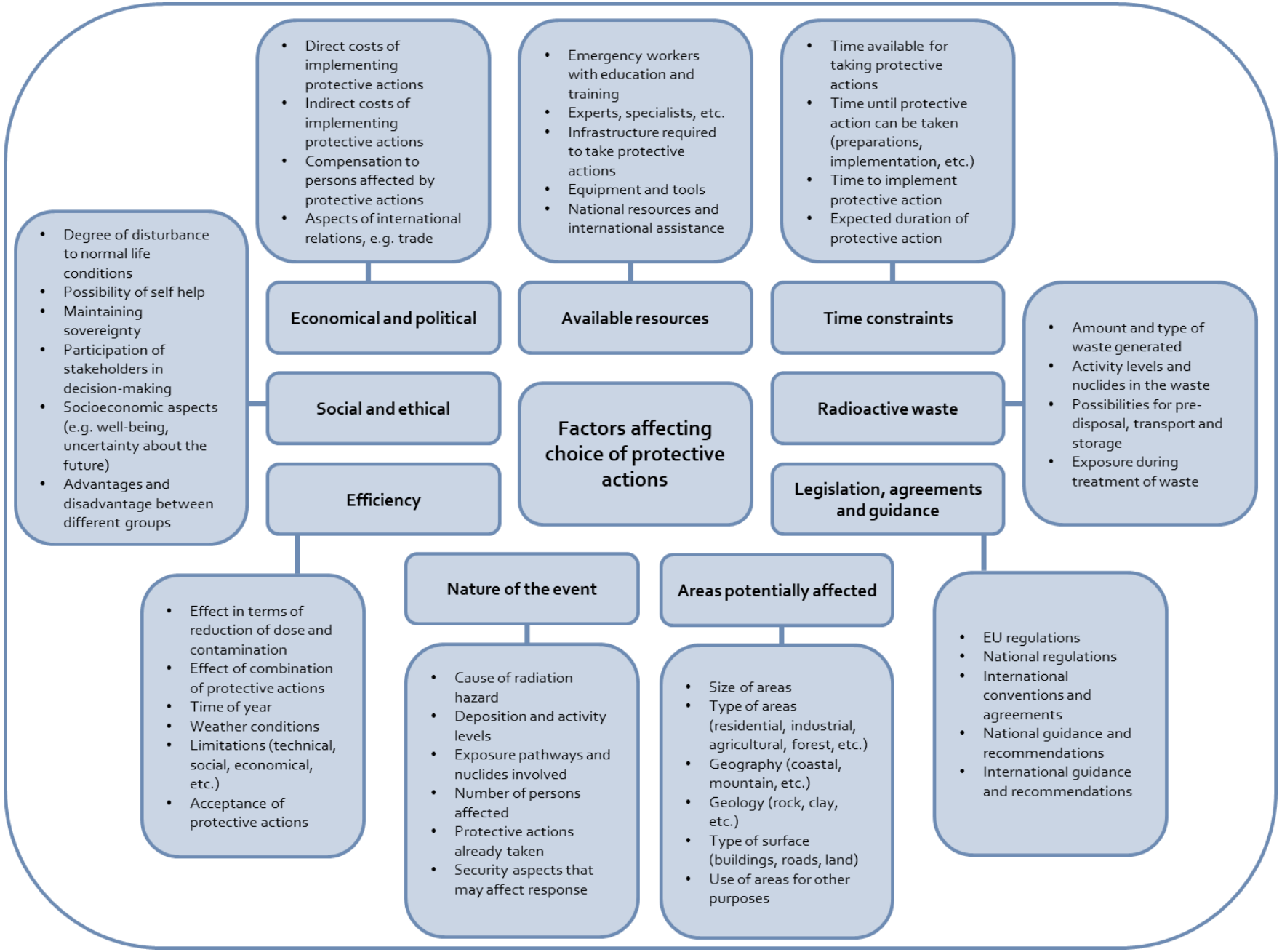

***Figure 3**. Other factors affecting protective actions.*

5. Public protective actions during nuclear or radiological emergencies

Protective actions are implemented during a nuclear or radiological emergency to reduce actual or potential exposure to radiation. In addition, other response actions that are not directly aimed at reducing the exposure may also be needed. Protective actions and other response actions can be summarized by the term emergency response actions, or simply emergency actions, and may possibly concern: members of the public, emergency workers, the environment, essential functions of society, industry and commerce, agriculture, food and feed production, water, and waste.

In the urgent response phase of an emergency, the emergency actions primarily focus on the population at risk and the critical functions of society. During the urgent phase, many of the emergency actions will be implemented based on triggers, such as declaration of a general emergency, or based on results of atmospheric dispersion prognoses. The relevant emergency actions to be considered during the urgent response phase of a nuclear or radiological emergency are listed in Figure 4 and further described in Part A of these guidelines.

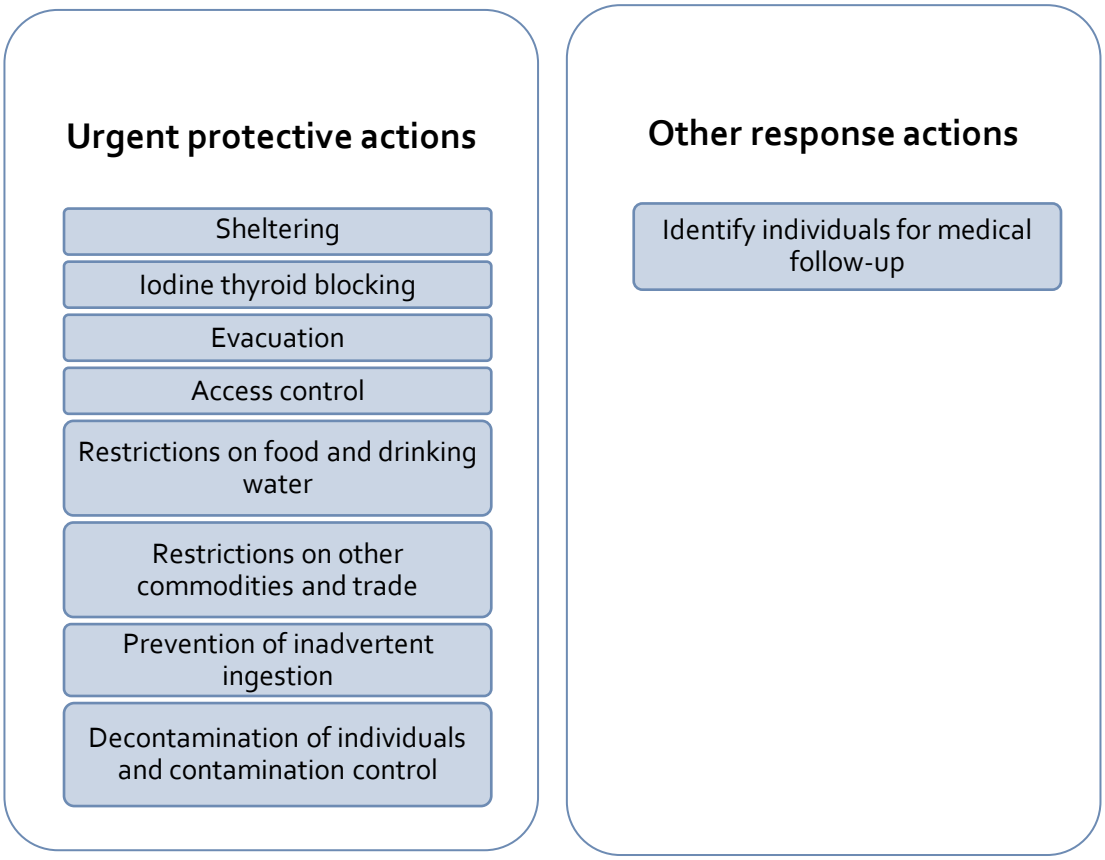

***Figure 4**. Protective actions and other response actions covered in these guidelines to be considered during the urgent response phase of a nuclear or radiological emergency.*

In the early response phase of an emergency, more time is available than in the urgent response phase and the uncertainties associated with the emergency are gradually reduced. The emergency actions applied in the urgent response phase are either continued, strengthened, relaxed or terminated, and new emergency actions may be introduced. During the early response phase of a nuclear or radiological emergency the emergency actions implemented will mostly be based on results from radiation monitoring. The relevant emergency actions to be considered in the early response phase of an emergency are given in Figure 5, and further described in Part B of these guidelines.

