Protective Measures in Early and Intermediate Phases of a Nuclear or Radiological Emergency

Nordic Guidelines and Recommendations

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INTRODUCTION

1 PREFACE

The Nordic guidelines and recommendations, 2014 are given by the Nordic radiation protection and nuclear safety authorities for protective measures in early and intermediate phases of a nuclear or radiological emergency. The document is intended as generic guidelines; covering all types of scenarios and are thus relevant for both accidents and intentional acts. The Nordic guidelines and recommendations are based on the Finnish guides for radiological emergency situations (STUK, VAL-guides [1,2]), and further developed through close Nordic cooperation. The VAL-guides implement the new ICRP approach [3,4], and in addition, the recommendations are in line with international guidelines and drafts available at the time. [5-7]

The Nordic guidelines and recommendations provide a common Nordic starting point for the practical application of protective measures for Nordic national authorities responsible for radiation protection in the event of a nuclear or radiological emergency. The common goal is to keep the exposure of the public as low as reasonably achievable, and in this pursuit to decontaminate the environment and recover to a new normal situation acceptable to society. 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.

The presented protection framework includes triggers and strategies for protective measures in the initial and intermediate phases, as well as a transition to recovery. Crisis communication is not included as it is believed to be more effectively dealt with from a stand-alone document.

Initially, in order to determine the type and extent of protective measures needed, an event has to be characterized as quickly as possible in order to estimate the nature and extent of consequences to be expected. Matters such as, what has happened, what type and how much radioactivity is involved, what part of the public will be or is being affected, etc., need to be assessed.

As soon as possible during the early phase, assessment should be complemented with a monitoring strategy. Each country has its own strategy, including a timeline for deploying the monitoring teams, with the overall goal to efficiently characterize the event and determine the consequences thereof.

The strategy for protective measures is the final component of the protection framework presented in this guide, to be used together with the characterization of an event and the monitoring strategy. A system for applying a reference level and using operational intervention levels (OIL's) for each protective action in the early and intermediate phase of an event is presented in Annex 3 and in Annex 2 there is a summary if operational intervention levels defined in this document The overall aim is: a) that the residual radiation dose should not exceed the reference level of 20 – 100 mSv during the first year after the event, including all radiation exposure pathways and protective measures, and b) that the protective measures that are applied, are optimized to achieve an actual residual radiation dose that is as low as reasonably achievable.

The presented OIL's are only indicative; it may be appropriate to carry out actions at higher or lower levels. Furthermore, the individual levels given in this guide do not ensure that the total residual radiation dose remains below the reference level in the first year. In an actual radiological or nuclear event, protective measures may need to be taken before measurements are actually carried out, especially in the early phase of an event. The OIL's are criteria for conditions that may or may not exist at the time protective measures need to be implemented. In the latter case they are intended as guidance. Estimates of the geographical extent of consequences of various types of radiological hazards are presented in Annex 1.

2 CONCEPTS AND DEFINITIONS

For the purpose of clarity and to ensure a common understanding of the content in the Nordic Flag Book, the scope of definitions is broader and in places more specific than those existing in e.g. the IAEA guides.

Nuclear or radiological emergency is a situation in which the members of the public, workers and/or rescue and emergency workers are, or may be, subject to radiation exposures higher than normal as a consequence of an imminent threat or actual exceptional event. This include situations where a) hazardous radioactive material is at risk of being spread, or have already been spread to the environment, or b) the shielding of a radioactive source is in danger of deteriorating or has already deteriorated, or c) a radioactive sealed source is, or is at risk of being, out of control.

Phases of a nuclear or radiological emergency

1. **The early phase of a nuclear or radiological emergency** means the threat and initial phase of a radiation hazard, including the initial events before deterioration of the shielding of a radioactive source or before radioactive material is released into the environment as well as the actual release. The early phase may result in an emergency exposure situation. The early phase ends when the radiation level in the environment no longer increases, and there is no further threat of additional, significant releases. As an example: In a nuclear power plant accident, the early phase of a nuclear or radiological emergency ends after the radioactive plume has passed by and there is no further threat of additional, significant releases. In the beginning of the early phase, estimates concerning probability, time and amount of a possible release are very uncertain. After the release the weather conditions and changes in weather, may substantially affect the consequences of the emergency. At this point, the nature, severity and extent of the incident remains uncertain, but its consequences and the need for protective measures must be assessed rapidly, despite the lack of precise information.

2. **The intermediate phase of a nuclear or radiological emergency** means an emergency exposure situation in which the radiation level is no longer increasing, and no new major radionuclide releases are reasonably anticipated. The intermediate phase can be, for example, the time after which the radioactive plume has passed, and where the main part of the radioactive material are already on the ground and fallout is no longer increasing significantly. The intermediate phase does not necessarily need to be preceded by an early phase. Alternatively, the duration of an early phase could have been very short, e.g. in the case where a contamination is identified after an unintended melting of a radioactive source, or in case of an explosion of a dirty bomb. In the intermediate phase it is possible to decide whether to lift, alleviate or change the early phase's protective measures and to introduce new protective measures. In addition, necessary actions to reduce long-term radiation exposure and decrease the amount of radioactive material in the environment should be initiated in this phase. The duration of the intermediate phase depends on, among other things, the cause of the radiation hazard. The intermediate phase can last from a few days to a few years.

3. **The recovery phase of a nuclear or radiological emergency** means an existing exposure situation where the activities of people and the society are adjusted to the prevailing radiation situation and where the focus is to bring society back to a new normal situation. Recovery typically includes actions made by citizens to reduce their own exposure, based on expert recommendations and advice as well as local and social knowledge. Long-term restrictions regarding the use of land and water areas are given when necessary, or the use of these areas and production is redirected. The decontamination of the environment from radioac-

tive material may be continuing, as may the management of radioactive waste. The duration of the recovery phase can be from months to decades depending on the situation.

The transition between phases will most likely be gradual. Furthermore, actors may be in different phases at the same point in time: For instance, one actor may be in one phase applying measures different to those applied by another actor in the following phase, at another location.

Protective measures mean measures that are taken to reduce people's actual or potential exposure to radiation. Such actions may concern people, the environment, functions of society, industry and commerce, agriculture, food- and feeds, water and waste containing radioactive material.

Radioactive material, to avoid the different perceptions of the definition of the term "radioactive substance", radioactive material is used throughout the document, meaning matters or substances emitting ionizing radiation or particles. In this context radioactive material has no connotation to the regulatory meaning of the term used in some countries.

Radiation level in this guide refers to the magnitude of radionuclides on different surfaces, external dose rate or the activity concentration in air, water or some other material.

Reference level of dose represents a level of residual radiation dose, received over one year, which is generally judged to be inappropriate to allow in radiological or nuclear emergencies. All exposure pathways and protective measures must be taken into account when assessing whether or not exposures exceed a reference level of dose. The aim is that with the implementation of protective measures, the residual dose, at least to most of the public, remains below this reference level. Even below the reference level, all feasible and reasonable actions should be carried out to reduce the exposure. The residual dose is lowered with time until a permanently acceptable situation is reached. When making the dose assessment all possible paths of exposure in the prevailing hazard situation must be considered.

Projected dose refers to the dose that would be expected to be incurred if a specified countermeasure or set of countermeasures — or, in particular, no countermeasures — were to be taken.

The **dose criterion** of a protective measure is the projected dose, caused by the nuclear or radiological emergency to an unprotected person, which, when exceeded or expected to be exceeded, would usually call for the protective measure to be implemented. For each separate protective measure, a dose criterion should be set. When making a dose assessment, no other protective measures are taken into account.

Residual dose denotes the dose expected to be incurred in the future (1 year) after intervention has been terminated.

Operational intervention level means a measurable value such as dose rate, radioactive contamination and activity concentration. When the operational intervention level is exceeded or expected to be exceeded, a protective measure is usually needed. The operational intervention level values presented in this guide are indicative, and, taking into account the actual conditions of the nuclear or radiological emergency being addressed, may need to be changed accordingly.

Triggers are observables, which are expected to be promptly available. Triggers can be used immediately and directly to initiate appropriate protective measures. Triggers may be expressed in terms of any observable circumstances, such as plant conditions, emergency action level, wind direction, distance or duration of a protective measure. Once the occurrence of a predefined trigger has been identified, the appropriate part of the protection strategy should be immediately implemented, without further delay or discussion.

Radioactive contamination refers to radioactive material on surfaces or in solids, liquids or gasses, where their presence is unintended or undesirable, - whether they have been spread intentionally or not. The consequential effects of contamination decrease as a result of radioactive decay and decontamination actions. Transfer of radioactive material in the environment and attachment of radioactive material to materials either chemically or biologically is also thought to lead to dilution and thus decreasing consequential effects. However, in some instances transfer, as well as chemical and biological processes, can result in concentration increases.

Contamination levels denote the severity of the radiation exposure as a result of contamination. It is used primarily when evaluating the need for decontamination. It is assumed that radioactive material is still on the surfaces of soil, buildings, goods etc. and have not migrated deeper into the soil or other material.

Maximum permitted levels of radioactive contamination denotes predefined or case-specific maximum levels of radioactive contamination in food, drinking water and animal feed (feeds), which may be enacted following a nuclear event or any other case of radiological emergency.

Radioactive waste refers here to radioactive material and devices, goods and matters contaminated by radioactive material, which have no use and shall be handled with due consideration of their radioactive inventory.

Other waste and discarded products means waste that might require radiation protection aspects to be taken into account in waste management during handling or recycling, but where the amount of radioactive material remains so minor that they will not be categorized as radioactive waste. In addition other waste includes waste which is not accepted for the intended use (e.g. food and feed) because of minor contamination.

Unprotected person refers to an unsheltered person, who has not been evacuated and does not receive iodine prophylaxis.

Evacuation is the rapid, temporary removal of people from an area to avoid or reduce short term radiation exposure in an emergency situation. Evacuation is an urgent protective action (a form of intervention). If people are removed from the area for a longer period of time (more than a few months), the term relocation is used. Evacuation may be performed as a precautionary action based on triggers associated with nuclear power plant conditions.

Temporary relocation means relocation for a period of days to months to another location, but where return is foreseeable.

Relocation means the non-urgent removal or extended exclusion of people from a contaminated area to avoid chronic exposure. Relocation is a longer term protective measure, with duration from months and up to two years. It may be a continuation of the urgent protective measure of evacuation. Relocation is considered to be permanent relocation (sometimes termed resettlement) if it continues for more than a year or two and return is not foreseeable; otherwise it is temporary relocation.

Permanent relocation means that the public and the necessary infrastructure is moved to another location Permanent relocations apply to situations in which it is presumed that the area cannot be restored to habitability.

Strong gamma and beta emitters are for example ^{58}Co, ^{60}Co, ^{106}Ru, ^{110m}Ag, ^{131}I, ^{134}Cs, ^{137}Cs, ^{144}Ce, ^{90}Sr, ^{192}Ir and ^{226}Ra.

Weak gamma and beta emitters are, for example, ^{3}H, ^{14}C, ^{51}Cr, ^{55}Fe and ^{63}Ni.

3 REFERENCE LEVEL OF EXPOSURE DURING THE FIRST YEAR

In an emergency, all protective measures aim to keep the exposure of the public as low as reasonably achievable and to minimize other harms as well as to recover past living to the extent it is reasonably possible. Throughout the situation the need for protective measures must be assessed continually. The need for changing, continuing or lifting the protective measures already taken should also be assessed. This assessment should also consider the duration of the actions in relation to radioactive decay and decontamination measures.

When planning for emergency response, the overall aim is that the annual residual radiation dose should not exceed the reference level chosen by each respective Nordic country. The chosen reference level should be between 20 and 100 mSv during the first year, including all radiation exposure pathways and protective measures (Fig. 1). The reference level includes the total residual dose expected as a result of interventions in both the early and the intermediate phase.

When assessing the residual radiation dose, the exposure pathways to be taken into account are direct radiation from an unshielded source, fallout or radioactive plume, inhaled radioactive material, contamination of skin, and radioactive material in food and drinking water – all to be incurred after interventions have been implemented.

Management of the radiation situation may take years altogether. Throughout this period the primary goal is to reduce the annual dose to the public to a level that is seen as permanently acceptable.

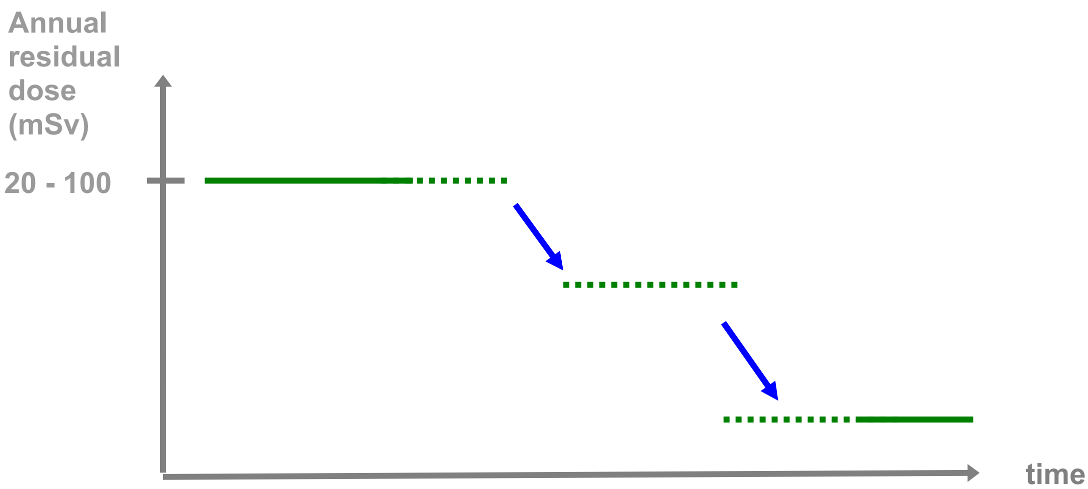

Figure 1*. Annual residual dose should be reduced as quickly as possible. In an emergency exposure situation the annual residual dose is the dose expected to be incurred in the future (time) after one or more interventions (arrows) has been implemented.*

In this guide, dose criteria expressed as projected dose have been defined for various measures. In addition, operational intervention levels expressed in measurable quantities to an order of magnitude (e.g. dose rate, concentration, etc.) have been set for each protective measure. A protective measure should be considered at latest, when an operational intervention level is exceeded, or is anticipated to be exceeded. However, it should be noted that the operational intervention level is only indicative, and countermeasures can be appropriate at higher or lower levels. Furthermore, it should be recognised that the individual levels given in this guide do not ensure that the total residual radiation dose will remain below the reference level.