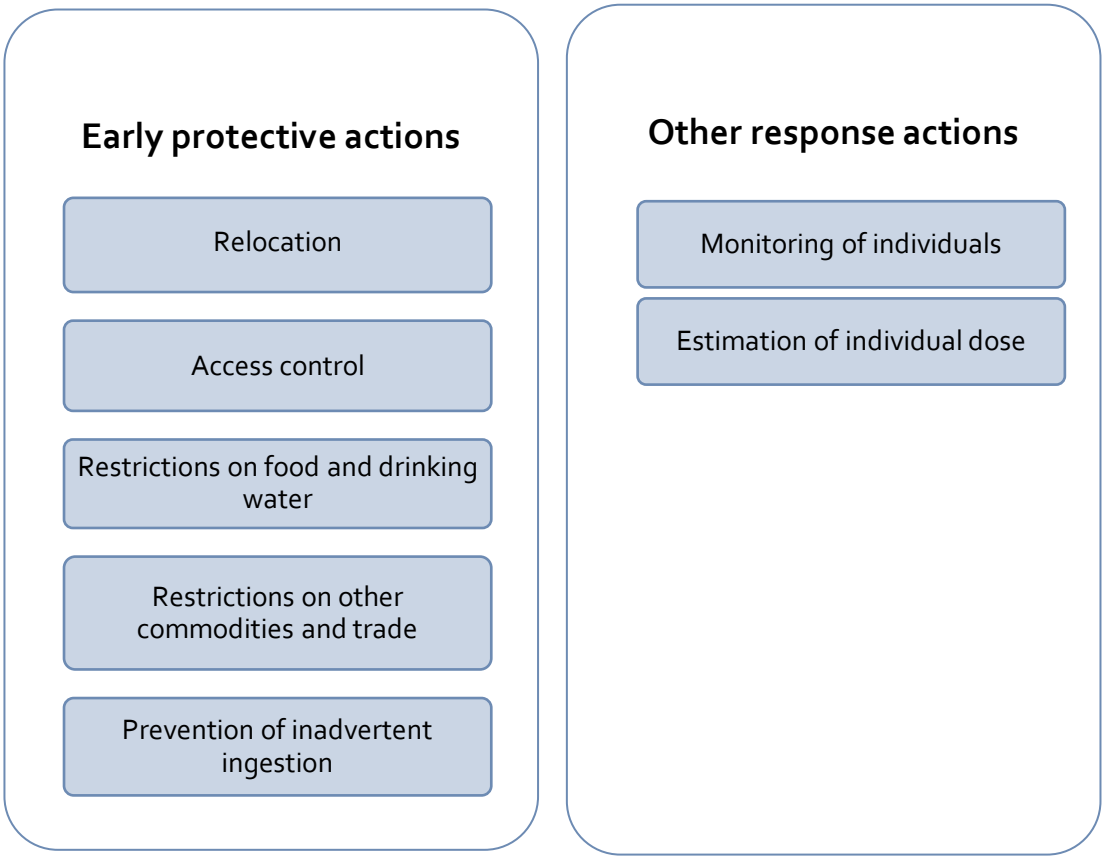

***Figure 5**. Protective actions and other response actions covered in these guidelines to be considered during the early response phase of a nuclear or radiological emergency.*

Other emergency actions than those listed in Figures 4 and 5, such as actions concerning the environment, keeping the public informed, providing medical care and psychosocial support and management of radioactive waste may also be implemented in the urgent or early response phases. These emergency actions are not within the scope of these guidelines. Apart from national plans and strategies for these actions, the Nordic countries have a joint manual [6], where co-operation regarding public communication is covered.

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Part A: The Urgent Response Phase

6. Public protective actions

The urgent response phase is defined by the IAEA [2] as "*the period of time, within the emergency response phase, from the detection of conditions warranting emergency response actions that must be taken promptly in order to be effective until the completion of all such actions*".

The protective actions and dose criteria presented in this chapter concern all nuclear or radiological emergencies. However, some of the protective actions are only relevant for nuclear or radiological emergencies involving a potential atmospheric release of radioactive materials. As the main focus of these guidelines is emergency actions within the emergency planning distances, public protective actions during nuclear emergencies within the emergency planning zones are described separately in section 6.9. The public protective actions relevant for radiological emergencies arising in places not known beforehand are described in section 6.10.

Depending on the emergency, a decision to implement public protective actions in the urgent response phase may be based on emergency class, dispersion and dose prognoses or monitoring results. The urgent response phase may last from hours to days.

6.1. Sheltering

Sheltering indoors reduces the inhalation of radioactive material dispersed in the air and limits the external radiation exposure. The effectiveness of sheltering depends on several factors such as building type, air filtration and exchange rate. In the area where sheltering is recommended, windows and doors should be closed and ventilation should be shut down where possible in all residential and office buildings as well as production facilities.

Depending on the scenario, the period that needs to be considered in dispersion and dose prognoses in order to cover the whole plume passage may vary. Typically, 2-7 days is enough to capture the release and passage of the plume for evaluation against the dose criterion.

Dose criterion for sheltering:

- 10 mSv effective dose during the time of plume passage.

The aim is to shelter before the exposure is expected to take place. The decision on sheltering must be made in a timely manner to provide adequate time for public information, preparation and implementation. Extended periods of sheltering are likely to lead to other problems. Depending on the individuals' needs and the prevailing circumstances, other protective actions should be considered instead if the need for sheltering is expected to last more than 24 – 48 hours.

6.2. Iodine thyroid blocking

During an emergency involving an atmospheric release of radioactive iodine, iodine thyroid blocking (ITB) can effectively prevent the accumulation of radioactive iodine in the thyroid gland. ITB is especially important for infants, children and pregnant or breast-feeding women because children and foetuses are more sensitive to radioactive iodine than adults are. Children and foetuses have higher uptake rates of iodine, and their thyroid glands are smaller, leading to higher tissue doses. Adults over 40 years of age are less likely to benefit from ITB. If there are not enough ITB doses available, infants, children (under 18), pregnant and breastfeeding women should therefore be given first priority. For some of the population groups that would benefit the most from ITB, a second intake is not an option and other protective actions would need to be considered instead [7].

ITB should not be considered as a stand-alone protective action but is generally recommended in combination with other protective actions such as evacuation and sheltering. ITB does not limit the exposure from other pathways. Protective actions related to the food chain and other forms of intake are discussed below.

Intake

The aim is to take ITB before the exposure is expected to take place. The optimal period of administration is less than 24 hours prior to, and up to two hours after, the expected onset of exposure. An intake would still have an effect up to eight hours after the onset of exposure, but not later than 24 hours after the onset of exposure [7].

Dose criteria for intake of pre-distributed ITB:
- 50 mSv equivalent dose to the thyroid gland for adults, and
- 10 mSv equivalent dose to the thyroid gland for infants and children (< 18 y).

Additional distribution

Given enough time, distribution of ITB within an area where ITB has not been pre-distributed could be considered during the urgent response phase before any significant releases have occurred. Depending on the national arrangements, the population size and geography of the affected area, additional distribution requires time to be arranged and could be problematic in combination with other protective actions such as sheltering. Therefore, the areas within the emergency planning distances where additional distribution of ITB could be considered may be delineated and prioritized by considering the dose criterion for intake. Areas where there is a risk of equivalent doses to the thyroid gland exceeding 50 mSv for the most vulnerable population groups should then be prioritized. The prioritized population groups are the same as described above: infants, children (under 18) and pregnant or breastfeeding women.

6.3. Evacuation

For facilities where an emergency could warrant public protective actions off site, emergency arrangements are in place in the form of emergency planning zones. Planning for emergency actions, including evacuation, within the emergency planning zones is described in section 6.9. Evacuation during nuclear or radiological emergencies arising in locations not known beforehand or affecting limited areas is described in section 6.10. Relocation during the early response phase is described in Part B of these guidelines.

6.4. Access control (large areas)

Access control is a protective action that either restricts entrance to a certain area except for absolutely necessary actions or that prohibits entrance to an area completely. Access control may be needed in large areas in situations where radioactive material has spread, is spreading, or may spread to a certain area. Access control restrictions may concern areas on land or at sea, airspace, specific facilities and the like.

During the urgent response phase, access control should be enforced in areas where the public has been evacuated to ensure that members of the public do not enter the evacuated area. Access control could also be used to limit access to an area where sheltering is recommended. No dose criterion is given in these guidelines for access control affecting large areas. Access control should instead be seen as a part of implementing and maintaining a decision on evacuation or sheltering.

Access control for limited areas is described in section 6.11.

6.5. Restrictions on food and drinking water

Dose criterion for restrictions on food and drinking water:
- 1 mSv effective dose during the first year.

Food and drinking water may be contaminated following an atmospheric release of radioactive substances to the extent that they are not suitable for trade or consumption. To protect consumers, i.e. members of the public, implementation of food restrictions may be needed during the urgent response phase.

In the context of protective actions for food and drinking water in a nuclear or radiological emergency, the term "restrictions" throughout this document refers to:

- Actions taken to protect the food chain and water supply systems from getting contaminated, or actions to reduce levels once contamination has occurred.
- Actions taken to limit individuals' ingestion of potentially or actually contaminated food and drinking water. This includes prohibition to market, advice against intake, and other dietary advice.

Both of the above are relevant in the urgent response phase. Actions to prevent contamination need to be implemented before deposition occurs. In such cases the estimated time of the release and expected arrival of the radioactive plume needs to be considered. Even though actions are taken to protect the food chain, precautionary prohibition to market certain types of food may be needed until activity levels in the food and drinking water have been shown to be below the maximum permitted levels.

In areas where the external dose rate does not exceed the normal radiation level, certain foods may still be contaminated at levels unsuitable for consumption or not allowed for trade. During the urgent response phase, where the radiological situation is still largely uncharacterized, it may be difficult to identify such areas. The authorities therefore have to provide advice and make decisions with due consideration of the limitations of available information.

Prohibition to market

Food, feed and drinking water containing radioactive contamination above specified maximum permitted levels will be prohibited from entering the market. To ensure that such products do not enter the market, it may be relevant in the urgent response phase to impose a precautionary prohibition to market certain foods in potentially affected areas. For a particular product, the prohibition in the urgent response phase is not based on actual measurements of activity levels but rather on the risk of exceeding the maximum permitted level.

During the urgent response phase, three types of products may need special attention due to the potential for fast transfer of radioactive substances to consumers:

- **Drinking water from surface water sources** contaminated by direct deposition on the water surface or at later stages in the processing [8, 9]. Shallow water supplies are particularly important to consider (cf. Table 1). Actions are most urgent if drinking water reaches consumers quickly.
- **Milk and other dairy products** where milk-producing animals graze on contaminated pastures or are given contaminated feed. Radioactive iodine, caesium and strontium are rapidly transferred from feed to end products.
- **Leafy vegetables and other foods** contaminated by direct deposition on edible plant surfaces. Leafy vegetables, such as lettuce, are particularly susceptible to high concentrations due to their large surface area in relation to weight.

These types of products may reach consumers within a few days. Leafy vegetables and milk are also highly susceptible to radioactive contamination (as evident from Table 1). Precautionary prohibition to market in potentially affected areas may therefore be needed until more detailed information is available (see also section 8.3). Ensuring safe drinking water is of vital importance. In cases where possibly contaminated drinking water can reach consumers within days, monitoring will be needed already during the urgent response phase to ensure acceptable levels.

The subject of maximum permitted levels is presented in more detail in section 8.3.

Advice against intake

For food not placed on the market, it may be relevant to issue advice against intake. This may be considered for specific types of food harvested or collected for personal consumption. Advice against intake is also relevant for certain private drinking water sources, for example rainwater or water from shallow surface sources.

Actions to prevent contamination

Possible actions to prevent (or reduce) radioactive contamination of food products include keeping animals indoors ("animal sheltering"), shutting off or reducing the ventilation if this can be done without endangering animal welfare, protecting feed already harvested, and covering cultivated crops. The time of the year will also affect the consequences of the radioactive fallout and which actions should be considered.

For milk and leafy vegetables, actions to prevent contamination in the urgent response phase are not likely to be enough to avoid prohibition to market. However, such actions may nonetheless facilitate recovery by reducing contamination levels and thereby shorten the duration of prohibition to market in later phases (c.f. section 8.3). Prohibition to market of drinking water may be avoided by switching to another water source, e.g., a ground water source.

References to more information on possible actions to prevent and reduce contamination is provided in Appendix 1.

Information available for decision-making

In the urgent response phase, decisions to impose restrictions on food will need to be made based on limited and uncertain information, e.g. results from atmospheric dispersion models and use of decision support systems.

Operational criteria in terms of deposition levels can be used in dispersion prognoses to identify areas where food and drinking water could be at risk of exceeding the maximum permitted levels, before monitoring data are available. The operational criteria in Table 1 provide a conservative starting point for the three categories of food products requiring special attention (see above) during the urgent response phase.

Table 1. Operational criteria where the EU maximum permitted levels in food and drinking water may be exceeded [9].

Product	Nuclide	Operational criteria (kBq/m^2)
Drinking water (surface source)	Cs-137 or I-131	100 (0,5 m dilution) 1 000 (10 m dilution)
Dairy products such as milk	Cs-137 + Cs-134 + Cs-136 Sr-89 + Sr-90 I-131	10 10 5
Leafy vegetables (or similar products)	Cs-137 + Cs-134 + Cs-136 Sr-89 + Sr-90	1 1

Additional food-chain transfer modelling (e.g., using FDMT[8]) may also be considered particularly in relation to potential contamination of meat (prognoses).

6.6. Restrictions on other commodities and trade

Dose criterion for restrictions on other commodities and trade:

- 1 mSv effective dose during the first year.

Prohibition to market

During an emergency, non-food commodities[9] put on the market or traded should have low levels of activity. Generally, the clearance or exemption levels for different non-food products in use before the emergency can be indicative of what is acceptable. The levels may still be in force and applicable also during an emergency.

[8] The terrestrial food chain and dose module used by the two standard European decision support systems ARGOS and JRODOS.

[9] I.e. products for sale to end-use consumers or to be traded with other businesses.

Commodities above these levels will be prohibited to market. The regulations may need to be adjusted, or new regulations may need to be put in place during the urgent response phase for (non-food) commodities.

To ensure that non-food commodities with unacceptable levels of contamination do not enter the market, it may be relevant in the urgent response phase to impose a precautionary prohibition to market for certain non-food commodities in potentially affected areas.

Advice against use

For members of the public, the advice on prevention of inadvertent ingestion also covers contamination from non-food commodities and trade, c.f. section 6.7.

Actions to prevent contamination

Commodities (raw materials[10] for production of non-food products) and products may become contaminated if not protected. Raw materials may be protected if it can be done in due time and with moderate costs. Factories and production facilities may be contaminated in the same manner as other indoor areas. In areas where sheltering is recommended windows, doors and vents should be closed and ventilation systems should if possible be shut off, whereby contamination of indoor areas and possibly production lines and products can be reduced.

6.7. Prevention of inadvertent ingestion

Dose criterion for prevention of inadvertent ingestion:

- 1 mSv effective dose during the first year.

Radioactive materials deposited on the skin, clothing or hair can lead to inadvertent ingestion, meaning that a person unintentionally gets the substance into their body. Radioactive materials may also be transferred to hands and skin when handling contaminated objects. This may also lead to inadvertent ingestion.

To reduce the risk of stochastic health effects from inadvertent ingestion, information is often a more effective measure than decontamination. A dose criterion is given to provide guidance on when information to prevent inadvertent ingestion may be necessary. Members of the public who may receive doses exceeding the dose criterion should be informed about measures they can take on their own. The information should include recommendations not to drink, eat, smoke, or keep hands near the mouth until hands are washed. Furthermore, it is recommended that activities that could result in the creation of dust that could be ingested or inhaled are avoided and that children avoid playing on the ground. The information should also include recommendations and information on how to avoid contamination from handling potentially contaminated objects in everyday life.

The need for information to prevent inadvertent ingestion may remain throughout the urgent response phase for members of the public living in affected areas where contamination may present a problem.

6.8. Decontamination of individuals and contamination control

Dose criterion for decontamination of individuals:

- 500 mSv equivalent dose to the skin.

Decontamination of members of the public would in some cases be needed to keep skin doses below the dose criterion. Possible events involve spread or spill of unsealed sources or exposure from airborne radioactive releases [10]. However, as the risks to health from skin contamination is small, decontamination of individuals should not delay other emergency actions, including treatment of injured patients [11]. For events involving an

[10] Raw materials such as wood, stone, peat etc. not used in food production.

atmospheric release of radioactive material such as nuclear emergencies, it is unlikely that skin doses to the public would exceed the dose criterion in areas outside of the emergency planning zones [12].