The operational intervention levels have been developed for single protective measures. However, single operational intervetion levels do not necessarily ensure that the residual dose will remain below the chosen reference level. When deciding upon a protection strategy, combinations of protective measures should be considered. Even if the operational intervention levels for individual countermeasures are not exceeded, countermeasures may be implemented for ensuring that the chosen reference level is not exceeded.

If, in the early phase some individuals or groups can be identified to have received doses near to or in excess of the reference level, more stringent protection may be applied to these individuals in subsequent management of accident consequences.

4 FACTORS AFFECTING THE CHOICE OF PROTECTIVE MEASURES

Especially during the intermediate phase, the benefits and disadvantages of possible protective measures must be assessed, prior to the decision of which measures to actually apply. There are many and varied protective measures and combinations thereof to be considered. In order to evaluate the efficiency of the applied measures, their combined impact must be taken into account.

The choice of protective measures is also affected by their assumed duration. Other considerations than radiation protection may be of importance when opting for countermeasures lasting several months or even years. Consequently, a thorough assessment of the scope and impact of the protective measures should be performed before decision making. In addition to radiation protection, the assessment should also include the influence of other factors such as: efficiency, timing, resources, waste management, surroundings, economy, social and ethical aspets, etc. (Fig. 2).

The magnitude of an exposure may be of significance and should be considered in relation to other factors, such as: ethical, social, environmental and economical aspects affecting the decision making (Fig. 3). In a radiological incident where the exposure is small, other factors may have more impact on decision making than the exposure itself. In a severe radiological emergency, radiation protection may take precedence over ethical, social, environmental and economical considerations, as the most important factor, although it may cause harm to people's normal living.

The aim is to keep the residual dose below the chosen reference level during the first year, taking into account all radiation exposure pathways and protective measures. If the projected annual radiation dose due to the radiation hazard without any protective measures is:

- higher than 10 mSv: it is necessary to apply appropriate protective measures;
- between 1 – 10 mSv: protective measures are usually appropriate;
- below 1 mSv: protective measures may be applied especially when they are simple and rational.

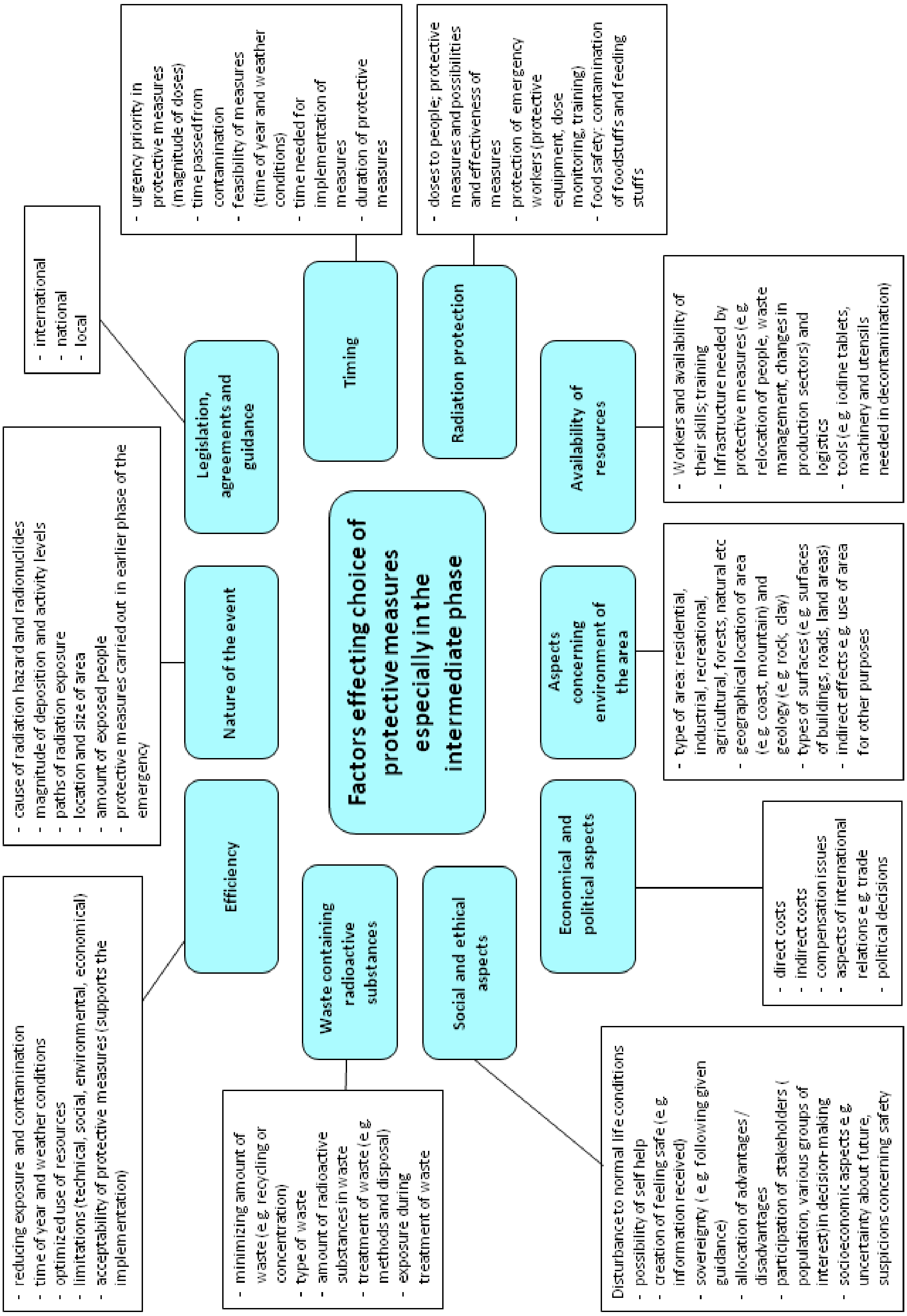

Figure 2. *Factors affecting the choice of protective measures especially in the intermediate phase*

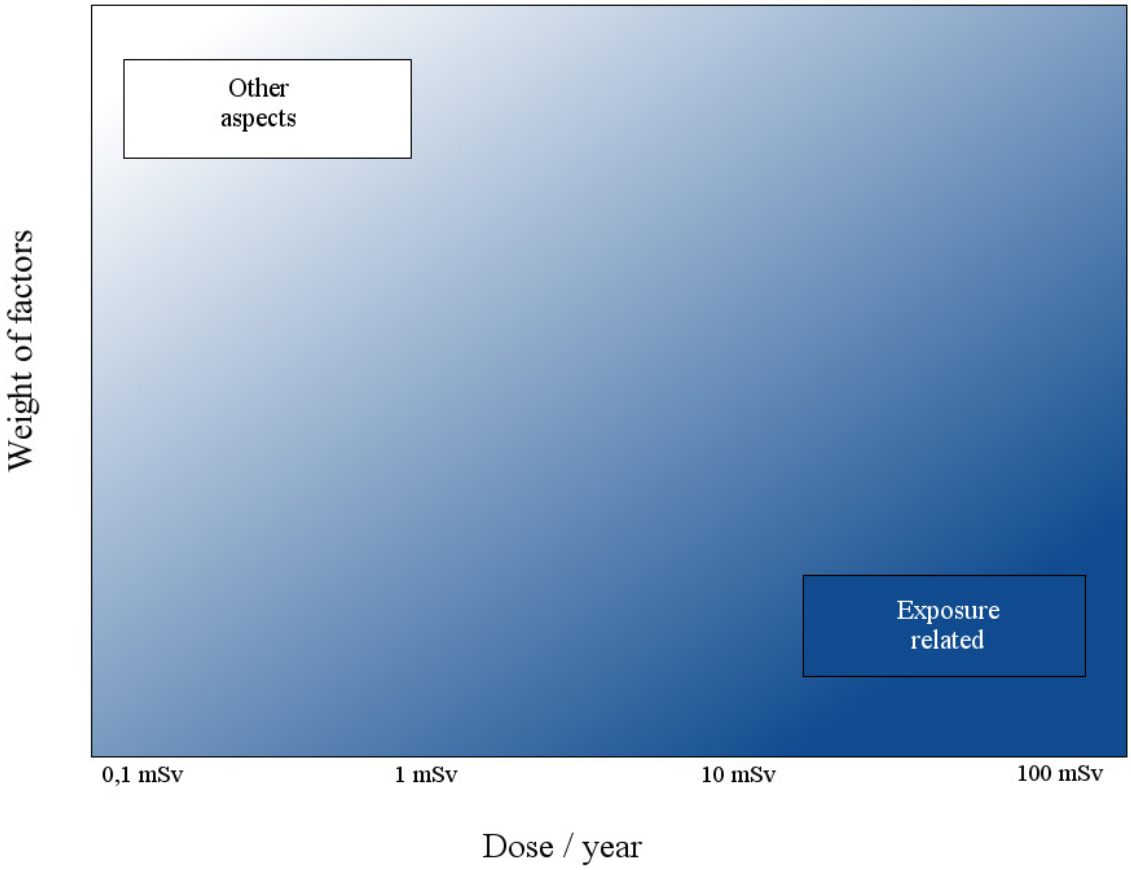

Figure 3. *The significance of the individual exposures versus other factors affecting decision making. Other factors gain increasingly more weight with decreasing individual exposures and vice versa.*

5 PROTECTIVE MEASURES DURING NUCLEAR OR RADIOLOGICAL EMERGENCIES

Protective measures are engaged to reduce people's actual or potential exposure to radiation. Such measures 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 containing radioactive material.

In the early phase of an emergency, the protective measures primarily focus on the public at risk, the emergency workers and the more critical functions of society, such as; protection of foodstuff and related commodities. The relevant measures to be considered during the early phase of an emergency are given in Figure 4 and further described in Part A of the document.

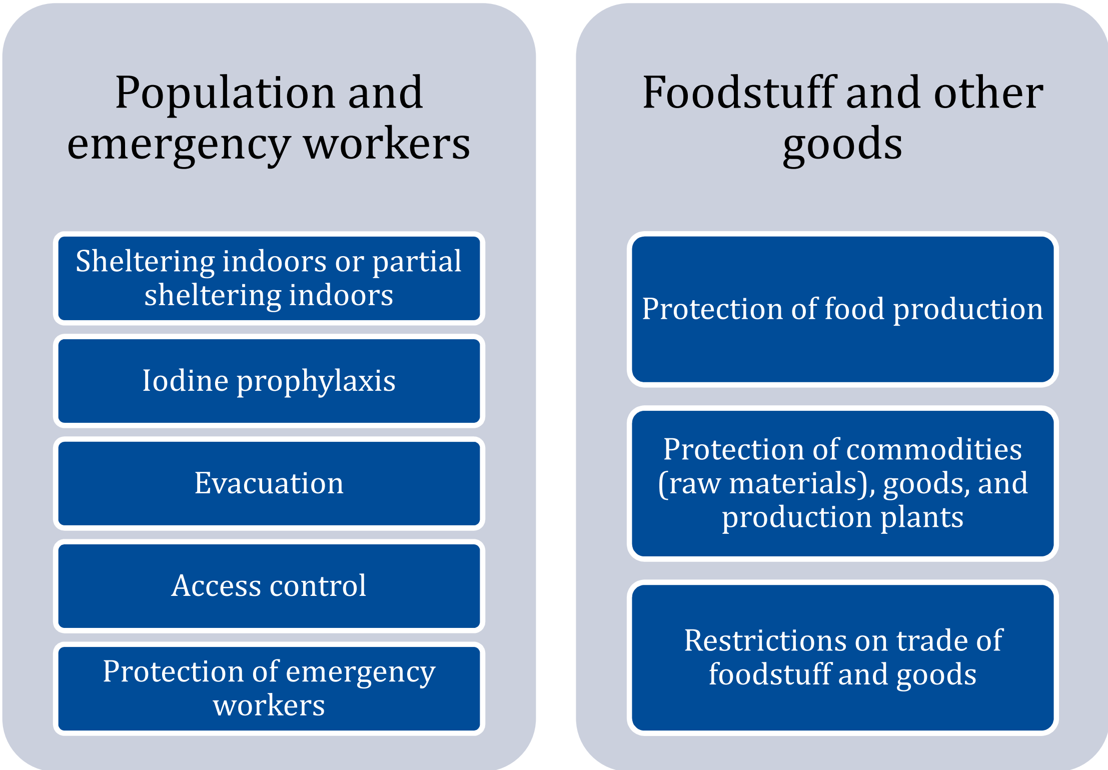

Figure 4. *Measures to be considered during the early phase of an emergency*

In the intermediate phase of an emergency, the protective measures are broadened and include also workers (other than emergency personnel) as well as environmental and industrial aspects, in addition to the primary measures implemented during the early phase. The protective measures applied in the early phase are either continued, strengthened, relaxed or lifted, and new measures, such as restrictions on foodstuff and water may be introduced.

In this phase a large number of factors may be relevant to take into account upon deciding the appropriate strategy and the suite of protective measures to implement (Fig. 2). Moreover, the wide range of possibly relevant measures in the intermediate phase underlines the need for a complete, comprehensive strategy, also in this phase.

As the monitoring strategy progresses, new access restrictions and control may be implemented in this phase in accordance with the acquired data. If relevant, measures to reduce suspension and further spreading of radioactive material should be applied in this phase.