Skin monitoring and other types of contamination control may be arranged during the urgent response phase. Depending on national arrangements, contamination control may be performed in connection with organized decontamination of individuals or elsewhere. When conducting contamination control, one or several OILs should be used to identify individuals that may need follow-up actions. In order to reduce doses by removing contamination, individuals should first take a shower and change into clean clothes as soon as possible. Depending on the scenario, the monitoring equipment used and national arrangements, IAEA OIL4[11] and OIL8[12] [13] are generally conservative levels that may be used to identify individuals that may need further actions such as medical follow-up (c.f. section 7.1).

Regardless of whether organized decontamination of individuals and contamination control are arranged, self-help actions for the public affected by an atmospheric release should be recommended during the urgent response phase, preferable in connection with information on how to prevent inadvertent ingestion (c.f. section 6.7). Such information on self-decontamination should include advice on changing clothes, showering and washing hands before meals for the purpose of reducing exposure.

Furthermore, there may be non-radiological reasons to perform contamination control. For this purpose, skin monitoring, thyroid monitoring and other types of contamination control may be arranged to provide public reassurance and thereby mitigate the non-radiological consequences of the emergency.

6.9. Protective actions in the vicinity of nuclear facilities

Domestic arrangements for effectively taking urgent protective actions and other response actions are in place within the emergency planning zones around a number of facilities in the Nordic countries. Arrangements in the vicinity of such facilities are not within the scope of these guidelines but are briefly summarized below with references for further reading.

Nuclear power plants

The nuclear power plants in Finland and Sweden are surrounded by two emergency planning zones:

- A precautionary action zone (PAZ), extending about 5 km from the plant. Within the PAZ, arrangements for taking precautionary urgent protective actions are in place to avoid severe deterministic effects.
- An urgent protective action planning zone (UPZ), extending about 20-25 km from the plant. Within the UPZ, arrangements are in place to implement urgent protective actions and other response actions to reduce stochastic effects. The emergency actions are the same as described in these guidelines.

Further reading on national arrangements and protection strategy for nuclear emergencies can be found in [14], [15] (Finland) and [9], [16] (Sweden).

Of special importance to these guidelines are the 100 km extended planning distances (EPD) from the Swedish nuclear power plants Forsmark and Ringhals as these extend into Finland and Denmark, respectively. An emergency at a nuclear power plant in Finland or Sweden may also have consequences for the food chain and other commodities within the ingestion and commodities planning distance (ICPD). However, at such large distances (300 km from national borders) there are several nuclear power plants in Europe where an emergency could have similar consequences to any of the Nordic countries, save Iceland.

Other facilities

Apart from the nuclear power plants, other nuclear or non-nuclear facilities can have emergency planning zones or extended planning distances, depending on the type of facility. The protection strategies cover a range of emergency actions that are a subset of those described in these guidelines, depending on the outcome of the hazard assessment for the facility.

[11] OIL4 is defined by the IAEA as 1 µSv/h above background 10 cm from the bare skin of the hand or face
[12] OIL8 is defined by the IAEA as 0.5 µSv/h above background in contact with the skin in front of the thyroid

Several different facilities exist within the Nordic countries. They are summarized with references for further reading in Appendix 2.

6.10. Protective actions for emergencies where the location is not known beforehand

Protective actions such as evacuation, sheltering and decontamination of individuals may be needed in the urgent response phase of a nuclear or radiological emergency arising in a location not known beforehand. Examples of activities and acts that may lead to such emergencies are authorized transports of nuclear or radioactive material, nuclear powered vessels at sea and criminal acts using nuclear or radioactive material including acts of terror. The dose criteria presented above in these guidelines are valid also for these emergencies. However, evacuation during emergencies where the location is not known beforehand is described in this section as it needs special attention.

Large-scale evacuation

The objective of maintaining public exposures below the reference level in connection with a nuclear or radiological emergency where the location is not known beforehand can be reached by timely evacuation. The dose criterion is therefore identical to the reference level used in the Nordic countries for such events: 20 mSv effective annual dose. For evacuation in connection with an atmospheric release of radioactive material, the dose criterion refers to the first 7 days, while for evacuation due to radioactive material deposited on the ground the dose criterion refers to the first year. For emergencies where the location is not known beforehand it is unlikely that the dose criterion for large-scale evacuation will be exceeded in large areas, but the dose criterion can be used for planning purposes.

Dose criterion for large-scale evacuation:

- 20 mSv effective dose during the first year.

Evacuation of limited areas

In the urgent response phase, evacuation and access control will be the first choices for many radiological emergencies affecting a small area or a building as the number of individuals affected by the decision and the area to be evacuated is limited. It is generally easier and faster to evacuate a limited area than a large area and thus the threshold for when evacuation would be justified is lower, but strongly situation dependent. For limited areas, the emergency response planning should therefore be based on access control using initial radii for areas to be evacuated and operational intervention levels rather than dose criteria. An operational intervention level for evacuation of limited areas is given here, whereas recommended radii to be cordoned off are given in section 6.11 on access control.

Operational intervention level for evacuation of limited areas:

- 100 µSv/h ambient dose equivalent rate.

Notice! The external dose rate does not account for all pathways of exposure, and shall thus not be used as justification for downsizing the cordoned off area. Downsizing can be done when the radioactive material is known, the anticipated amounts of radioactive material in the air and the actual contamination of the area are known.

6.11. Access control (limited areas)

Access control to limited areas may be needed in a situation where radioactive material has spread, is spreading, or may spread within a limited area or due to external exposure to radiation from a radioactive source. The incident site – called the cordoned off area – should then be isolated to stop the public from entering. Table 2 provides indicative guidance on the size of the cordoned off area in response to radiological emergencies with radiation sources.

Table 2. Size of cordoned off areas during various radiological emergencies.

Radiological emergency outdoors	**Size of cordoned off area**
- unexploded or exploded radioactive dispersal device (RDD) (so-called dirty bomb) - fire or explosion (e.g. gas explosion), with a high-active radioactive source or an assumption of such a source	- 300 m radius
- a possibly high-active radioactive source, damaged or without shielding; no danger of explosion or fire - leaking, possibly high-active radioactive source; no danger of explosion or fire	- 30 m radius
Radiological emergency indoors	**Size of isolation area**
- damage of a possibly high-active radioactive source, loss of shielding or leaking of a liquid or gaseous radioactive source	- nearby spaces including the floors above and below, adjacent rooms - in case of leakage of a gaseous radioactive source, nearby spaces where radioactive gas may be dispersed, even the whole building
- possible melting down of a high-active radioactive source in a steel factory	- the furnace building, and the area where contaminated materials (products, slag, dust) exist

7. Other response actions for the public

7.1. Identify individuals for medical follow-up

Dose criteria for medical follow-up of internally exposed individuals:
- 100 mSv effective dose
- 100 mSv equivalent dose to the thyroid

As described in section 6.8, contamination control may be arranged for those individuals who have been in an area with significant airborne activity. The main reason to conduct contamination control is to identify individuals that may have received high internal doses due to inhalation of radioactive substances. Two dose criteria are given for when medical follow-up of internally exposed individuals is warranted. The first criterion relates to committed effective dose where further medical follow-up due to whole body exposure would be warranted. The second criterion relates to committed equivalent thyroid dose where medical follow-up due to inhalation of radioactive iodine would be warranted.

Population thyroid screening[13] should be avoided [17]. Instead, efforts should be made to establish a thyroid monitoring programme[14], i.e. offer higher-risk individuals medical follow-up based primarily on results from thyroid measurements. Due to the biological and physical decay of iodine, thyroid monitoring should be done as soon as possible, but no later than six weeks after inhalation of radioactive iodine. It is therefore reasonable to initiate measures or preparations already during the urgent response phase aiming at identifying individuals who will need further medical follow-up.

When conducting contamination control to identify individuals who need medical follow-up, the dose criteria should be translated to one or more operational intervention levels. IAEA OIL8 [13] may be used, as appropriate and depending on the monitoring equipment used. Individuals should have changed into clean clothes and taken a shower before monitoring is conducted to minimize influence from external contamination in the monitoring results.