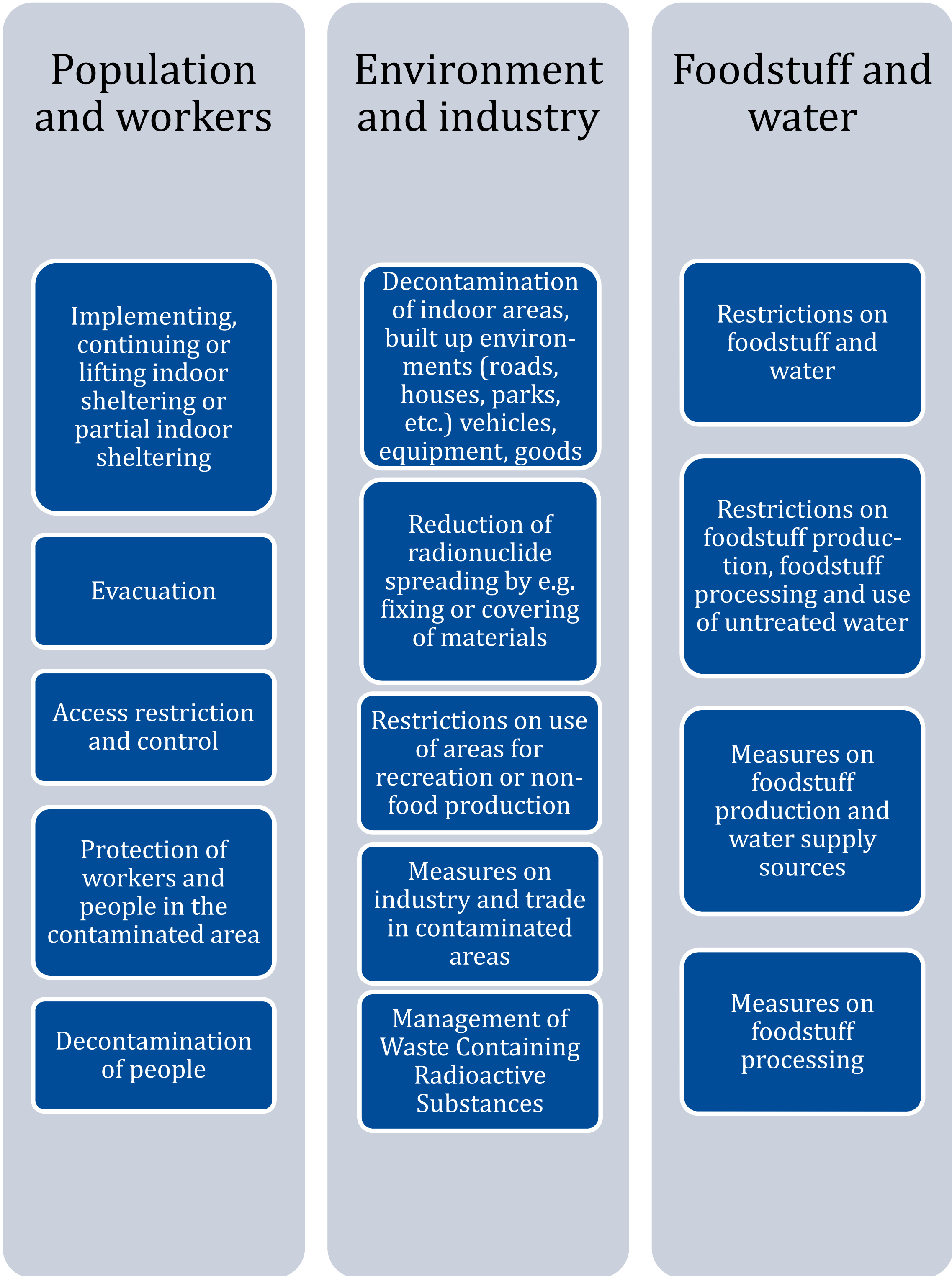

Figure 5. *Measures to be considered during the intermediate phase of an emergency*

Decontamination measures should also be applied, both in relation to people and places. Decontamination points should be set up as appropriate and waste management, routes and disposal sites should be established in accordance with the nature and amount of the waste.

Protective measures concerning the environment, industrial production and transport, national and international trade may also be implemented in the intermediate phase. The relevant measures to be considered in the intermediate phase after an accident are given in Figure 5, and further described in Part B of the document.

PART A:

THE EARLY PHASE OF AN EMERGENCY

6 PROTECTIVE MEASURES FOR THE PUBLIC

The protective measures and operational intervention levels presented in this chapter concern all nuclear or radiological emergencies. The protective measures are described individually, but are linked to other protective measures in a way that they form parts of relevant protection strategies. The actual strategy should be developed *during* an emergency, taking all current factors and circumstances into account.

The chapters 6.1 - 6.3 concern all kinds of nuclear or radiological emergencies excluding accidents at nuclear facilities with predefined emergency planning zones. Protective measures in the emergency planning zones around nuclear facilities will, in the early phase, be implemented primarily based on predefined triggers (e.g. plant status, emergency action levels) and this is described in chapter 6.4.

6.1 Sheltering indoors

Indoor sheltering reduces the inhalation of radioactive material and also limits the external radiation exposure. The effectiveness of sheltering indoors depends on several factors such as building type, air filtration and exchange rate. The duration of sheltering is an important factor.

Dose criteria: Sheltering indoors should take place if the total dose to an unprotected person is or is anticipated to be over 10 mSv in two days.

Operational intervention level for sheltering indoors:

- external dose rate is or is anticipated to exceed 100 µSv/h,

or

- the concentration in the (outside) air is or is anticipated to exceed
  - alpha emitters 1 Bq/m^3 (plutonium-239 and americium-241),
  - beta emitters 1000 Bq/m^3 (strontium-90),
  - strong gamma emitters 10 000 Bq/m^3 (cesium-137).

The aim is to shelter indoors before the exposure is expected to take place. The decision on sheltering indoors has to be made in a timely manner to provide adequate time for public information, preparation and implementation.

In the area of sheltering indoors, the ventilation should be shut down where possible in all residential and office buildings as well as production facilities.

The radiation situation after a nuclear weapons explosion is different from e.g. the radiation situation after a severe nuclear plant accident. In a nuclear explosion a large amount of strongly radiating radioactive material is generated and the external dose rate may rise to very high levels. Then people should shelter in civil defence shelters in areas where such radioactive fallout may occur. In case there are no shelters, or civil defence shelters are not immediately available for use, people should shelter indoors as well as possible.

Partial sheltering indoors

Partial sheltering indoors is a measure that is less stringent than sheltering indoors. It will, during the early phase, primarily be implemented at longer distances from the accident site or to protect children and pregnant women specifically. During partial sheltering indoors unnecessary time spent outdoors is restricted. It is especially important to minimize the time that children stay outdoors.

Dose criteria: Partial sheltering indoors should take place if the projected dose to an unprotected person is 1 to 10 mSv in two days.

Operational intervention level for partial sheltering indoors:

– external dose rate is or is anticipated to exceed 10 μSv/h,

or

– the concentration in the air is or is anticipated to exceed
  - alpha emitters 0,1 Bq/m^3 (plutonium-239 and americium-241),
  - beta emitters 100 Bq/m^3 (strontium-90),
  - strong gamma emitters 1 000 Bq/m^3 (cesium-137).

6.2 Iodine prophylaxis

Taking stable iodine can effectively prevent the accumulation of radioactive iodine into the thyroid gland. Iodine tablets are especially important for children and pregnant women because the thyroid glands of children are more sensitive to radiation than those of adults. If there are not enough tablets, children and pregnant women should be given first priority. The effect of iodine tablets on adults over 40 years of age is only minor.

Iodine prophylaxis is rarely used as a stand-alone action.

Dose criteria: Iodine tablets should be taken, if available, when the dose to the thyroid gland is estimated to be over 50 mGy for adults, and over 10 mGy for children under 18.

Operational intervention levels for taking iodine tablets:

Adults:

– external dose rate is or is anticipated to exceed 100 μSv/h,

or

– iodine in inhaled air is or is anticipated to exceed 10 000 Bq/m^3 for two days.

Children under 18 years of age and pregnant women:

– external dose rate is or is anticipated to exceed 10 μSv/h,

or

– iodine in inhaled air is or is anticipated to exceed 1000 Bq/m^3 for two days.

Concerning the dosage of iodine tablets, the dosage instructions on the drug case should be followed. A person who is hypersensitive to iodine or has a diagnosis of perturbation or some other condition of the thyroid gland should not take iodine tablets.

One dosage of iodine gives a protection for one day and partially for another successive day. The iodine should be taken 1–6 hours before the exposure to radioactive iodine, which gives a 100 % protection. The protection is weaker the later the iodine is taken. If the iodine tablet is taken 18 hours after inhalation of radioactive iodine, it will no longer decrease the radiation dose to the thyroid gland.

In case the exposure to airborne radioactive iodine (a radioactive plume) extends for more than 24 hours, it should be considered to order another dosage of iodine to be taken. Re-taking iodine tablets is weighed on the basis of the concentration of radioactive iodine in the air. The operational intervention levels are the same as given above. The iodine dosage for newborn babies less than one week of age is not to be re-administered in order to avoid disturbing the function of the thyroid gland.

Supervision of radionuclide contents in foodstuffs and dietary guidance will ensure that foodstuffs containing harmful amounts of radioactive iodine are not used. The use of stable iodine is not an acceptable option for protection against eating contaminated food (see chapters 9 and 12).

6.3 Evacuation

Dose criteria: Evacuation shall be carried out as rapidly as possible, in case the effective dose to an unprotected person without any other actions is estimated to be over 20 mSv in one week after the accident and if it can be anticipated already in this phase that sheltering indoors will last longer than two days.

To the extent possible, evacuation is to be carried out before the radioactive plume arrives to the area. In the early phase, when the plume is near the area concerned or already present in the area and there are radioactive material in the air being inhaled, people should shelter indoors until instructed otherwise.

Evacuation in the intermediate phase is discussed in the part B. Evacuation in the vicinity of domestic nuclear power plant is discussed in the chapter 6.4.

In case the emergency concerns a) a threat of radioactive material from radiation sources spreading in an event, b) intentional spreading of radioactive material to the environment or c) other danger caused by radiation, such as external radiation, people in the isolation area (see Table I) should be quickly evacuated. The highest priority should be given to the evacuation of people outdoors.

6.4 Urgent actions in the vicinity of nuclear facilities only

When there is a threat of a severe accident at a nuclear facility, rapid decisions shall be made to protect the public in the emergency planning zones of the facility. Decision making is based on the prevailing situation at the facility, the estimate of its development and the probability of release of radioactive material into the environment. The magnitude and nature of the possible release cannot be estimated for certain. Therefore the operational intervention levels based on estimated doses or releases cannot be applied in the threat phase.

The recommended planning basis for carrying out protective measures for the public in the emergency planning zones is that the measures can be completed in about four hours after decisions on protective measures have been made. As it takes time to give warning and instructions to the public and to complete protective measures in a timely manner, authorities should intensify their capabilities for launching and implementing protective measures already when the operator announces a site area emergency at the plant.

Domestic nuclear power plants

Urgent evacuation should be carried out in the area covering about 5 kilometres from the plant in case there is a threat of a significant radioactive release into the environment or in case a specific predefined trigger occurs.

Evacuation is necessary at latest when the operator announces a general emergency at the plant. If there is a threat that the reactor can be damaged rapidly, evacuation of the 5 km zone shall be launched immediately independent of the prevailing on-site emergency class. If evacuation is not possible due to e.g. immediate release or threat of a release, or extreme weather conditions, members of the public in the vicinity of the plant should shelter indoors and be instructed to administrate iodine.

Simultaneously with evacuation of members of the public in the vicinity of the plant measures should be launched in order to shelter the public indoors and to administrate stable iodine also in those parts of the emergency planning zone where release might disperse and where estimates of effects call for such countermeasures. In addition, it may be considered whether there is a need and possibility to evacuate some parts of the public in the emergency planning zones, e.g. children in schools and nurseries, in the expected direction of passage of a radioactive plume.

If the release will continue or it is anticipated to continue for more than two days, it may be necessary, in order to reduce the radiation exposure, to partly or entirely evacuate the public sheltered indoors in the vicinity of the accident site, even if there is still radioactive material in the air. The right timing of implementing the measure requires an estimate of the development of the accident situation and weather conditions.

Other nuclear facilities

For facilities like research reactors and nuclear powered ships in national harbours, the system of emergency planning zones and implementation of early countermeasures as described above should be applied as far as relevant. The size of the emergency planning zones and the evacuation zone should be adjusted, also taking into account the size of the actual reactor.

7 PROTECTIVE MEASURES ON ACCESS TO POTENTIALLY HAZARDOUS AREAS

7.1 Access control (large areas)

Access control is a protective measure, that either restricts entrance to a certain area except for absolutely necessary actions or, that prohibit entrance to an area completely. Access control is needed in situations where radioactive material has spread, is spreading or may spread to a certain area.

Restrictions may concern land or urban areas, harbours, airports, ships, trains and the like.

Operational intervention level for access control:

– the external dose rate is or is anticipated to exceed 100 µSv/h,

or

– the concentration in the air is or is anticipated to exceed
  - alpha emitters 1 Bq/m^3 (plutonium-239 and americium-241),
  - beta emitters 1000 Bq/m^3 (strontium-90),
  - cesium-137 and other strong gamma emitters 10 000 Bq/m^3.

7.2 Access control (limited areas)

Access control to limited areas may be needed during a situation when radioactive material remains confined within a limited area.

The incident site should be isolated if there is an indication or threat of exposure unintentional spreading of radioactive material into the environment due to an accident with radioactive sources, or due to intentional spreading of radioactive material or due to external exposure to radiation from a radioactive source. Table I provides indicative guidance on the size of the area cordoned off in response to various events with radiation sources.

Table I. *Size of restricted areas during various incidents*

Site of incident outdoors	Size of cordoned off area
– unexploded or exploded radioactive dispersal device (RDD) or so-called dirty bomb – fire or explosion (e.g. gas explosion), with a high-active radioactive source or an assumption of such a source	– area in which the dose rate exceeds 100 μSv/h, radius however at least 300 m
– a possibly high-active radiation source, damaged or without a protective shield; no danger of explosion or fire – leaking, possibly high-active radioactive source; no danger of explosion or fire	– area in which the dose rate exceeds 100 μSv/h, radius however at least 30 m
Site of incident indoors	**Size of isolation area**
– damage of a possibly high-active radiation source, loss of shielding or leaking of a liquid or gaseous radioactive source	– nearby spaces including the floors above and below, adjacent rooms and other areas where dose rate exceeds 100 μSv/h – in case of leakage of a gaseous radiation 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 and other areas in which the dose rate exceeds 100 μSv/h

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 defined and when the estimates on the spreading, the anticipated amounts of radioactive material in the inhaled air and also the actual contamination of the area are known.*

8 PROTECTIVE MEASURES FOR EMERGENCY WORKERS

8.1 Exposure of emergency workers

Workers involved in urgent protective and mitigation measures, as well as in other urgent work, may be exposed to radiation (*emergency occupational exposure*) at levels higher than those for members of the public.

Emergency response organisations shall ensure that emergency occupational exposure remains, whenever possible, below the dose limit for occupationally exposed workers. Pregnant female workers shall not be assigned work leading to exposure (emergency occupational exposure).

Doses exceeding the dose limit shall be managed in the following manner:

1. Emergency response organisations shall ensure that reference levels for emergency occupational exposure shall be set, in general below an effective dose of 100 mSv;, except in specific cases identified in the national emergency plan. In such cases, appropriate reference levels above 50 mSv shall be defined.

2. In exceptional situations, in order to save life, prevent severe radiation-induced health effects, or prevent the development of catastrophic conditions, a reference level for an effective dose from external radiation of emergency workers may be set above 100 mSv, but not exceeding 500 mSv.

3. Emergency response organisations shall ensure that emergency workers who are liable to undertake actions whereby an effective dose of 100 mSv may be exceeded are clearly and comprehensively informed in advance of the associated health risks and the available protection measures and undertake these actions voluntarily.

4. In the event of an emergency occupational exposure, emergency response organisations shall require radiological monitoring and medical surveillance of emergency workers if deemed necessary. Individual monitoring or assessment of the individual doses shall be carried out as appropriate to the circumstances.

8.2 Urgent measures

Rapid response to save lives or to prevent serious injuries may be necessary immediately after an accident. Urgent measures include measures for gaining control of the source or the exposure situation. Urgent measures to restrict radiation exposure also comprise work related to conducting evacuations, as well as, work needed to maintain general safety and security of the society during sheltering indoors.

For events involving licensed facilities, emergency workers executing urgent measures are most likely licensee staff, but may also include rescue personnel, police and medical personnel.

Protective measures should be arranged to limit emergency occupational exposures to a minimum. Doses of workers shall be assessed, determined and the results notified to the relevant national regulatory body. In case an emergency worker dose exceeds 50 mSv, the worker should be offered health surveillance.

Mitigating the consequences of the accident and other necessary work

Mitigating the consequences of the accident and other necessary work during the early phase of a nuclear or radiological emergency include, for example: Security and access control measures, mapping of the radiation field and other measurement activities, essential social and health services, as well as general maintenance of critical infrastructure of the society such as supply and distribution of electricity, food and water.

Work should be planned and implemented in such a way that emergency occupational exposures are kept as low as reasonably achievable.

8.3 Protection of emergency workers and members of the public

Emergency workers involved in urgent protective measures, mitigating the consequences of the accident and other necessary work, must use protective clothes, appropriate respirators and, when necessary (see Table II), take stable iodine while working in contaminated areas. Indicative operational intervention levels for different worker protection measures are presented in Table II.

The anticipated level of exposure should be assessed prior to the commencement of tasks and a plan should be made as to how doses will be monitored during the work. Unless personal dosimeters are in use, the level of exposure should be assessed based on levels of external dose rate at the place of work and working hours.

It should be noted, that the reference levels for emergency workers apply to effective doses from external radiation and that protective measures and equipment to avoid internal exposure by inhalation of radioactive material or contamination of the skin, therefore must be in place as a general preparation to any accident.

Other work in the area

People that practice their own profession in the area where protective measures are carried out are to be recognised as members of the general public as regards radiation protection.

Table II. *Operational intervention levels and protective measures for emergency workers.*

Operational intervention levels for protection of emergency workers	
– the external dose rate is or is anticipated to be 10 - 100 μSv/h or – the airborne concentration is or it is anticipated to be ▪ alpha emitters 0.1 - 1 Bq/m^3 ▪ beta emitters 0.1 - 1 kBq/m^3 ▪ cesium-137 and other strong gamma emitters together 1 - 10 kBq/m^3	– protective clothing and respiratory protection when in contaminated areas – an iodine tablet during emergencies in predefined risk facilities where significant amounts of iodine may be involved – an iodine tablet if a general recommendation of iodine prophylaxis has been issued to the public – work time and locations are recorded as accurately as possible – if an external dosimeter is in use, dose rates are recorded at regular intervals e.g. once an hour – if there are personal dosimeters or a joint dosimeter for a work group, they shall be used according to instructions
– the external dose rate is or is anticipated to be 100 - 1000 μSv/h or – the airborne concentration is or it is anticipated to be ▪ alpha emitters 1 - 10 Bq/m^3 ▪ beta emitters 1 - 10 kBq/m^3 ▪ cesium-137 and other strong gamma emitters together 10 – 100 kBq/m^3	In addition to the previous measures: – if the situation continues over a longer period (50 – 500 hours), the total working time of a worker needs to be planned and restricted in order to make sure that the total dose does not exceed 50 mSv

– the external dose rate is or is anticipated to be 1000 - 10000 μSv/h or – the airborne concentration is or it is anticipated to exceed ▪ alpha emitters 10 - 100 Bq/m³ ▪ beta emitters 10 - 100 kBq/m³ ▪ cesium-137 and other strong gamma emitters together 100 - 1000 kBq/m³	Staying in contaminated areas is restricted when possible and when it does not impede necessary urgent work. For instance; to ensure the safety of the mobile measurement teams, decisions need to be made regarding continued radiation monitoring and other measurement actions which take place outdoors. In addition to the previous measures: – the total working time of workers needs to be restricted (5 – 50 hours) in order to make sure that the total dose does not exceed 50 mSv unless special circumstances apply and a higher dose is allowed for – working time and locations are recorded as accurately as possible
– the external dose rate is or is anticipated to exceed 10000 μSv/h or – the airborne concentration is or it is anticipated to exceed ▪ alpha emitters 100 Bq/m³ ▪ beta emitters 100 kBq/m³ ▪ cesium-137 and other strong gamma emitters together 1000 kBq/m³	Only work which is absolutely necessary to ensure the safety of the public is conducted In addition to the previous measures: – working times are restricted (< 5 hours); if possible, the dose to a worker is restricted to 50 mSv – working time and locations are recorded separately as accurately as possible

9 PROTECTIVE MEASURES FOR PRODUCTION OF FOOD AND OTHER GOODS

9.1 Measures on food production, other raw materials and production facilities

Food production

Protection of food production should be initiated as soon as possible. For example, radioactive iodine is rapidly transferred into milk if the cattle are fed with contaminated feed. On the other hand, alpha emitters do not transfer into e.g. milk and meat as efficiently as iodine and cesium. Even if the external dose rate does not exceed the normal radiation level, radioactive material may be accumulated into foodstuffs to the extent that they are not eligible for marketing and consumption.

Food, which is cultivated for personal consumption and which is grown or stored outdoors, may become contaminated if not protected. The protection of such food should be considered if it can be done easily and quickly enough.

Operational intervention levels for protection of food production:

- the external dose rate is, or is anticipated to be, higher than 1 μSv/h,

or

- the concentration in the air is or is anticipated to exceed
  - alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241),
  - beta emitters 10 Bq/m^3 (strontium-90),
  - strong gamma emitters 100 Bq/m^3 (cesium-137, iodine-131, a.o.).

For sustaining uncontaminated domestic animal products, it is necessary to ensure clean feed and drinking water to livestock. The time of the year may affect which measures should be used. Possible measures are, among others, keeping the animals indoors and shutting down or reducing the ventilation in case it is possible and without endangering the well-being of the animals. Other actions concerning protection of livestock are e.g. harvesting new feed growing in the fields and protecting the feed already stored, before it becomes contaminated. Contamination of cultivated lands can be prevented by covering, if it is possible considering timing and extent of cultivations. During emergencies, neither rainwater nor surface water shall be used as drinking water for animals or for irrigation.

Commodities and products

Commodities (raw materials for production) and products stored outdoors may become contaminated if not protected. Raw materials should be protected if it can be done in due time and with moderate costs.

Operational intervention level for raw materials and products:

- external dose rate is or is anticipated to exceed 10 μSv/h,

or

- the concentration in the air is or is anticipated to exceed
  - alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241),
  - beta emitters 100 Bq/m^3 (strontium-90),
  - strong gamma emitters 1000 Bq/m^3 (cesium-137, a.o.).

Factories and production facilities

Factories and production facilities may be contaminated in the same manner as other indoor areas. It is important to stop ventilation and, if possible, stop production until the outdoor air inventory and external dose rate is below the operational intervention levels given for factories and production facilities. By doing this, contamination of indoor areas and possibly production lines and products can be reduced.

For ensuring clean household water, in water treatment plants using aeration, ventilation should be stopped or activated carbon filters should be used.

Operational intervention level for factories and production facilities:

– external dose rate is or is anticipated to exceed 10 μSv/h,

or

– the concentration in the air is or is anticipated to exceed
  - alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241),
  - beta emitters 100 Bq/m^3 (strontium-90),
  - strong gamma emitters 1000 Bq/m^3 (cesium-137, a.o.).

9.2 Restrictions and recommendations concerning trade of foodstuffs and other goods

The Commission of the EU can, once contamination of the environment is deemed probable or imminent, issue maximum permitted levels of radioactive contamination agreed in advance for radioactive material in foodstuffs and drinking water. It is important to make sure that the public is not exposed to radiation due to contaminated foodstuffs and also that no contaminated foodstuffs are placed on the market.

However, in the early phase it may be necessary to set a temporary ban on foodstuff and other natural goods from areas which are known, or anticipated to be heavily contaminated. The ban may be withdrawn when safety of foodstuff and other natural goods are ensured. Similarly, it could be rational to follow the EC maximum permitted levels of radioactive contamination and temporarily enforce them on the national level even though information concerning the situation is still limited.

Operational intervention level for temporary banning of foodstuffs and other natural goods:

– external dose rate is or is anticipated to exceed 10 μSv/h,

or

– the concentration in the air is or is anticipated to exceed
  - alpha emitters 0.1 Bq/m^3 (plutonium-239 and americium-241),
  - beta emitters 100 Bq/m^3 (strontium-90),
  - strong gamma emitters 1000 Bq/m^3 (cesium-137, a.o.).

PART B:

THE INTERMEDIATE PHASE OF AN EMERGENCY

10 PROTECTIVE MEASURES FOR THE PUBLIC

In the intermediate phase, the operational intervention levels form a basis for implementing protective measures from a radiation protection perspective. However, if residual doses to the public received during the early phase have been close to the chosen reference level, it may be appropriate to follow more stringent criteria than described in Part B.

Protective measures as described in Part B are relevant for the intermediate phase of any radiological or nuclear emergency.

10.1 Sheltering indoors

In the early phase of a radiological or nuclear emergency, sheltering indoors reduces the dose via inhalation and from direct exposure. In the intermediate phase, sheltering indoors may be necessary to continue in order to reduce the external exposure and to prevent contamination of people and indoor areas. After an eventual plume passage, sheltering locations should generally be ventilated, unless weather conditions can be expected to cause significant re-suspension of deposited radioactive material into the air.

In case of a nuclear power plant accident; if the passing of a radioactive plume takes less than 24 hours, then the sheltering indoors may be lifted partly already in two days. Even if the radioactive release is anticipated to continue for several days, it might still be appropriate to partly lift sheltering indoors after a few days.

Continuing or implementing sheltering indoors

Dose criteria: Sheltering indoors should be continued, or implemented if additional monitoring identifies more contaminated areas, if the projected total dose to an unprotected person exceeds 10 mSv in two days.

Operational intervention levels for continuing or implementing sheltering indoors:

– external dose rate exceeds 100 μSv/h,

or

– total deposited amount of strong gamma and beta emitters exceeds 10 000 kBq/m^2,
– deposited amount of alpha emitters exceeds 100 kBq/m^2 assuming the alpha emitters are in non-fixed form on the surface.

If the external dose rate or the deposition does not decrease below the operational intervention levels in two days, evacuation of the public in the area should be considered. In this case instructions must be given to the public, in order for it to prepare for evacuation and safe behaviour during evacuation through contaminated outdoor surroundings.

Partial sheltering indoors

The measure: "Partial sheltering indoors", means restricting staying outdoors only to necessary short-term actions. Partial sheltering may be recommended after the passage of a radioactive plume, or in case of a nuclear power plant accident where the release continues for a long period, however in significantly smaller amounts relative to the early phase. Areas where sheltering has not previously been applied, but which are subsequently identified to be more contaminated than previously assumed, may also be subject to partial sheltering recommendations.

Dose criteria: Partial sheltering indoors is relevant when the projected total dose to an unprotected person is higher than 10 mSv in the first month after the accident but still below 10 mSv in two days. This measure however presumes that exposure will decrease rapidly or can be reduced effectively by decontamination.

Operational intervention levels for partial sheltering indoors:

- the external dose rate is below 100 µSv/h; partial sheltering should be continued as long as the external dose rate exceeds 10 µSv/h,

or

- the total deposition of strong gamma and beta emitters is 1 000 - 10 000 kBq/m^2,
- the contamination by alpha emitters exceeds 10 - 100 kBq/m^2 and the radioactive substances may be in non-fixed form on surface.

Indoor areas should be ventilated and cleaned thoroughly (see chapter 11) immediately after bypass of the main plume or when information has been received that sheltering indoors can be partly lifted.

Instructions on how to perform the necessary actions outdoors are needed. During partial sheltering, especially children's outdoor activities must be restricted to a minimum.

During partial sheltering measures should be initiated to sustain important society functions, as for instance: Health care services, food store supply and necessary public transportation. Also measures for environmental decontamination should be initiated. (see chapter 11)

Lifting the sheltering indoors

Determining when to lift sheltering indoors partially or completely is based on e.g.: Data on the released radioactive material, the prevailing radiation situation, and the duration of the current sheltering indoors period. As prolonged sheltering rapidly cause other than radiological detriments, the total duration of sheltering indoors should generally not exceed two days. After two days the lifting or partial lifting of sheltering indoors should be considered and if the radiation level is still too high for sheltering indoors to be lifted, the public should be evacuated.

Dose criteria: Sheltering indoors can be lifted when the total projected dose to an unprotected person is below 10 mSv per month. In addition lifting requires that exposure will decrease rapidly or can be decreased effectively by e.g. decontamination.

Operational intervention levels for lifting the sheltering:

- the external dose rate is below 10 µSv/h,

or

- the total deposition of strong gamma and beta emitters is less than 1 000 kBq/m^2,
- deposition of alpha emitters is less than 10 kBq/m^2.

10.2 Restrictions of entrance to contaminated areas

Operational intervention levels for restrictions of entrance to contaminated areas:

– the external dose rate exceeds 100 µSv/h,

or

– the deposition of strong gamma and beta emitters in total exceeds 10 000 kBq/m^2,

or

– the amount of alpha emitters on surfaces exceeds 100 kBq/m^2 irrespective of potential mobility.

For contaminated areas only necessary entries are allowed, for example, those related to rescue services, food supply and other crucial services such as evacuation and urgent decontamination actions. Residence time in the area should be restricted to a minimum. When leaving the contaminated area to enter a less contaminated or clean area, monitoring and decontamination of vehicles and people is essential to avoid further spreading of radioactive material.