Monitoring of members of the public could also be conducted for reassurance purposes. The capacity built up during the urgent response phase to identify individuals who need medical follow-up could also be used to comfort worried individuals. However, given the radiological importance of identifying individuals for medical follow-up, monitoring of worried-wells should not be a priority during the urgent response phase.

[13] Defined by the IARC as: "*… actively recruiting all residents of a defined area, irrespective of any individual thyroid dose assessment, to participate in thyroid examinations …*"

[14] Defined by the IARC as: "*… an elective activity offered to higher-risk individuals … with a thyroid dose of 100 – 500 mGy or more, who may choose how and whether to undergo thyroid examinations and follow-ups …*"

Part B: The Early Response Phase

8. Public protective actions

The protective actions and dose criteria presented in this chapter mostly concern nuclear emergencies with significant atmospheric releases affecting large areas, as the urgent and early response phases during a radiological emergency in many other cases will be difficult to distinguish from each other. The early response phase is described by the IAEA as: "*The period of time, within the emergency response phase, from which a radiological situation is already characterized sufficiently well that a need for taking early protective actions and other response actions can be identified, until the completion of all such actions*." [2]. The early response phase may last from days to weeks.

Depending on the emergency, a decision to terminate or implement additional public protective actions during the early response phase will most likely be based on actual conditions derived from radiation monitoring rather than pre-planned response. Compared with decisions on protective actions taken during the urgent response phase, decision-making on protective actions during the early response phase therefore generally involves reduced uncertainties and allows some degree of stakeholder involvement. All decisions need to be justified, and with more time available during the early response phase, there will be more time to optimize as compared to the urgent phase.

During the early response phase, the affected population should receive more detailed information from the authorities on projected doses and relevant actions in different areas. Even though it is still an emergency exposure situation, such information, along with information on how to reduce exposure, will allow individuals to gradually regain a higher level of control as well as more support in making informed decisions about everyday matters.

8.1. Relocation

Relocation is the temporary or permanent removal or extended exclusion of people from an area to avoid long term exposure from deposited radioactive material. Relocation should be considered in areas where results from radiation monitoring show that effective doses due to ground deposition exceeds the dose criterion starting from the end of significant releases up to one year from the onset of the emergency. The shorter the projected time to exceed the dose criterion is for a specific area, the higher the priority that should be given to relocating the population in that area. The goal is to finalize decisions on relocation within approximately one month from the end of significant releases.

Dose criterion for relocation:

- 20 mSv effective dose from the end of significant releases to one year from the onset of the emergency.

The dose criterion refers to external exposure from radioactive materials deposited on the ground. In Finland the 20 mSv effective dose criterion during one year considers termination of evacuation or (temporary) relocation. The Finnish dose criterion for (temporary) relocation is expressed differently[15]. However, the aim to keep residual doses to the public below 20 mSv during the first year after the end of significant releases is the same in all Nordic countries. Depending on national arrangements and criteria, including operational intervention levels, there are different ways to ensure that this aim is met.

Given that adequate protective actions and other response actions, including food restrictions and actions to prevent inadvertent ingestion, have been successfully implemented during the urgent phase and are maintained during the early response phase, the main exposure pathway during the early response phase for people living in areas affected by atmospheric releases will be external exposure from radioactive materials deposited on the ground.

[15] In Finland the dose criterion for (temporary) relocation is 10 mSv during a month, after the first month and taking remedial actions into account.

In the early response phase, it is important to separate doses received during the urgent response phase from calculated projected doses based on monitoring results. Doses received by the population during the release, for instance due to inhalation of radioactive material in the air, will be unknown or associated with large uncertainties. Projected doses calculated from a set time are compared to the dose criteria. Doses already received are therefore not considered in the comparison. For this reason, the integration time for the dose to compare with the dose criterion for relocation is expressed as starting from the end of significant releases to one year from the onset of the emergency.

Residents in areas with deposited radioactive material will have some degree of protection from normal indoor occupancy. As the projected doses to be compared with the dose criterion for relocation involve integration times ranging from weeks to a year, it is recommended to consider both occupancy and shielding factors in the dose assessment. The representative person should then no longer be an unprotected person but rather a person with representative living habits for the population in question. An occupancy factor of 80 % indoor stay combined with 60 % shielding when indoors results in an overall reduction of doses by about 50 %. Using 40 mSv for an unprotected person can therefore be a conservative choice when evaluating against the dose criterion. Planned protective actions such as decontamination may also be appropriate to consider in the evaluation.

Areas where external effective doses to the population during the first year are expected to be just above 20 mSv will require special attention. It may take weeks before a decision to relocate the population in an area can be taken. Remedial actions that are taken or planned, in particular environmental decontamination, may also affect the decision. In such cases it is foreseen that the decision on relocation will be strongly connected to the transition phase and the termination of an emergency, as described further in Part C of these guidelines.

8.2. Access control

In the early response phase, access control should be maintained in areas where the public has been evacuated to ensure that unauthorized persons do not enter the evacuated area. No dose criterion is given in these guidelines for access control affecting large areas. Access control should be seen as a part of implementing and maintaining a decision on evacuation.

As part of the adjustment of the protection strategy during the early response phase, relaxing or adjusting the access control might be warranted. For example, the radiological situation may allow for evacuated people to gain short-term temporary access to their homes or property. Short-term temporary access may be considered only when the radiological situation is sufficiently well characterized, most likely towards the end of the early phase. An example is the decision to allow access to restricted areas to evacuate pets and livestock during the Fukushima-Daiichi accident in Japan [18].

8.3. Restrictions on food and drinking water

Dose criterion for restrictions on food and drinking water:

- 1 mSv effective dose during the first year.

For definition of the term "restrictions" in the context of protective actions on food and drinking water in these guidelines, see section 6.5.

Prohibition to market

Once the European Commission has official information on a nuclear or other radiological emergency that is likely to lead to or has led to significant radioactive contamination of food and feed, regulations on maximum permitted levels[16] of radioactive contamination in food and feed to be placed on the market will be implemented. These values are based on a reference level of 1 mSv in the first year. National competent

[16] Council regulation (Euratom) 2016/52

authorities will decide whether the maximum permitted level for liquid food should also apply to drinking water in their respective national regulations. The maximum permitted levels[17] are presented in Table 3.

As described in section 6.5, it may be necessary to impose a precautionary, general prohibition to market food, feed and drinking water from certain areas in cases where the final products may exceed the maximum permitted levels. Such prohibitions may need to apply until the products have been shown to be below the maximum permitted levels.

While dispersion prognoses are used during the urgent response phase to identify areas where food and drinking water are at risk of exceeding the maximum permitted levels, the restrictions enforced during the early response phase will be based on monitoring data for products as soon as such data is available. Initially, measured dose rates from the ground (e.g., using IAEA OIL3[18] [13]) or deposition data of specific radioactive substances (cf. Table 1) can be used until contamination levels in food and drinking water have been adequately characterized.

For situations in which food and drinking water are at risk of exceeding the maximum permitted levels of radioactivity, actions to prevent or reduce radioactive contamination should be considered (see below).

If the EU implements regulations according to Euratom 2016/52, existing national and EU[19] regulations on radioactive contamination in food following the Chernobyl accident (or other relevant regulations) will be suspended.

Table 3. Maximum permitted levels for radioactive contamination in food in Euratom 2016/52. The maximum permitted levels applied to each isotope group should be treated independently. See Euratom 2016/52 for more details.

	Activity concentration (Bq/kg)		
Isotope group	**Infant food[a]**	**Dairy produce and liquid food[b]**	**Other food except minor food[c]**
Sum of isotopes of strontium, notably Sr-90	75	125	750
Sum of isotopes of iodine, notably I-131	150	500	2 000
Sum of alpha-emitting isotopes of plutonium and transplutonium elements, notably Pu-239 and Am-241	1	20	80
Sum of all other nuclides of half-life greater than 10 days, notably Cs-134 and Cs-137[d]	400	1 000	1 250

[a] Food intended for the feeding of infants during the first 12 months.
[b] Values are calculated taking into account consumption of tap-water and the same values could be applied to drinking water supplies at the discretion of competent authorities in Member States.
[c] Maximum permitted levels for a defined set of minor foods are ten times higher.
[d] Carbon-14, tritium and potassium-40 are not included in this group.

Euratom 2016/52 also includes maximum permitted levels of caesium-134 and caesium-137 in feed to be placed on the market (Table 4), to contribute to the compliance with maximum permitted levels for food.