Restrictions of entrance to a contaminated area may not be feasible for transport by rail or by inland waterways. When transport by rail is concerned there are not necessarily any optional routes. Necessary train passage should then utilise the shortest possible route and the train carriages should then be monitored and decontaminated when needed. Transport by inland waterways is more preferable than any other form of transport, since external dose rates are very low in water areas, even when the surrounding land areas are heavily contaminated.

Access control can be relaxed when the external dose rate is below 100 µSv/h. Entries to a contaminated area can be allowed for the implementation of services necessary for the society, such as: health care, food supply or public transportation. Such entries should be accomplished along routes by which monitoring and decontamination points can be provided. The above mentioned also concerns airports, harbours and frontier transit points.

Access control or decontamination points are typically not needed any more when the external dose rate is below 10 µSv/h.

10.3 Evacuation and relocation

General aspects

Evacuation signifies a rapid, temporary removal of all or part of the members of public present in the contaminated area to a safe region by order of the authorities. Evacuation includes measures to secure the living conditions and important functions of society at the site of evacuation. Voluntary and spontaneous evacuation of an area, in the absence of a formal evacuation order, is not included in the concept of evacuation. Other authoritative relocations, executed under the responsibility of authorities, may supplement the evacuations when needed. Such relocations could for instance relate to transfers of animals, facilities and organisations of trade and industry, etc.

The premise of an evacuation is that the resulting relocation of people should be as short as possible. The evacuated areas should be decontaminated using all feasible methods in order to establish suitable living conditions. In case a temporary or permanent relocation is considered, other factors than the radiological situation, will have bearing on this decision.

Relocation has a strong impact on people's lives. Instead of a temporary relocation, living in the contaminated area as well as trade and industry may be continued after specifically aimed decontamination actions and implementation of restrictions of use for designated areas. It may be appropriate to carry out a temporary relocation during the implied decontamination actions.

Evacuation

Dose criteria: Evacuation should take place rapidly to avoid a projected dose to an unprotected person of over 20 mSv during the first week after the emergency.

Operational intervention levels for evacuation of the population:

If the following conditions last for more than two days

– external dose rate is higher than 100 μSv/h,

or

– total deposition of strong gamma and beta emitters is higher than 10 000 kBq/m^2,
– deposition of alpha emitters is higher than 10 kBq/m^2 assuming the alpha emitters are in non-fixed form on surfaces.

Evacuation can also be carried out when radiation levels are lower than the operational intervention levels if it can be easily and quickly carried out, for example, when a small group of people is concerned. Relaxing the conditions of the operational intervention level may be appropriate in cases where evacuation is difficult due to for example the large number of people to be evacuated or lack of transportation capacity. In these cases, evacuation can be carried out partially, focusing on certain individual groups of people, such as children and pregnant women.

Relocation

The duration of relocation should be based, not only on the radiation monitoring and dose calculations, but also on societal, psychological and economic considerations. In resettlement of populations, significant consequences are associated with rearranging and / or rebuilding public infrastructure, e.g. schools, health care, work places etc.

An evacuation may lead to relocation or permanent relocation of the members of public to uncontaminated areas, if it turns out that radiation levels in evacuated areas do not decrease at the anticipated rate. It is necessary to consider relocation if the projected dose to an unprotected person exceeds 10 mSv in one month after the decontamination of the area.

The duration of relocation can be from a few days to months or even up to two years (relocation) as long as return is reasonably foreseeable. Otherwise the relocation is termed permanent relocation. Relocation can also be started weeks or months after the actual emergency took place, if it is estimated useful, in order to reduce the long-term exposure from the deposition. In this case the deposited activity would not require a rapid evacuation but, on the other hand, the accumulate doses during long-term exposure could be considerable.

Operational intervention levels for relocation:

– external dose rate in habited areas is on average higher than 10 µSv/h,

or

– deposition of strong gamma and beta emitters is in total higher than 1 000 kBq/m^2,
– deposition of alpha emitters is higher than 10 kBq/m^2, and mobile.

10.4 Lifting evacuation or relocation

Dose criteria: The public can return to an area, when the dose to an unprotected person is less than 10 mSv in the first month after return and when it can be expected that the monthly dose will decrease rapidly due to e.g. decontamination or radioactive decay. It should still be assessed and confirmed, however, that the annual dose will remain below the chosen reference level taking all the protective measures; e.g. decontamination, into account.

Operational intervention levels for lifting evacuation or relocation:

– the external dose rate is on average less than 10 µSv/h in habited areas and it is expected to decrease quickly, or
– deposition of strong gamma and beta emitters is in total below 1 000 kBq/m^2 and will decrease rapidly,
– deposition of alpha emitters is less than 10 kBq/m^2 and will decrease rapidly.

10.5 Reducing exposure of inhabitants in contaminated areas

Inhabitants in contaminated areas can reduce the exposure from radiation by performing several actions. Instructions on which measures to implement and how to do so should be issued by the authorities. The instructions may include the following:

- Radiation doses may be significantly reduced by simple ventilation and cleaning of indoor areas. During decontamination, cleaning and other types of dusty work, protective clothing and respirator should be used, when necessary.
- Washing reduces the amount of ingested radionuclides. It is especially important to wash hands frequently and carefully.
- Leaving outdoor clothing and shoes by the door when entering a building, as well as frequent washing and changing of clothes reduces the degree of recontamination of indoor areas. Also pets should be cleaned before entering an indoor area.
- Air filters should be changed or cleaned as quickly as possible after the passage of the radioactive plume.
- Decontamination of yards and the outer surfaces of residential buildings reduces the dose from the living environment. During decontamination activities - especially in case of dusty work - protective clothing and respirators should be used.

- The dose from foodstuffs is reduced when needed by restricting the use of self-grown products, and such products as wild berries, mushrooms and game.
- Decontaminating vehicles, tools and goods used outdoors and redoing this after moving about in the contaminated area may further reduce doses.

10.6 Protection of workers in the contaminated area

Necessary work during the intermediate phase

During the intermediate phase of an emergency there is usually no need to perform urgent actions which may result in transgression of dose limits. Workers, either self-employed or working under an employer, involved in protective and mitigation measures are subject to the dose limits for occupationally exposed workers.

In the intermediate phase, actions that alleviate the consequences of an emergency are, for example: decontaminating indoor areas and the environment, repairing and decontaminating the accident site and other buildings, securing the contaminated area, various surveying to determine radiation levels and managing and disposing of waste generated during decontamination. Other necessary works are, e.g., health care and social services, maintaining public law and order as well as civil infrastructure (e.g. supply of electricity, heating, water foodstuffs, etc.).

This work is a planned activity, and as such, worker exposures and radiation doses should be assessed prior to, and monitored during, the work.

Protective measures shall be planned and performed in the way that the radiation dose to workers is as low as reasonably achievable and the dose limits are not exceeded. Protection of a worker is the responsibility of the employer, unless they are specifically assigned under an emergency organisation.

Operational intervention levels to reduce radiation dose to workers:

- external dose rate in working environment is higher than 10 μSv/h,

or

- deposition of strong gamma and beta emitters is higher than 1 000 kBq/m^2,
- deposition of alpha emitters is higher than 10 kBq/m^2, if the alpha emitters are mobile.

Operational intervention levels for lifting measures to reduce radiation dose to workers:

- external dose rate in working environment is less than 1 μSv/h,

or

- deposition of strong gamma and beta emitters on surfaces is less than 100 kBq/m^2,
- deposition of alpha emitters is less than 1 kBq/m^2, if the alpha emitters are in non-fixed form on surfaces.

The overall aim is to reduce radiation dose by decontamination and other actions as rapidly as possible and sensible. Decontamination should be continued as long as these actions reduce radiation dose efficiently and effectively

10.7 Measures to reduce radiation doses to members of the public working in contaminated areas

People who do not participate in the work to alleviate the consequences of the emergency but exercise their own profession in the contaminated area, are equated with members of the public as regards radiation protection. If the projected dose to such a person is higher than the dose to the rest of the public, he should be given instructions on how to reduce the radiation dose. Protection of workers is the responsibility of the employer.

- In case the work place cannot be moved from a contaminated area and postponing the work will cause major disadvantages (e.g. in some production plants), exposure should be limited by reducing exposure time and by, e.g., decontaminating the working environment.

- In the case of work which can be postponed without major harm (e.g. logging woods), the work should be carried out later when the projected dose due to external as well as internal exposure has reduced.

Primarily, exposure of workers should be reduced by decontaminating the working environment. It is important to recognise the work phases and methods which cause the highest exposure (e.g. dust producing activities) and target decontamination and other actions to those.

Examples of measures to reduce radiation doses to workers:

- reducing inhalation of airborne radionuclides by limiting dust generation and suppressing suspension (e.g. by wetting of dusty surfaces),
- requiring workers to wear protective clothing and respirators if at risk of inhaling radioactive dust while working,
- requiring workers to clean their skin by washing thoroughly after work,
- stopping contamination from spreading into clean working areas,
- if possible, moving radioactive waste to a place where it does not cause any dose to workers,
- minimizing work periods in contaminated areas and in the immediate vicinity of radioactive material or by appropriate use of radiation shielding, and
- restricting working time.

10.8 Decontamination and monitoring of people and clothing

Decontamination is needed to reduce the accumulated dose of a contaminated person and to stop the contamination from spreading into clean areas. Radiation monitoring of persons and their clothes should be offered. The monitoring program should take into account the need for monitoring of de facto contamination as well as monitoring to confirm non-contamination.

Radiation monitoring of members of the public

Radiation monitoring as well as decontamination facilities should be arranged for those people who have been in a contaminated area or are moving from one contaminated area to a less contaminated area. Monitoring and decontamination facilities should be situated in a suitable local station, e.g. at a public indoor swimming pool, sports facility or school wash rooms. Personal data and radiation monitoring results shall be recorded.

Those people who are suspected most contaminated are monitored first. However, monitoring should ideally be arranged for everybody who wants to get measured and have possibly been in the contaminated area.

Thyroid monitoring

Thyroid monitoring is usually not needed for decision making purposes. Information on thyroid doses is used in assessing total residual dose. For these purposes monitoring should be activated if it can be feasibly arranged and carried out in a timely manner.

The significance of the results of thyroid monitoring is dependent on the time of the measurement after exposure, as the amount of iodine in the thyroid is reduced relatively rapidly. Activating a thyroid monitoring program among pregnant women and children should be considered, when the iodine concentration in the air is or is anticipated to exceed 1000 Bq/m^3 for two days.

Decontamination of people

Decontamination of people is needed to remove radioactive material from skin. The aim of decontamination is to bring surface specific activities below 4 Bq/cm^2 for strong gamma and beta emitters and below 0.4 Bq/cm^2 for alpha emitters. These radiation levels can be detected only by use of a surface contamination monitor. Decontamination is always necessary when survey monitors detect dose rates exceeding the prevailing dose rate at the monitoring station. Decontamination may be carried out by the contaminated individual or in a controlled environment:

- If monitoring of a person results in dose rates exceeding the station background by no more than 0.5 μSv/h, the exposed person is given instructions to wash at home or someplace designated for that purpose. Clothes should either be washed or disposed of.

- If monitoring of a person results in dose rates exceeding the station background by 0.5 μSv/h or more, the exposed person should be guided to a controlled decontamination location where the efficiency of decontamination can be verified by monitoring.

Operational intervention levels for normal decontamination:

– if the external dose rate measured near the skin exceeds the prevailing dose rate, but it is less than 0.5 μSv/h compared to the prevailing dose rate of the monitoring station,

or

– if the amount of strong gamma and beta emitters on skin surfaces is higher than 1 Bq/cm^2 but less than 1000 Bq/cm^2, or if the amount of alpha emitters on skin surfaces is higher than 0.1 Bq/cm^2 but less than 100 Bq/cm^2.

Operational intervention levels for guiding a contaminated person to a controlled decontamination:

– if external dose rate measured near the skin exceeds the prevailing dose rate of the monitoring place by more than 0.5 μSv/h,

or

– if the amount of beta emitters on skin surfaces exceeds 1000 Bq/cm^2 or if amount of alpha emitters on skin surfaces exceeds 100 Bq/cm^2.

The decontamination process should be repeated if needed. When cleaning no longer reduces the contamination as verified by measurements, the cleaning can be stopped. If the dose rate remains above 0.5 μSv/h, the character of the contamination should be determined, e.g. if it is internal.

Individuals who have been severely contaminated shall be decontaminated as described above and subsequently sent for further examination and possible further decontamination actions. Very serious contamination causes a significant risk of skin damage and risk of ingestion of radionuclides.

Operational intervention levels for sending a contaminated person to further examination:

– dose rate measured near skin surface exceeds the prevailing dose rate by more than 2 μSv/h,

or

– if the amount of beta emitters on skin surfaces exceeds 10 000 Bq/cm^2, or if the amount of alpha emitters on skin surfaces exceeds 1 000 Bq/cm^2.

For example, if strontium-90 activity concentrations on the skin were to exceed 10 000 Bq/cm^2, the resulting skin dose over two hours would be more than 50 mSv. Most likely people could get seriously contaminated only at the place of accident, as, e.g., the firemen that were extinguishing the reactor fire at Chernobyl nuclear power plant. People who are severely contaminated (orders of magnitude above the OIL's) shall be offered long term medical surveillance.

Managing contaminated clothes and shoes

Contaminated clothes and shoes cause a radiation dose to the person wearing them and may spread radioactive material into areas that are less contaminated. To determine the contamination of clothes and shoes, they are monitored separately.

- If the external dose rate measured from the surface of clothes or shoes exceeds the prevailing dose rate by 0.5-10 μSv/h, the clothes or shoes should be changed as soon as possible. Contaminated clothes and shoes must be washed and monitored before they are used again.

- If the measured dose rate exceeds 10 μSv/h, the clothes and shoes should immediately be placed in sealed plastic bags for intermediate decontamination or disposal. There should be clean clothes and shoes available at decontamination stations.

11 PROTECTIVE MEASURES TO REDUCE RADIATION EXPOSURE IN THE ENVIRONMENT

The environment comprises urban and developed, cultivated, as well as natural areas. Urban and developed areas include residential and business areas, industrial areas, cultivated and other farming areas, road-, harbour-, airport- and warehouse areas, parks, playgrounds and other built-up recreation areas (e.g. golf courses, skiing centres, camping areas and public beaches). The natural environment encompasses all other areas in the region.

The objective of decontamination and other actions to reduce the radiation dose is to obtain contamination levels as low as reasonably achievable. In order to evaluate the need for decontamination, contaminated segments of the environment should be labelled in accordance with the contamination levels predefined in table III. The contamination level should then be used to assess potential doses.

In the first year, the dose from the environment should not exceed 10 mSv. When assessing the radiation dose from the environment, the exposures received in different areas; both indoors and outdoors, should be taken into account. The individual operational intervention levels given in this chapter do not, however, ensure that the total radiation dose due to human activities in a contaminated environment will remain below 10 mSv.

Decontamination generates radioactive waste the management of which is discussed in Chapter 13.

Table III*: Contamination levels denote the severity of the radiation exposure as a result of contamination and are used primarily to evaluate the need for decontamination.*

Contamination levels[1)]	External dose rate	Strong gamma and beta emitters together	Alpha emitters, possibly in non-fixed form on surface
Extremely contaminated	over 100 μSv/h	over 10 000 kBq/m^2	over 100 kBq/m^2
Heavily contaminated	10 -100 μSv/h	1 000 - 10 000 kBq/m^2	10 - 100 kBq/m^2
Contaminated	1 - 10 μSv/h	100 - 1 000 kBq/m^2	1 -10 kBq/m^2
Slightly contaminated	less than 1 μSv/h	less than 100 kBq/m^2	less than 1 kBq/m^2
Non-contaminated (no protection measures anticipated)	contamination is low that dose rate is on the level of normal background	no contamination at all or very low contamination	no contamination at all or very low contamination

[1)]It is assumed that radioactive material is still on the surfaces of soil, buildings, goods etc. and have not migrated deeper into the soil or other material

11.1 Decontamination and other actions to reduce dose

During fallout the first actions should be directed to environments where people spend most of their time or where a lot of people stay with a priority to children. These kinds of environments are, among others: residential houses, schools, children's day care centres, commercial buildings, offices, production plants, yards, parks and roads. In production facilities also all such structures and equipment should be cleaned from which radioactive material could be transported into the products. In certain public places, such as schools, children's day care centres and shopping centres the effectiveness of decontamination should be verified. If, following decontamination, high values are still detected, decontamination should be repeated.

Decontamination and ventilation of indoor areas is very important. Ventilation and decontamination is needed since some radioactive material will enter buildings despite efforts to block the air intakes. Especially, efficient cleaning is needed with such indoor areas where people spend much of their time. Cleaning should be carried out as quickly as possible after the contamination, in order to avoid permanent attachment of radionuclides to various surfaces and to limit exposure. Cleaning should be repeated to avoid recontamination. Decontamination efforts should be prioritized so as to clean areas in order of decreasing occupancy. Radioactive material should be reduced and removed also from vehicles and from tools and goods that have been used outdoors. When moving from a more contaminated area to a less contaminated or clean area, measurement and decontamination points should be arranged and all traffic from the area should be directed via these points. At these points the contamination of vehicles, power tools, tools, goods and people are measured.

Radiation dose caused by the work should be taken into account in decontamination and cleaning. Protective clothing and respirators should be used when needed, especially, if the work is dusty.

Indoor areas

The radiation dose can be reduced significantly using simple cleaning methods for indoor areas. Decontamination of indoor areas should be done like an ordinary and thorough cleaning. Re-suspension of radioactive material causes contamination of skin, hair and clothes, increases the dose via inhalation and re-contaminates already cleaned indoor areas. Use of a wet cloth for dusting and wiping doors and walls as well as washing of floors and windows helps to reduce the risk of re-suspension. Vacuum cleaner bags and filters should be removed and placed in sealed plastic bags. Care should be taken not to re-suspend or inhale dust. Used vacuum cleaner bags should be disposed of in the same way as air filters from ventilation units (see below). Other waste generated in cleaning can be disposed of together with ordinary waste.

Operational intervention levels for cleaning indoor areas:
Cleaning indoor areas

– the external dose rate outdoors exceed 1 μSv/h,

or

– outdoor deposition of strong gamma and beta emitters exceeds 100 kBq/m^2,
– outdoor deposition of alpha emitters exceeds 1 kBq/m^2, and potentially mobile.

Thorough cleaning of all indoor surfaces

– the external dose rate outdoors exceed 10 μSv/h,

or

– outdoor deposition of strong gamma and beta emitters exceeds 1 000 kBq/m^2,
– outdoor deposition of alpha emitters exceeds 10 kBq/m^2, and it is possibly in non-fixed form on surfaces.

Indoor areas that were actively ventilated while deposition of airborne radionuclides occurred could be heavily contaminated. Recommendations regarding changing appropriate air filters as soon as deposition has ceased should be considered. This stops the radioactive materials attached to air filters from detaching and spreading in the surroundings. Used air filters and waste from filters should be sealed in a plastic bags or containers and delivered according to instructions given in the situation to a separate waste collection point arranged for this.

Urban and developed areas

In urban and developed areas the surfaces to be cleaned vary considerably with respect to character and size. Surfaces can roughly be divided as follows:

– outside surfaces of buildings,
– roads, streets, covered areas, e.g., asphalted, tiled, sand covered and paved areas,
– land areas and green spaces, e.g., lawns, sports fields, sand based curses, uncared for urban areas,
– trees and bushes.

Operational intervention levels for urgent decontamination of built-up environment:

– external dose rate exceeds 10 μSv/h,

or

– outdoor deposition of strong gamma and beta emitters exceeds 1 000 kBq/m^2,
– outdoor deposition of alpha emitters exceeds 10 kBq/m^2, and potentially mobile.

Decontamination is started in the immediate surroundings of people, e.g., yards, passages and other areas that people have to use. The first actions are those that can be made easily and widely. The goal of decontamination actions is to reduce the external dose rate below 1 μSv/h, in order to allow lifting of restrictions on entrance or use of the area. Even below this action level it may be appropriate to carry out decontamination actions.

Factors that affect choice and prioritisation of methods of decontamination are:

- radioactive materials and their amounts,
- weather conditions during contamination and after it, e.g. rain,
- extent of contaminated areas,
- character of surfaces to be cleaned,
- effectiveness of the desired cleaning, time and resources needed for cleaning,
- time of season, and
- the public in the area to be decontaminated, which affects the urgency and possibility of the public to participate in cleaning of immediate surroundings.

If radioactive material cannot be removed from the environment, it could be appropriate to have it fixed where it is or cover the contaminated surfaces. This will limit the potential for airborne spreading, inhalation and contamination. Fixing and covering might be a good solution in certain cases, especially if the contamination consists mainly of short-lived radionuclides.

Fixing material will not decrease external gamma radiation or external dose rate due to strong beta emitters. Only by covering contaminated surfaces with a thick enough layer of clean material will reduce the external dose rate.

Natural environment

Decontaminating the natural environment is usually not appropriate, especially if resources are needed to decontaminate areas of higher priority. In order to minimize radiation doses, restrictions of use should be issued.

Vehicles and other machinery

Vehicles and other machinery that have been outdoors during fallout become contaminated, like the surrounding environment, and need to be decontaminated before use.

Operational intervention levels for decontaminating vehicles and machinery:

- external dose rate is over 1 μSv/h,

or

- deposition of strong gamma and beta emitters is higher than 100 kBq/m^2,
- deposition of alpha emitters is higher than 10 kBq/m^2, and potentially mobile.

Vehicles and other machinery and tools used for managing contaminated materials should be decontaminated regularly. With this measure mainly the dose of the person operating the vehicle or the tool is reduced. In vehicles and other machinery the activity is accumulated especially in air filters, on wings, chassis, and tires. Vehicles, machinery and tools should be cleaned by washing with clean water.

Usually the available monitors are survey meters that only measure external gamma dose rate. Decontamination is always needed when a survey meter detects dose rates exceeding the prevailing dose rate at the monitoring site. In order to avoid contaminating the survey meter, measurements are performed as close as possible to the object to be measured, without touching it.

When monitoring contamination levels of vehicles, measurements should be performed inside the vehicle. If the external dose rate due to radioactive material on surfaces of a vehicle or machinery exceeds the prevailing dose rate in the monitoring area by 1 μSv/h, it should be taken to thorough decontamination. For example, if the external dose rate inside a vehicle or machinery is over 1 μSv/h, operating such a vehicle for 200 hours may cause a dose of 0,2 - 2 mSv to the driver.

Operational intervention levels for using vehicles and other machinery:

After a thorough decontamination, a vehicle or other machinery *can only be used for temporary and short-term transportations and operations if the*

– external dose rate measured inside the vehicle still exceeds 1 µSv/h.

After a thorough decontamination, a vehicle or other machinery *is not to be used if the*

– external dose rate measured inside the vehicle still exceeds 10 µSv/h.

Hand tools and goods

Hand tools and goods that have been outdoors are contaminated in the same way as the environment, which is why they need to be washed before use.

Operational intervention levels for cleaning tools:

– external dose rate is higher than 1 µSv/h,

or

– deposition of strong gamma and beta emitters exceeds 10 kBq/m^2,

– deposition of alpha emitters exceeds 1 kBq/m^2 and is potentially mobile.

Tools that are used to handle contaminated materials should be cleaned regularly. This measure reduces, above all, the radiation dose to the person using the tools.

The aim is to avoid bringing large numbers of items from contaminated areas to less contaminated or clean areas before first verifying the contamination level of the goods. If goods are however brought they shall be monitored at a measurement point. Decontamination is always needed if a survey meter detects values exceeding the prevailing dose rate of the monitoring place. Measurements are performed as close as possible to the object without touching it.

Items that have been outdoors without protection and also in certain cases goods that have been indoors may be surface contaminated. Such items shall be decontaminated. In case items are in a package, the outer layer of the package should be removed. In case decontamination of the article or tool is not possible or the external dose rate of the article, even after cleaning, exceeds the prevailing dose rate of the monitoring place by 1 µSv/h, the items shall be covered and sealed with plastic foil as well as possible and their use should be assessed separately case by case. The plastic will stop the spreading of contamination from the goods when moving them about.

If the external dose rate on the surface of a tool or article exceeds the prevailing dose rate of the monitoring place by 10 µSv/h, the item should be stored temporarily in a place where it does not cause any dose to workers or members of the public.

The acceptability of raw materials used in trade should be assessed. The assessment should separately consider the activity concentration of the raw material, transport of radionuclides and behaviour of radionuclides in the production process and the purpose of use of the end product.

Decontamination points

Sites or points of decontamination should be set up in places that provide easy access to a sewer system for waste washing waters. Separate collection of washing waters is not usually needed. Washing points will become contaminated and radionuclides can be accumulated, e.g., to sedimentation basins. This is why decontamination points should be cleaned regularly. Decontamination workers at washing sites should wear protective and washable clothes and, as appropriate, respiratory protection. Protective clothes are to be changed and washed regularly.

It is recommended to have a collection point for removed, contaminated package or wrapping materials at decontamination sites.

Measurement and decontamination points shall be arranged for rail and waterborne traffic in suitable places and, as appropriate, also at airports and frontier crossing points.

11.2 Restrictions on use of areas

Regarding decontamination, residential areas should be given first priority. In addition, other urban and developed areas should be decontaminated. Areas that have not yet been decontaminated might need use restrictions. Restrictions of use are given to areas whose use is not entirely necessary, such as recreational areas.

Restrictions of use of land areas may also concern its use for future purposes, for example, for residential use or agricultural activities. Restrictions of use of land areas for future purposes in the recovery phase are not included in this guide.

When giving restrictions for areas in recreational use, both contamination risk and external dose rate should be taken into account. Contamination risk here means that skin, hair and clothes are contaminated and radioactive material is transported, for example, into indoor areas or to clean areas. During the first few months, restricted entry in the area might be needed to reduce the contamination risk, even though the external dose rate would not require it. The contamination risk decreases rather quickly and thus restrictions are probably necessary for the maximum of one year.

Restrictions of use of recreational areas are, for example:

- restricting people from moving and training outdoors, for example, in nature, parks and leisure areas,
- restricting use of shores (e.g. beaches),
- restricting use of parks and other public outdoor areas, e.g. children's playgrounds, and
- restricting fishing, hunting and collecting of mushrooms and other products of nature.

Operational intervention levels for restriction of use of built-up recreational areas (e.g. parks, playgrounds):

– external dose rate is higher than 1 μSv/h,

or

– deposition of strong gamma and beta emitters in total exceeds 100 kBq/m^2,

or

– deposition of alpha emitters exceeds 1 kBq/m^2 and it is possibly in non-fixed form on surfaces.

Restriction that concern use of children's playgrounds, staying in parks, public events (e.g. outdoor concerts, outdoor fairs, athletic competitions such as orienteering) and use of recreational areas (e.g. amusement parks, camping areas, golf courses, ski centres, outdoor routes) can be relaxed or lifted in most fallout situations after a few months.

Operational intervention levels for restriction of recreational use of natural areas (e.g. forests):

– external dose rate is higher than 10 μSv/h,

or

– deposition of strong gamma and beta emitters in total exceeds 1 000 kBq/m^2,

or

– deposition from alpha emitters exceeds 10 kBq/m^2 and possibly mobile.

The same activity concentration levels are used with game, fish, berries and mushrooms and other natural products as with other foodstuffs on the market. It should be noted that even if fishing and picking mushrooms should be restricted for a longer period because of the high activity concentrations, the restrictions on entry for the area can be lifted earlier.

In water areas the radioactive material are diluted in the vast amount of water. Even if fishing is restricted it would not hinder other recreational use (e.g. boating, swimming). Staying at the shore might have to be restricted, though, because of contamination of shore soil.

It should be taken into account that pets (e.g., dog and cats) bring radioactive material inside on their fur and feet. This is why the walking areas should be chosen to keep the contamination of pets as low as possible and why the animals should be washed after coming in, if possible.

11.3 Industry and trade in contaminated area

Contamination of the environment may have an effect on industry and trade and therefore give reason to take actions. Such actions can be, e.g., redirection of production or, in an extreme case, to restrict production. Contamination of the environment may affect

- production, e.g. industry, forestry, professional fishing, peat and bio fuel production, and

- other trades, e.g. central warehouses and services of travel and leisure in the contaminated area.

When considering whether to continue production or trade, the following should be taken into account: dose to workers, contamination of products or raw material and also possible dose to customers.

Acceptability of non-food products

Acceptability of use of products should be assessed separately for each product taking into account the product's concentration or contamination level and end use. Exemption and clearance levels shall not be used during emergencies.