[17] The period of validity of implementing regulations shall be as short as possible. The duration of the first implementing regulation following a nuclear accident or any other case of radiological emergency shall not exceed 3 months. Implementing regulations shall be periodically reviewed by the Commission and, if appropriate, amended.
[18] IAEA OIL3: Ambient dose rate of 1 μSv/h (above background) at 1 m above ground level
[19] Commission Implementing Regulation (EU) 2020/1158.

Table 4. Maximum permitted levels for radioactive contamination in feed (caesium-134 and caesium-137).

Feed for	Activity concentration in feed[a,b] (Bq/kg)
Pigs	1 250
Poultry, lambs and calves	2 500
Other	5 000

[a] These levels are intended to contribute to the observance of the maximum permitted levels for food; they do not alone guarantee such observance in all circumstances and do not lessen the requirement for monitoring contamination levels in animal products destined for human consumption.
[b] These levels apply to feed as ready for consumption.

Codex guideline levels for radionuclides in food moving in international trade following a nuclear or radiological emergency are described in Appendix 1.

Advice against intake and other dietary advice

For food not placed on the market, national authorities should consider issuing advice against intake for specific types of food that are harvested or collected for personal consumption, as well as drinking water from certain private drinking water sources. In addition, it may be relevant in the early response phase to issue other dietary advice to limit consumption of certain products or to perform specific actions to prevent or reduce contamination.

Actions to prevent and reduce contamination

Decisions to implement actions to prevent or reduce contamination may still depend on monitoring data, which initially will be limited (as described above). For actions that are not very urgent, and are considered invasive, it may be best to wait until more knowledge is available before making a decision.

A range of possible actions may be relevant, depending e.g. on the type of product, the extent of contamination and time of year. Some actions implemented to reduce contamination in the urgent phase (c.f. section 6.5), may continue to be appropriate in the early phase.

See Appendix 1 for references to more information on actions to prevent and reduce radioactive contamination in food, feed and drinking water.

Monitoring of contamination levels

In order to place food on the market and depending on national arrangements, producers and/or national authorities need to show that activity concentrations in food products do not exceed the maximum permitted levels. During the early response phase, more information will be available on the radiological situation in different areas. Based on this characterization authorities with responsibilities concerning food, feed or drinking water should consider which requirements are needed and what actions can be taken to verify activity levels in different types of foods.

Measurements of activity content in food, feed and drinking water will likely be a vital part of this assessment. The analytical capacity will initially be limited but is likely to increase gradually to meet the requirements. Apart from the measurements, authorities with responsibilities with regard to food, feed or drinking water may also need to conduct analyses to verify that the routines and methods used are working as intended. Documentation and certification are likely to be of great societal or economic importance, even if levels are assumed to be low. This may be the case e.g. with drinking water or important export foods.

In the early response phase, food basket studies or other programmes to assess the effectiveness of food restrictions may be initiated by authorities with responsibilities with regard to food, feed or drinking water. These programmes may be accompanied by whole body monitoring programmes to verify the effect of the food

restrictions by estimation of committed effective doses in certain groups or individuals, as described in section 9.1.

8.4. Restrictions on other commodities and trade

Prohibition to market

Also during an emergency, non-food commodities put on the market (or traded) should have low levels of activity. As for food, the levels imposed during the urgent response phase to put non-food commodities on the market (including trade) will be kept during the early response phase. Acceptable contamination levels will likely be close to exemption or clearance levels to maintain public trust. With more time, adjustments of certain levels may be done if necessary. Gradually, the monitoring and analytical capacity of producers will be built up to meet the requirements. This process is likely to continue, and the capacity improve throughout the early response phase. Furthermore, verifications will be easier to conduct as the short-lived radionuclides decay.

As for food, authorities with responsibilities with regard to commerce and trade as well as radiation protection need to verify the methods and routines used. Documentation and certification are likely to be of great societal or economic importance, even if levels are assumed to be low. Market mechanisms such as consumers' demand or producers' efforts to maintain the trust of the public may become important factors in the response.

Overall, the doses to the public and workers from commodities and trade are expected to be very low and comparable to the levels before the emergency.

Advice against use

For the public, the advice against intake from non-food commodities and trade will be part of the information on how to prevent inadvertent ingestion, c.f. section 8.5.

8.5. Prevention of inadvertent ingestion

Dose criterion for prevention of inadvertent ingestion:

- 1 mSv effective dose during the first year.

The information on how to prevent inadvertent ingestion of radioactive material that started during the urgent response phase should continue and be duly adapted during the early response phase. While the information initially focussed on how to avoid inadvertent ingestion of radioactive materials in the air deposited on an individual's body or clothes, focus should now be redirected to inform people living in areas with radioactive materials deposited on the ground. Therefore, the advice should primarily focus on good hand hygiene, i.e. to continue washing hands before meals.

Other important information could be advice on when and how to clean one's home, i.e. simple activities or measures that can be taken to avoid spreading of radioactive materials from the outside to the indoor environment.

As with all protective actions during the early response phase, it is important to adapt the information based on information from radiation monitoring. Relaxing, lifting, or intensifying the information to the public in a certain area will be possible, as the radiological situation is better understood.

9. Other response actions for the public

9.1. Monitoring of individuals

The importance of quickly establishing a thyroid monitoring programme is described in section 7.1. Even if planning and arrangements for thyroid monitoring are initiated during the urgent response phase, it is likely that thyroid monitoring will continue into the early response phase. Groups of the population that may have received different thyroid doses during the release should be identified based on dispersion prognosis, monitoring results and occupancy during the release.

Assuming there is no need for medical treatment (which cannot be ruled out within the emergency planning zones), first priority should be given to identifying individuals who will need further medical follow-up (section 7.1), i.e. individuals who may have received more than 100 mSv equivalent dose to the thyroid. Next, to estimate individual health risks, individuals who may have received more than 10 mSv equivalent dose to the thyroid should be identified and included in the monitoring programme. Such a programme could also reassure worried individuals who may have been exposed to radioactive iodine in connection with the release. Infants, children and pregnant women should be given priority when setting up the monitoring programme.

Apart from thyroid monitoring, a whole-body monitoring programme should be established to estimate individual effective doses received by intake of radioactive material after significant releases have ended. Whole-body monitoring should primarily be conducted to monitor whether food restrictions and information to prevent inadvertent ingestion work as intended. Whole-body monitoring should therefore primarily be conducted in areas affected by these actions. Since such actions – especially food restrictions and monitoring of activity levels in food – can be expected to continue for a long time, whole-body monitoring can turn into long-term actions such as a control programme to follow up intake via food (particularly caesium).

The capacity for monitoring of individuals with internal contamination built up during the urgent and early response phases could also be used to comfort worried individuals. However, monitoring of worried-wells should not be a priority.

9.2. Estimation of individual dose

The importance of quickly establishing a thyroid monitoring programme is described in section 7.1 and the possible prioritization of different exposed groups is presented in section 9.1. Once results from thyroid monitoring are available, they can be combined with occupancy information on an individual level to assess individual thyroid doses. Since the aim of such dose estimations are to assess health risks for individuals and evaluation of health risks to representative groups of the population, they are part of the medical response and not further described in these guidelines.

As described in section 9.1, a whole-body monitoring programme should be established. Estimation of individual effective doses received by intake of radioactive material via food and drinking water or by inadvertent ingestion should be conducted based on the monitoring results. Effective doses from food and drinking water are expected to be low if food restrictions are working as indented. The risk to health will therefore also be low. Establishing a whole-body monitoring programme and estimation of individual effective doses to certain representative groups of the population will be the responsibility of other actors than the health services. Once initial estimates have shown that doses are low, i.e. in line with the criteria presented for food restrictions and inadvertent ingestion (1 mSv/y) in sections 8.3-8.5, the programme may turn into a long-term programme to follow up intake via food. Experiences in the Nordic countries from the Chernobyl accident have shown that many actors, including representatives of the population groups monitored, will need to be involved in setting up and maintaining such a programme.

10. Termination of protective actions

Some protective actions are only relevant in a certain phase of a nuclear emergency. Recommendations concerning the termination of protective actions, regardless of whether they are urgent or early protective actions, are summarised in this chapter.