During a nuclear or radiological emergency, concentration or contamination limits should be considered for each product according to their end use. If the limits cannot be reached, raw materials could be acquired from clean areas. Also the production can be redirected in order to produce less contaminated products or products for other purposes. Case-specific instructions on the acceptability of use of products are given by the regulatory authorities.

Forestry

In the natural environment, there are methods to reduce transport of radioactive material from ecosystem into end products. For example, in forestry, fertilising decreases the uptake of radionuclides by roots of plants and trees. Fertilising has an effect of many years. Profitability and time of realising depend on the growing period of trees and forest type.

When obtaining wood, logging times can be planned so that trees are felled before their gradual uptake of radionuclides through the roots. On the other hand, suitable harvest time can be decided in the long run, also considering, e.g., fertilising and decay of radioactive material.

Use of raw material can be directed to, e.g., paper manufacturing (not mechanical wood processing such as manufacturing furniture and building houses) where only a part of the radioactive material finds its way to the end product. However, directing raw materials to other uses may create new exposure pathways which may need attention. These may include accumulation of radionuclides to certain parts of the industrial processes which may cause exposures to the workers, accumulation of waste or increases in the releases of radionuclides to the environment.

12 PROTECTIVE MEASURES ON FOODSTUFFS, DRINKING WATER AND ANIMAL FEED

In a nuclear or radiological emergency, foodstuffs, raw materials, household water and animal feed may become contaminated. Contamination can also occur in various phases of production and processing, e.g. in field cultivation and to some extent also in green houses, storehouses, production plants and stores. In the intermediate phase, radioactive material may be transported via the food chain into foodstuffs. In fallout situations the surface water becomes contaminated but groundwater remains clear.

Maximum levels of radioactive contamination (maximum permitted levels) for foodstuffs, household water and feed are needed in order to decrease radiation doses by ingestion. If the permitted levels are exceeded, the products in question are not to be used. Similarly, limitations may be needed for foodstuff and feed production, and for water supply, if it is estimated that the maximum permitted activity levels of products and drinking water are exceeded. It is however possible to take actions that decrease the amount of radioactive material in foodstuffs, drinking water and animal feed. These actions secure the utility of products and drinking water, and the continuation of production.

Limitations on the use of foodstuffs may be more stringent than what the activity levels would require. This is necessary if the total radiation dose via other exposure pathways cannot be reduced to acceptable levels, even if measures, such as decontamination of the environment, have been taken to decrease the radiation exposure. In the choice, implementation and timing of such measures, and factors other than just exposure are to be taken into account.

The concentrations of radioactive material in foodstuffs, drinking water and feed shall be determined before release to the market. The products should be measured with a method appropriate for the purpose. The concentrations of radionuclides can also be assessed based on the characterization of the fallout in the area and subsequent evaluation of the transfer of radioactive material into foodstuffs, drinking water and feed. However, such assessments should always be verified by measurements.

12.1 Maximum levels for foodstuffs, drinking water and animal feed

Enforcing the maximum permitted levels of the EU

In fallout situations, restrictions for use of foodstuffs might have to be considered to ensure, among other things, safe food supply and clean foodstuffs as well as aspects of social and economic factors connected to food production. In the regulations of the EU, preparations have been made for the EU Council to issue, on the proposal by the EU Commission, a separate resolution concerning implementation of case-specific maximum permitted levels of radioactive contamination for foodstuffs and drinking water.

The Commission can, when contamination of the environment is very probable or has already taken place, enact the earlier confirmed maximum permitted levels for radionuclides in foodstuffs and drinking water (Table IV). The maximum permitted levels are applied in the EU's internal trade, including import into EU, and the member states are obliged to follow them. Foodstuffs that exceed the maximum permitted levels are not to be exported, either. In Finland the same maximum levels are used, also for situations in which the Commission has not yet given the activity levels for enactment.

The maximum permitted levels can be changed, if the situation calls for it, and their validity can be adjusted by the Council resolution.

Maximum permitted levels can be lowered when it is possible and reasonable to reduce the dose from foodstuffs during a situation lasting several years.

Elevating the maximum permitted levels may be necessary if there is a wide crisis due to some other reason than radiation hazard, concerning food supply, or if the issue concerns distinct foodstuff which is not frequently used.

Maximum levels for foodstuffs and drinking water

The aim[1] is that the total radiation dose from foodstuffs in the first year after the emergency is below 1 mSv. In severe events, in which it is not possible to keep dose levels below 1 mSv, care should be taken that the dose, however, is in all cases below 10 mSv during the first year. In Table IV the individual maximum levels (activity concentrations) do not guarantee that the total radiation dose from foodstuffs is below 1 mSv.

Table IV. *EU Maximum permitted levels for various foodstuffs and drinking water*

	Activity concentration, Bq/kg		
Radionuclides[1]	**Baby[2] food**	**Dairy products and liquid foodstuffs[3]**	**Other foodstuffs[4]**
Strontium isotopes in total	75	125	750
Iodine isotopes in total	150	500	2 000
Plutonium and trans-plutonium isotopes in total	1	20	80
Other radionuclides in total[5], with half-life over 10 days, e.g. ^{134}Cs and ^{137}Cs	400	1 000	1 250

1) Maximum levels for different groups of radionuclides are not dependent on each other. Each level applies separately.
2) Infants up to 6 months.
3) Including drinking water.
4) For some not frequently used foodstuffs, e.g. certain spices, the activity levels to be enacted are ten times higher than the values in this table for basic foodstuffs.
5) Not including: C-14 (carbon), K-40 (potassium) and tritium

[1] The aim in Codex Alimentarius (CODEX STAN 193-1995, Rev.3-2007)

Restrictions due to the Chernobyl accident

Due to the Chernobyl accident, the following maximum levels for foodstuffs imported from outside the EU are still valid: For dairy products and baby food, the accumulated maximum level of caesium-137 and caesium-134 is 370 Bq/kg. For other foodstuffs the accumulated maximum level of caesium-137 and caesium-134 is 600 Bq/kg [2].

For natural products on the market, including game, mushrooms and fishes of prey in lakes, the valid Commission recommendation[3] is that the accumulated caesium-137 and caesium-134 concentration in products does not exceed 600 Bq/kg in internal trade of the EU.

The activity levels due to the Chernobyl accident are suspended if the activity levels of Table IV are put into force due to a new nuclear or radiological emergency.

International trade of foodstuffs with countries outside the EU

The international trade of foodstuffs follows the Codex Alimentarius that includes recommended guideline levels[4] (activity concentrations) for foodstuffs (Table V), in case the national or EU food legislation does not demand otherwise. The activity limits concern both export and import trade. When exporting foodstuffs, the legislation of the country of destination shall be followed.

The aim of the Codex Alimentarius is to keep the annual radiation dose from foodstuffs below 1 mSv. The total dose is kept below 1 mSv if the proportion of contaminated foodstuffs that are near the guideline levels is 10% and the proportion of clean foodstuffs is 90% of the total consumption during the first year. Codex Alimentarius guideline levels have not been lowered in the later years, as it is assumed that the amount of contaminated products in international trade is decreased due to, among others, market mechanism and measures to decrease the activity concentrations in foodstuffs. It is likely that the proportion of contaminated foodstuffs will remain clearly below one percent of the total consumption.

Countries may consider lowering the limit values relative to the Codex Alimentarius on the national level, if the proportion of near-to-maximum contaminated foodstuffs is more than 10% in the country in question. For instance, such a situation may occur following very extensive fallout. Countries may also consider a lower value for extensively used foodstuff such as milk.

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[2] Council regulation (ETY) N:o 737/90 and its amendments in Council regulations (EY) N:o 686/95, 616/2000 and 806/2003

[3] 2003/274/Euratom

[4] 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.”

Table V. *Guideline[1] levels for foodstuffs in trade with countries outside the EU.*

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

1) *Codex Alimentarius*

Maximum permitted levels for feedstuffs in the EU

In the EU, the maximum permitted levels for feedstuffs by the Council resolution are shown in Table VI. The maximum permitted levels of feedstuffs do not guarantee that the activity concentrations of foodstuffs produced are below the set value. Feedstuffs with activity concentrations close to the maximum permitted levels can only be used as a part of feeding.

Maximum permitted levels apply to trade in the EU, including import to the EU, and the member states are obliged to follow them. Feedstuffs exceeding the maximum permitted levels must not either be imported. In Finland the same action levels are used also for situations where the Commission has not yet given the activity levels for enactment.

Table VI. *EU Maximum permitted levels for feedstuff (caesium-134 and caesium-137)*

Group of animals	**Activity concentration in feed, Bq/kg** [2 and 3]
Pigs	1250
Poultry, lambs and calves	2500
Other	5000

1) Commission regulation (Euratom) No. 770/90
2) The values of feed take into account any accumulation in the food chain, in order for food not to exceed the maximum permitted levels; the values do not guarantee this in all situations, and they do not eliminate the obligation to examine the activity concentrations of animal products that are intended for food.
3) These values are applied with ready feeds.

12.2 Actions and restrictions concerning food production, processing and water supply

The aim of actions and restrictions concerning food production, processing and water supply is to keep the concentrations of radioactive material in foodstuffs and water for human consumption below the maximum levels given in chapter 12.1. The products that have been well packaged or covered in the early phase, such as raw materials and feed, will remain clean.

The activity concentrations can be lowered through various actions in food production and water supply. The applicability of the selected actions is affected by the extent of fallout, time of contamination, the concerned foodstuffs and the production conditions of the area. In choosing, realising and timing these actions, also other factors than merely decreasing the radiation dose are taken into account.

Foodstuffs and feed exceeding the maximum values are not to be allowed on the market. Products that exceed the maximum levels or which are not acceptable because of the radioactive material in them should be processed as waste (see Chapter 13), unless the products can be otherwise utilised.

Contamination of production plants may also contaminate the end products or raw materials. This is why thorough decontamination of production plants is necessary, even in the areas of relatively low contamination. At later stages, raw materials are the most significant cause for contamination of the end product in food production and further processing. Raw materials can be obtained from clean areas or, for example, a similar substituting raw material can be used. In processing, the possibilities to decrease activity concentrations in the end products are limited and there is no guarantee that consumers will accept the products for use.

12.3 Measures concerning use of natural products and cultivation for own consumption

National radiation protection authorities and food safety authorities will give advice and recommendations to households on cultivation for own consumption and use of natural products. Advice may concern possibilities to have foodstuffs measured or, for example, recommendations to avoid such species of plants, fish, game or mushrooms that accumulate significantly more radioactive material than others. The radiation dose from natural products and self-cultivated crops should be kept as low as reasonably achievable (ALARA).

13 PROTECTIVE MEASURES ON MANAGEMENT OF RADIOACTIVE WASTE

13.1 Separation of waste

Waste that contains radioactive material may be generated in decontamination or from discarded products. These wastes cannot necessarily be processed via the normal waste management because of the following.

- The amount of waste produced, especially resulting from decontamination and restrictions of use of foodstuffs.
- The waste may be unsuitable for the normal waste management (e.g. disposal of milk).
- The radionuclide inventory exceeds the limit for disposal via normal waste management routes.

Waste containing radioactive material should be sorted, to the extent possible, according to the amount of radioactive material and type of waste. Waste of different type and different activity levels should be kept apart so they can more easily be utilised in various practical applications or disposed safely. Where contaminated goods, structures, devices, materials or material are concerned, the contaminated parts of goods are separated from the clean parts as far as possible. It is better that a smaller amount of moderately active waste is generated than a large amount of low active waste.

The amount and quality of the waste from decontamination actions should be assessed before taking any action. Decontamination should then, as far as possible, be carried out according to plan, to keep the magnitude and extent of deposition known.

Types of waste containing radioactive material, among others, are:

- solid materials, such as collected dust from streets, incineration ash, waste from demolished buildings, soil, goods, devices,
- liquids, such as wash waters,
- sewage sludge from wastewater and raw water treatment,
- snow, such as surface snow removed from yards,
- biomasses, such as growth, feed, peat, ashes, and
- discarded foodstuffs.

If the amount of waste is large, the waste should be processed to reduce the amount or to convert it into a more suitable form in order to dispose of it. Possible ways of processing, among others, are

- composting the biomass, digestion or incineration,
- filtering liquids,
- distilling liquids,
- diluting liquids,
- solidifying liquids,
- chemically treating liquids.

It should be noted that by composting, the radioactive material is concentrated so effectively that the end product shall not be used for cultivating foodstuffs.

13.2 Disposal solutions

Disposal of waste containing radioactive material is to be based on some of the following main principles:

Aging

If the waste contains only short-lived radioactive nuclides, temporary storage of the waste is often the best solution.

Encapsulation

Waste should be located remotely from the living environment. Usually, waste is disposed of at an enclosed and covered/roofed dumping area. Some waste can be used in earthworks. Exceptional emergencies involving more or less intact radioactive sources (industrial or medical) may generate waste that have to be located in a dedicated final repository for radioactive waste.

Dilution

Dilution is usually not acceptable, but may in certain cases be the best solution as a whole. For example, a large amount of mildly contaminated snow might be appropriate to dump into the sea: the radioactive material will be diluted into such a large volume that it has no significance from a radiation protection point of view. Alternatively, if the snow is dumped on solid ground, the melting of the snow may concentrate the radioactive material on the soil, or melt waters may transport some or all of the radionuclide inventory into the environment.

13.3 Categories of waste containing radioactive material

Various types of radioactive waste are generated after decontamination measures. Waste may need processing in order to reduce volume and/or mass. Radioactive waste can be divided roughly into four waste management categories according to the activity concentration (Tab. VII). The waste may have to be moved to another category due to accumulation of radioactivity in processing.

Waste containing radioactive material can be divided into four categories:

- Category I: Waste requiring encapsulation and isolation from the environment
- Category II: Waste requiring controlled waste management to reduce radiation dose
- Category III: Waste requiring assessment of waste management to reduce radiation dose
- Category IV: Waste, without waste management risks (material unsuitable for intended use due to slight contamination).

Table VII. *Activity concentrations of waste categories. Applies to large volumes of over 100 m³, stricter limit values can be applied to smaller volumes.*

Category	**Activity concentration (kBq/kg)**		
	Alpha emitters	**Strong gamma and beta emitters**	**Weak gamma and beta emitters**
I	over 100	over 1 000	over 10 000
II	1 – 100	10 - 1 000	100 - 10 000
III	0.1 – 1	1 - 10	10 - 100
IV	below 0.1	below 1	below 10

13.4 Management of waste containing radioactive material and possible recycling

Category I. Waste requiring encapsulation and isolation from the living environment

Wastes in category I contain such large amounts of radioactive material that they must be encapsulated from the living environment according to radiation protection principles.