Protective actions can be terminated at different times and in different areas during an emergency. One of the main factors affecting the termination of a protective action is how long time it can continue. For example, an extended period of sheltering is likely to lead to other problems, such as upholding health care. During the urgent response phase, additional factors connected to the termination of a protective action are to a large degree the same factors that will trigger the protective action to be taken, notably; the alarm level and whether there has been a release and the possibility for new releases. In the early phase, the termination of protective actions is also governed by how long they can continue but will in addition be based on results from radiation monitoring and limited stakeholder involvement.

Evacuation and relocation

Evacuation or relocation can be terminated in a specified area if the annual effective dose due to exposure from deposited radioactive material can be kept below 20 mSv taking effects of remediation into account.

Dose criterion for terminating evacuation or relocation:

- Below 20 mSv effective dose during one year, taking remedial actions into account.

In case of a nuclear emergency large areas can be affected by deposited radioactive material. For areas that are within the scope of these guidelines, i.e. outside of the emergency planning zones, the recommendations and reasoning concerning relocation in section 8.1 will also be relevant for terminating evacuation.

Sheltering

Sheltering can be terminated in a specified area when significant releases no longer affect or may affect that area. Termination of sheltering can be followed by recommendations for the public on actions limiting radiation doses, e.g. temporarily restricting the time spent outdoors. Following the termination of sheltering, the premises should be ventilated to reduce the concentration of radioactive materials in the indoor air.

As mentioned in part A (section 6.1) extended periods of sheltering are likely to lead to other problems. Sheltering may then have to be terminated and other urgent protective actions, notably evacuation, should be considered instead.

Iodine thyroid blocking

Additional and complementary distribution of ITB should be terminated upon declaration of a general emergency. As mentioned in section 6.2, a second intake of ITB would be associated with difficulties. Therefore, if more than 24 hours have passed since intake of ITB was recommended in a specified area outside of the emergency planning zones and given that ITB would still be warranted, other protective actions such as sheltering (without ITB) should be considered as an alternative to repeated intake of ITB.

Information to prevent inadvertent ingestion

Actions to prevent inadvertent ingestion can be terminated in a specified area based on results from radiation monitoring.

Decontamination of individuals and contamination control

Advice on decontamination of individuals (self-decontamination) can be terminated in a specified area when significant releases no longer affect or may affect that area.

Restrictions on food and drinking water, or other commodities and trade

Actions to prevent contamination of food and drinking water and or non-food commodities can be terminated in a specified area when significant releases no longer affect or may affect that area.

Other restrictions on food and drinking water or non-food commodities can be terminated in a specified area based on results from radiation monitoring and dose assessments to representative persons. Restrictions and recommendations for food and drinking water or non-food commodities can also be turned into long-term actions, such as a control programme for food put on the market.

Access control

Enforcing access control should be seen as a part of implementing and maintaining a decision on evacuation or sheltering. Therefore, no specific criterion for terminating access control are given here.

Monitoring of individuals

Thyroid monitoring can be terminated when it is no longer possible to measure iodine activity in the thyroid at a level corresponding to the priorities for thyroid monitoring presented in section 9.1, i.e. 100 mSv and 10 mSv equivalent dose to the thyroid.

As experience from the Chernobyl accident in the Nordic countries shows, whole-body monitoring can turn into long-term actions such as a control programme to follow up intake via food.

Estimation of individual dose

Estimation of individual thyroid dose can be terminated when refined dose estimations or thyroid monitoring no longer are meaningful. Estimation of individual effective dose can be terminated or turned into a long-term control programme when effective doses are shown to be low and decreasing.

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Part C: The Transition Phase

11. Transition and termination

Part C of these guidelines focuses on overarching issues concerning the transition and termination of an emergency exposure situation following a nuclear emergency with significant atmospheric releases affecting large areas. For other emergencies without atmospheric releases of radioactive material, e.g. emergencies affecting limited areas as described in 6.10 and 6.11, the early phase and the transition phase will be difficult to distinguish from each other. Considering these phases will then be of limited use in emergency preparedness and response if the emergency exposure situation can be terminated swiftly.

The transition phase is defined by the IAEA as: "*the period of time after the emergency response phase when (a) the situation is under control, (b) detailed characterization of the radiological situation has been carried out and (c) activities are planned and implemented to enable the emergency to be declared terminated*" [2].

The exposure situation in the transition phase is still an emergency exposure situation even though the emergency response phase (i.e. the urgent and early response phases covered in part A and B of these guidelines) is over. A clear distinction between the early phase and transition phase will not be possible. The main difference between the phases will be better information on the radiological situation during the later phases. More information, together with additional time in the transition phase, will allow for further involvement of different stakeholders and optimization.

11.1. Remediation

Remediation includes actions reducing the exposure in areas affected by ground contamination, either through actions directed at the ground contamination (decontamination actions) or through actions that change the exposure pathways from the ground contamination. In the transition phase, both aspects of remediation can be effective to prevent or reduce exposures, i.e.:

- Removing or reducing the magnitude of the ground contamination; or
- Information or restrictions to change habits or behaviour, thereby limiting possible exposures of the population living in areas with ground contamination.

Remediation should be initiated as soon as possible during the transition phase. As described in Part B of these guidelines (section 8.1) a decision on relocation should take remediation into account. Examples of information and restrictions that can change the exposure pathways are access control and food restrictions, which are also described in Part B of these guidelines (c.f. sections 8.2-8.3). Some of these actions may have been implemented already during the urgent response phase.

The need for remediation is dependent on the resulting levels of radioactive materials on the ground from the emergency, and therefore also geography and situation dependent. Despite these circumstances and the fact that remediation is also closely connected to relocation, general dose criteria for what type of remediation could be needed depending on the level of projected effective dose during the first year are given in Table 5. These dose criteria are guidance levels, aiming at setting the ambition for what level of dose could warrant what remedial actions.

Further guidance on remediation – including guidance on remediation strategy and remediation plans – can be found in IAEA GSG-15 [19].

Table 5. Guidelines for dose criteria for remedial actions that may be used in planning. When calculating doses for the first year, the dose integration may start from the end of significant releases. Adapted from [9].

Remedial action	Annual effective dose (mSv)
A remediation plan should be produced and basic[a] remedial actions may be warranted	1
Basic remedial actions are likely to be warranted	5
Advanced[b] remedial actions may be warranted	10
Advanced remedial actions are likely to be warranted	20
Advanced remedial actions are likely to be insufficient to enable resettlement of the area for several years	50

[a] Basic remedial actions may include clearing of ditches and removing soil under downspouts etc.
[b] Advanced remedial actions may include large-scale decontamination of buildings and land.

Waste from decontamination

Waste, including radioactive waste, may arise from protective actions and other response actions that are taken in a nuclear or radiological emergency. The generation of waste can be expected to increase significantly in the transition phase when remedial actions, including decontamination, are implemented. Planning and arrangements for radioactive waste and other types of waste must be in place as part of the protection strategy before taking remedial actions that may generate waste. Such arrangements and plans include, among other things, methods allowing for the characterization, predisposal management and storage of radioactive waste [3].

No further guidance on the management of radioactive waste arising from nuclear or radiological emergencies is given in these guidelines.

11.2. Transitioning from an emergency exposure situation

An emergency exposure situation can transition to a planned or an existing exposure situation. All exposure pathways are to be taken into account but the possibility to transition to a planned exposure situation will mainly be dependent on the level of exposure from deposited radioactive material from the emergency. Thus, following a nuclear emergency with large areas affected by deposited radioactive material, the transition is likely to take place at different times in different areas.

For the regulation of radiation protection for the public this means:

- Following the transition to a planned exposure situation, the same regulations on radiation protection as before the emergency will apply; and
- Following the transition to an existing exposure situation, new regulations on radiation protection will apply, different from both the emergency exposure situation and the planned exposure situation before the emergency.

If a transition to a planned exposure situation is not possible, the radiation protection during the transition phase should as far as possible aim for the same level of ambition as will apply in the existing exposure situation that follows.

A requirement for the transition from an emergency exposure situation to an existing exposure situation in a certain area is that it is possible to establish a reference level of 20 mSv annual effective dose, or lower. The

reference level for an existing exposure situation following an emergency exposure situation is not set beforehand and can therefore be lower than 20 mSv annual effective dose.

The transition phase ends when all areas have transitioned to either a planned or existing exposure situation. This also marks the end of the emergency exposure situation.

11.3. Termination of an emergency exposure situation

Terminating an emergency exposure situation after a nuclear or radiological emergency affecting large areas is a complex process that involves many different actors and stakeholders. As the transition is likely to take place at different times in different areas, the termination is also likely to be a stepwise process, comprising a few different terminations along the way.

In general, the termination of the emergency according to national civil protection laws also means termination of the emergency exposure situation. The process of terminating an emergency exposure situation can be described as several steps, some of which decision makers and experts from civil protection and radiation protection communities might not necessarily be familiar with. The steps that will have to be carried out in order to terminate the emergency exposure situation are summarised in the list below, adapted from [2] and [16]. Some of the steps in the list are out of scope for these guidelines but given here for completeness.

1. Decide on a reference level to be used for transitioning to an existing exposure situation
2. Actions for food control and follow-up to ensure that food limits are not exceeded
3. Actions to ensure that exemption levels for commodities are not exceeded
4. Actions to prevent inadvertent ingestion adapted to the prevailing circumstances
5. Whole-body monitoring in order to follow up food restrictions, restrictions for commodities and actions to prevent inadvertent ingestion
6. Mapping of the current and the future radiation situation and exposure pathways
7. Estimation of received and projected radiation doses and related health risks for representative groups in the population, taking different courses of actions into account
8. Actions to inform those concerned about possible health risks
9. Registration of persons that need medical follow-up and development of programs for medical follow-up to the extent necessary given estimated individual radiation doses
10. Mapping of and actions to mitigate non-radiological consequences
11. Development of a strategy to handle psychosocial health for people living in affected areas
12. Mapping of prerequisites and actions that are reasonable to implement for individuals as well as society as a whole for the purpose of living in an area where the radiation levels are higher than before the emergency
13. Planning in order to ensure that community functions are in operation before people return to evacuated areas
14. Planning and implementation of remedial actions that are reasonable in order for people to remain in an area or necessary in order for people to move back to an evacuated area
15. Verification that workers involved in recovery operations can work in accordance with regulations that apply in planned exposure situations
16. Handling of limited areas outside evacuated areas where the criteria for relocation is fulfilled
17. Access control for areas that shall remain evacuated and planning for control of these areas
18. Return to areas subject to precautionary evacuation and evacuation before and during releases to the extent possible given the established reference level for an existing exposure situation and taking the effects of remedial actions into account
19. Involving stakeholders in affected areas as well as a process for this to continue over time
20. Handling of radioactive waste that stem from actions taken during the emergency exposure situation
21. Transition of responsibility and relevant information, if necessary, from organisations handling the emergency exposure situation to the organisations handling the existing exposure situation
22. Preparations and implementation of administrative and legal prerequisites to handle an existing exposure situation including financial, technical and personnel resources

23. Starting the task to develop a long-term plan for radiation monitoring
24. Starting the task of compensation for people affected by the emergency

References

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4. ICRP, Assessing Dose of the Representative Person for the Purpose of the Radiation Protection of the Public, Publication 101a, 2006.
5. SSM, Protective Actions in Nuclear or Radiological Emergencies - Planning Basis for Events in Emergency Preparedness Category IV, Report 2020:15e, 2020.
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17. IARC, Thyroid Health Monitoring After Nuclear Accidents – IARC Expert Group on Thyroid Health Monitoring After Nuclear Accidents, International Agency for Research on Cancer (IARC) Technical Publication No. 46, 2018.
18. ICRP, Radiological protection of people and the environment in the event of a large nuclear accident: update of ICRP Publications 109 and 111, Publication 146, 2020.
19. IAEA, Remediation Strategy and Process for Areas Affected by Past Activities or Events, GSG-15, 2022.

Appendix 1: Further reading related to restrictions on food and drinking water

International and Nordic national guidelines and recommendations on restrictions on food and drinking water are summarized with references for further reading in this appendix.

EURANOS handbooks relevant for food and drinking water:

- Brown J, Hammon DJ, Kwakman P., Generic handbook for assisting in the management of contaminated drinking water in Europe following a radiological emergency, EURANOS (CAT1)-TN (09)-02, 2009.
- Nisbet AF et. al, Generic Handbook for Assisting in the Management of Contaminated Food Production Systems in Europe following a radiological emergency v2, EURANOS (CAT1)-TN (09)- 01, 2009

Codex Alimentarius:

- Codex Alimentarius. General Standard for Contaminants and Toxins in Food and Feed, CDX 193-1995, Rev. 2009, Amended 2019.

The Codex Alimentarius Commission's "General Standard for Contaminants and Toxins in Food and Feed" includes guideline levels[20] for radionuclides in food moving in international trade following a nuclear or radiological emergency. This is relevant for the Nordic countries in situations where EU regulations does not apply. Codex guideline levels presented in Table A1-1 are developed based on the dose criterion of 1 mSv from food in the first year.

Table A1-1. Guideline levels in Codex Alimentarius for food in international trade.

	Activity concentration (Bq/kg)	
Radionuclides	**Infant foods**	**Other foods**
Pu-238, Pu-239, Pu-240, Am-241 in total	1	10
Sr-90, Ru-106, I-129, I-131, U-235 in total	100	100
S-35, Co-60, Sr-89, Ru-103, Cs-134, Cs-137, Ce-144, Ir-192 in total	1 000	1 000
H-3, C-14, Tc-99 in total	1 000	10 000

[20] The guideline level is defined as "*The maximum level of a substance in a food or feed commodity, which is recommended to be acceptable for commodities moving in international trade. When exceeded, governments should decide whether, and under what circumstances, the food should be distributed within their territory or jurisdiction.*"

National references related to preventing or reducing contamination in food and drinking water:

Finland

- Toimintatavat talousveden laadun turvaamiseksi - Radioaktiiviset aineet *(Procedures for securing the quality of household water: radioactive substances)*. Valvira Ohje 4/2016 (in Finnish and Swedish).

Norway

- Komperød M, Thørring H, Østmo TA. Tiltak for næringsmidler ved en atomhendelse *(Countermeasures for food and drinking water in a nuclear event)*. Teknisk dokument nr. 24. Østerås: Direktoratet for strålevern og atomsikkerhet, 2022 (in Norwegian).

Sweden

- Produktion och hantering av livsmedel vid radioaktivt nedfall (*Food production in connection with radioactive fallout*), Livsmedelsverket, 2020 (in Swedish).
- Sanering inom primärproduktionen: vägledning (*Decontamination in primary production: Guidelines*), Myndigheten för samhällsskydd och beredskap, 2022 (in Swedish).
- Motåtgärder i växtodlingen efter ett nedfall av radioaktivt cesium vid olika nedfallsnivåer och årstider *(Countermeasures in crop cultivation after fallout of radiocaesium at different levels and seasons)*, Jordbruksverket, 2008 (in Swedish).

Appendix 2: Other nuclear facilities in the Nordic countries

A number of different nuclear and non-nuclear facilities (other than nuclear power plants) exist in the Nordic countries with emergency planning zones (UPZ) and/or emergency planning distances (EPD). They are summarized with references for further reading in Table A2-1.

Table A2-1. Other nuclear and non-nuclear facilities with emergency planning zones and/or distances in the Nordic countries.

Facility	Emergency planning zones and distances	Further reading
The fuel fabrication plant in Västerås, Sweden	UPZ extending about 0.7 km	SSM Report 2017:27e, Appendix 4
The central interim storage facility for spent nuclear fuel outside of Oskarshamn, Sweden	EPD extending about 2 km	SSM Report 2017:27e, Appendix 5
European spallation source in Lund, Sweden	UPZ extending about 0.7 km	SSM Report 2018:22e
Spent fuel final disposal facility and encapsulation plant in Olkiluoto, Finland	Covered by Olkiluoto NPP planning zones	

In the other Nordic countries there are no nuclear facilities or non-nuclear facilities with emergency planning zones or distances. In Norway, DSA have assessed radiological consequences of a nuclear accident involving a nuclear powered vessel in the ports of Oslo and Tromsø (Grøtsund). These assessments are publicly available online in Technical Document No. 26 Konsekvensvurdering knyttet til generisk anløp av reaktordrevet hangarskip til Oslo havn (*Consequence assessments for scenarios related to visits by nuclear-powered aircraft carriers to Oslo harbour,* in Norwegian) and Technical Document No. 20 Konsekvensvurderinger for scenarier knyttet til anløp av reaktordrevne fartøy til Grøtsund (*Consequence assessments for scenarios related to visits by nuclear-powered vessels to Grøtsund,* in Norwegian).


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