Waste in this category cannot be processed in normal waste management as the radiation effects would not remain acceptably low. The waste must either be temporarily stored (especially in case of short-lived radionuclides) or encapsulated permanently with suitable actions (especially in case of long-lived radionuclides).

Doses to workers involved in category I waste management may be significant. Workers must therefore be monitored and their doses should be assessed and optimized when planning and executing waste management tasks.

Waste in category I does not normally occur in an extensive fallout situation. It may be generated, however, when waste containing less radioactive material is processed and radioactivity is concentrated into a smaller volume or mass.

Category I waste may thus include: processed ash from incineration or composted biomass, air filters with significant amounts of radioactive material accumulated during the passing of a radioactive plume; material from mechanical brush cleaning of streets. Also, if rainwater in buildings is led directly to topsoil, the discharge spot in the soil may hold large amounts of radioactive material. In an emergency involving an industrial or medical radiation source, this type of waste may occur right at the accident site.

Category II. Waste requiring controlled waste management to reduce radiation dose

Waste in this category requires controlled waste management in order to keep the radiation effects at an acceptable level. The waste must either be stored temporarily (especially in case of short-lived radionuclides) or encapsulated permanently by a suitable measure (especially in case of long-lived radionuclides). The number of possible actions may however be a lot more variable than in the case of waste in category I.

Doses to workers involved in category II waste management may be significant. Workers must therefore be monitored and their doses should be assessed and optimized when planning and executing waste management tasks. When a strong gamma emitter is concerned, such as caesium-137, the dose to a worker handling this kind of waste may be 1 - 10 mSv per month.

Category II waste includes: removed topsoil and snow, dust bags of vacuum cleaners and other cleaning utensils, ash from incineration of peat and other bio fuels. The amount of waste in this category may be thousands of cubic metres.

Category III. Waste requiring assessment of waste management to reduce radiation dose

Recycling, management and final disposal of different waste types is mainly based on their normal use, but with optional choices, aspects of radiation safety should be considered. In choices of waste storage and disposal, such solutions shall be looked for where needs for processing and later storing of large masses would remain minor.

Decontamination products of category III can be used for constructing roads, streets and similar, and also for landscaping when otherwise suited for this kind of use. In this case it should be ensured that a thick enough layer of clean material is placed over the decontamination products. In case of constructing, for example, a road, it is enough if the covering layer consists of 10 - 20 cm of rock material. Decontamination products should not be left in the immediate vicinity of residences.

When choosing the disposal site, the future use of the area shall be taken into account. If the disposal site is intended to be used for primary production of foodstuffs, such a thick layer of clean material is needed that ploughing and roots of plants do not reach the waste layer.

Doses to workers involved in waste management are unlikely to exceed 1 mSv per month.

Category III waste include: food and feeds exceeding the permitted maximum levels, topsoil and plants removed in decontamination of the living environment as well as contaminated goods, materials and structures that cannot be decontaminated to meet the release criteria. The amount of waste in this category may be hundreds of thousands of cubic metres or more.

In waste management, the concentration of radioactive material shall be taken into account. As a result of composting or other similar process the activity level of waste may increase to levels thereby moving the waste into category II.

Category IV. Waste, without waste management risks

This type of waste originates from material which is unsuitable for its intended use due to slight contamination. Radiation protection requirements does not limit disposal of this waste in a normal way.

Doses to waste management workers are considered insignificant or unlikely, but doses to users or consumers are considered unjustified.

Category IV waste include: food, feeds and raw materials that are below the permitted maximum levels (see table of food action level), and also other goods and products below the limit values which are not acceptable to intended use due to radioactive contamination. The amounts of waste may be thousands of cubic metres or more.

ANNEX 1: Estimated geographical extent of consequences due to various radiation hazards

The table below gives examples of various nuclear or radiological emergencies and the greatest presumable extent of consequences. It presents estimates on the extent of the area of needed protective measures for a severe case. Note that effects in various hazard situations may vary considerably depending on the nature and specific circumstances surrounding any given emergency.

Geographical extent of consequences	Cause of nuclear or radiological emergency	Maximum distance from point of dispersion calling for radiological protective measures
Widespread fallout	fallout from nuclear weapon explosion	from a few kilometres to a thousand kilometres; depends on the nature and size of the weapon, explosion height and prevailing weather conditions
	severe accident at nuclear power plant	evacuation from a few kilometres even to 20-30 km; sheltering indoors up to tens of kilometres; partial sheltering indoors up to even 200 km; measures concerning protection of livestock and other production may be needed in the range of thousands of kilometres
	crash of nuclear-powered satellite	entry restrictions into crash area and decontamination from radioactive materials that may have spread over an area of hundreds of square kilometres
Regionally limited fallout	spent nuclear fuel storage accident; in case cooling is lost and fuel is damaged resulting in zirconium fire	tens of kilometres
	severe reactor accident on a nuclear vessel	tens of kilometres
	accident in storage, handling or transportation of nuclear weapons, where the uranium or plutonium of the weapon is exposed or is evaporated into air	tens of kilometres
	spreading radioactive material by an explosive, i.e. a dirty bomb or other deliberate contamination of a limited region with radioactive material	a few kilometres
	accident in transfer or transport of spent nuclear fuel	hundreds of meters

Contamination of indoor areas or immediate vicinity of the accident site	Release of radioactive material during transport	hundreds of metres
	accident (fire, chemical explosion, melting) at the site of radioactive material	event site, hundreds of metres at most
	unshielded high activity source	less than one hundred metres
	accident in use of radioactive material	indoor areas at the site
	intentional contamination of indoor areas with radioactive material	the indoor areas concerned

Annex 2: Summary tables for operational intervention levels defined in document

Table A2.1: Protective actions in the early phase (part A).

Dose Rate	Protective Action
1 µSv/h	Protection of food production
10 µSv/h	Partial sheltering
10 µSv/h	Iodine prophylaxis for children under 18 years old and pregnant women
10 µSv/h	Protection of commodities and products
10 µSv/h	Protection of indoor spaces of factories and production facilities
10 µSv/h	Temporary banning of foodstuffs and other natural goods
100 µSv/h	Sheltering indoors
100 µSv/h	Iodine prophylaxis for adults
100 µSv/h	Access control

Note 1: All protective actions also have OILs based on airborne concentrations.
Note 2: In addition, urgent actions in the vicinity of a nuclear facility can be done based on the plant condition.
Note 3: Criteria for protective measures of emergency workers are not included in the table; see table in section 8 for these.

Table A2.2: Protective actions in the intermediate phase (part B).

Dose Rate	Protective Action
1 µSv/h	Cleaning indoor spaces
1 µSv/h	Decontamination of vehicles, machinery, and tools
1 µSv/h	Restriction of built-up recreational areas
10 µSv/h	Partial sheltering indoors
10 µSv/h	Actions to reduce doses to workers
10 µSv/h	Thorough cleaning of all indoor surfaces
10 µSv/h	Urgent decontamination of built-up environment
10 µSv/h	Restriction of recreational use of natural areas
10 µSv/h after decontamination	Temporary relocation
100 µSv/h	Restrictions on entering contaminated area
100 µSv/h	Sheltering indoors
100 µSv/h for more than two days	Evacuation

Note 1: All protective actions also have OILs based on ground contamination.
Note 2: OILs for lifting the protective actions are not included in the table. Refer to section on the given protective action for these.

Annex 3: Calculation examples as the basis for operational intervention levels (OILs)

The operational intervention levels are developed to be applicable to all types of radiological or nuclear scenarios excluding nuclear detonations. Taking into account the various types of uncertainties present in the evaluation of any radiological or nuclear event, the operational intervention levels have been derived as orders of magnitude and are indicative. Based on the specifics of the situation, its development and emergency phase, it may be appropriate to carry out actions at higher or lower levels. However, a protection strategy for the early and intermediate phase of a radiological or nuclear emergency, based on the operational intervention levels presented in the Nordic guidelines and recommendations, will be in line with the concept presented in the ICRP 103.

The operational intervention levels for each protective action have been derived from chosen dose criteria expressed as projected doses. Many factors that will lower projected doses have not been taken into account, e.g. radioactive decay and weathering effects. In addition, all projected doses are calculated assuming that persons are staying outdoors all the time.

In the tables below some examples as the basis for operational intervention levels have been presented. The dose coefficients for workers have been used in the calculations although the protective actions mainly concern the public. The difference between the coefficients for workers and the public is not significant.

Cs-137, Sr-90 and Pu-239 were used to calculate intervention levels for gamma, beta and alpha emitters. Taking into account the uncertainties of a real event, these intervention levels are applicable to other gamma, beta and alpha emitting nuclides.

1) Examples of calculations

External gamma	**Dose criteria:** projected dose 10 milliSv in two days
As other contributors to dose may exist, the operational intervention level was rounded down from the calculated value to the closest order of magnitude.	**OIL** Dose rate = 10 000 microSv / (2 x 24 h) = 208 microSv/h = $2 \cdot 10^{-4}$ Sv/h ➔ **100 microSv/h**

Concentration in air (internal dose via inhalation)	**Dose criteria:** projected dose 10 milliSv in two days	
Assumed inhalation rate 1 m^3/h As other contributors to dose may exist, the operational intervention level was rounded down from the calculated value to the closest order of magnitude.	**Alpha** Committed effective dose for workers (BSS 96/29/Euratom); Pu-239: $4.7 \cdot 10^{-5}$ Sv/Bq	**OIL** Concentration in air = (0.01Sv/(2 x 24h)) / ($4.7 \cdot 10^{-5}$ Sv/Bq x 1 m^3/h) = 4.4 Bq/m^3 ➔ **1 Bq/m^3**
	Beta Committed effective dose for workers (BSS 96/29/Euratom) Sr-90: $1.5 \cdot 10^{-7}$ Sv/Bq	**OIL** Concentration in air = (0.01Sv/(2 x 24h)) / ($1.5 \cdot 10^{-7}$ Sv/Bq x 1 m^3/h) = 1400 Bq/m^3 ➔ **1000 Bq/m^3**
	Gamma Committed effective dose for workers (BSS 96/29/Euratom) Cs-137: $6.7 \cdot 10^{-9}$ Sv/Bq	**OIL** Concentration in air = (0.01Sv/(2 x 24 h)) / ($6.7 \cdot 10^{-9}$ Sv/Bq x 1 m^3/h) = 31 100 Bq/m^3 ➔ **10 000 Bq/m^3**

Total deposition	**Dose criteria:** projected dose 10 milliSv in two days	
In case of strong gamma and beta emitters, exposure is caused by direct radiation from the deposition. In case of alpha emitters, exposure is caused by inhalation (radionuclides in air due to re-suspension). As other contributors to dose may exist, the operational intervention level was rounded down from the calculated value to the closest order of magnitude.	**Strong gamma and beta** Dose rate caused by fresh deposition i.e. all activity still on the surface: Cs-137: 2.5·10-12 (Sv/h)/(Bq/m2)	**OIL** Deposition on the ground = (0.01Sv/(2x24h))/ ($2.5 \cdot 10^{-12}$ (Sv/h)/(Bq/m^2))= 80 000 000 Bq/m^2 ➔ **10 000 000 Bq/m^2**
	Alpha, detachable from surfaces Committed effective dose for workers (BSS 96/29/Euratom) Pu-239: $4.7 \cdot 10^{-5}$ Sv/Bq Re-suspension factor (RF) varies significantly depending on circumstances. For fresh fallout a value $1.2 \cdot 10^{-6}$ m^{-1} is often used. However, RF can be a factor of 10 higher for many reasons (urban conditions, traffic, arid climate). In order to take account for this, RF is multiplied by a factor of 5, i.e. a value RF = $6 \cdot 10^{-6}$ m^{-1} is used.	**OIL** Concentration in air = (0.01Sv/(2x24h)) / ($4.7 \cdot 10^{-5}$ Sv/Bq x 1 m^3/h) = 4.4 Bq/m^3 Deposition = concentration / $6 \cdot 10^{-6}$ m^{-1} 4.4 Bq/m^3 / $6 \cdot 10^{-6}$ m^{-1} = $7.4 \cdot 10^5$ Bq/m^2 ➔ **100 000 Bq/m^2**

2) Examples of operational intervention levels for protective actions

In the early phase of an emergency:

Sheltering indoors **Dose criteria:** projected dose over 10 milliSv in two days **OIL:** dose rate = 10 000 microSv / (2 x 24 h) = 208 microSv/h ➔ **100 microSv/h**	**Partial sheltering indoors** **Dose criteria:** projected dose 1 – 10 milliSv in two days **OIL:** dose rate = 1000 … 10 000 microSv / (2 x 24 h) = 21 … 208 microSv/h ➔ **10 µSv/h**

In the intermediate phase of an emergency:

Lifting sheltering indoors **Dose criteria:** projected dose due to deposition less than 10 milliSv in one month <u>and</u> will decrease rapidly **OIL:** during first month dose rate = 10 000 microSv / (30 x 24 h) = 14 microSv/h ➔ **10 microSv/h**	**Short term evacuation** **Dose criteria:** projected dose due to deposition over 20 milliSv during first week **OIL:** dose rate = 20 000 microSv / (7 x 24 h) = 119 microSv/h ➔ **100 microSv/h**
Temporary relocation **Dose criteria:** projected dose due to deposition over 10 milliSv per month despite e.g. decontamination of the area **OIL:** Dose rate = 10 000 microSv / (30 x 24 h) = 14 microSv/h ➔ **10 microSv/h**	**Lifting temporary evacuation** **Dose criteria:** projected dose due to deposition less than 10 milliSv in one month <u>and</u> will decrease rapidly **OIL:** during first month after return = 10 000 microSv / (30 x 24 h) = 14 microSv/h ➔ **10 microSv/h**

References

[1] STUK, VAL Guide 1, *Protective Actions in Early Phase of Nuclear or Radiological Emergency* (in Finnish only)

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[3] Annals of the ICRP, PUBLICATION 103, *The 2007 Recommendations of the International Commission on Radiological Protection*

[4] Annals of the ICRP, PUBLICATION 109, *Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situation*

[5] EU-BSS 2013, *Proposal for a COUNCIL DIRECTIVE laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation*

[6] IAEA, GS-R-2, *Preparedness and Response for a Nuclear or Radiological Emergency*

[7] IAEA, GS-G-2.1, *Arrangements for Preparedness for a Nuclear or Radiological Emergency*