Nordic Intervention Criteria for Nuclear or Radiological Emergencies - Recommendations

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

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PREFACE

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CONTENT

1. SUMMARY

Recommendations of the Nordic radiation protection authorities on application of international criteria in a nuclear or radiological emergency in the Nordic countries are presented. The recommendations are focused on the generic intervention levels for various actions to protect members of the public and workers undertaking an intervention. Prompt precautionary actions for the near zones around the Finnish and Swedish nuclear power plants are defined. These actions are; preventive sheltering, iodine prophylaxis and precautionary evacuation. No special intervention levels for these precautionary actions have been set, because implementation of these actions is always based on very limited information about an accident. These actions can be initiated on a mere indication of possible release of radioactivity. The indication might be an alarm or any other predefined signal.

Intervention levels for actions to protect members of the public are based on the concept of avertable dose. They are in line with the international recommendations. With regard to iodine prophylaxis, a national approach is recommended due to different national policies of advance distribution of iodine tablets. The longer term intervention actions, temporary relocation and permanent resettlement, will be based not only on radiation protection factors but also on wider judgement of the overall situation. For that reason, no generic intervention levels, in terms of radiation dose, are recommended[1]. The intervention levels for various protective actions are presented in the following table.

Table 1. Generic intervention levels for actions to protect members of the public.

Protective action	**Generic intervention level as an avertable dose**
Sheltering	10 mSv within two days (effective dose)
Iodine prophylaxis	National recommendations
Evacuation	50 mSv within one week (effective dose)
Temporary relocation	No predetermined intervention level
Permanent resettlement	No predetermined intervention level

Workers undertaking an intervention have been categorised into different groups according to their work. Radiation protection criteria for these workers are consistent with the international recommendations. Workers who are undertaking their normal occupation in the area affected by an accident, but who are not directly engaged with the accident itself, are regarded equally with members of the public. Some of these workers might be exposed to increased radiation due to their occupation, and they should receive detailed instructions on protective measures.

[1] The Nordic radiation protection authorities are aware of the internaltional recommendations for generic intervention levels of 30 mSv/month for initiating and 10 mSv/month for terminating temporary relocation and a projected lifetime dose of 1 Sv for permanent resettlement. The doses to be compared with these intervention levels will usually exclude food and water.

2. INTRODUCTION

Recommendations from the Nordic Radiation Protection Institutes on Action Levels in cases where sources of exposure to ionising radiation are not under the control of the authorities were included in the Report on the Applicability of International Radiation Protection Recommendations in the Nordic Countries in 1976 (1). These recommendations dealt with abnormal exposures of occupationally exposed persons and with abnormal exposures of members of the public. The recommendations regarding exposure of the public were restricted to the case of contamination of a limited area after a short-term release of iodine-131.

With the Chernobyl accident in 1986 it became evident that large-scale reactor accidents can have an important impact at long distances from the accident site. The fall-out from the Chernobyl accident in some areas of the Nordic countries more than 1000 km from the demolished reactor was the highest outside the former USSR.

The large impact of the Chernobyl accident and various approaches to deal with the consequent radiation situation in European countries led to a considerable effort by the international community to prepare new international recommendations and practical guidance for protection of the public in a nuclear or radiological emergency. New recommendations and practical guidance have been issued by ICRP (2,3), OECD/NEA (4), IAEA (5, 6, 10, 11), WHO (7), CEC (8, 9). In the preparation of this report the Council Directive 96/29/EURATOM (8) has been taken into account.

The international recommendations and guidelines cannot be used directly in an emergency situation. Preplanning and regular exercises, taking national and local conditions into account, are a prerequisite for both national authorities and major nuclear facilities to be able to handle an emergency situation in an optimal way. However, the international recommendations and guidelines can give a harmonised basis and approach for preparing national emergency preparedness plans and for decision making in a real emergency situation.

The geographical, demographic and political background in the Nordic countries has for many years been a solid basis for highly developed collaboration between the Nordic governments, administrations and industries. This is especially true in the field of radiation protection. A close co-operation between the Nordic authorities in preparedness for nuclear emergencies and in actual intervention situations will also be important in the future. This is necessary due to the fact that the Nordic countries have several nuclear power plants in their own territory and a substantial number of power plants and military installations are located in the surrounding countries.

A harmonised Nordic application of international recommendations on intervention criteria in a nuclear or radiological emergency is an important base for preparing national emergency plans and for co-operation and mutual understanding between the authorities in a real emergency situation. A common Nordic basis can also make a contribution to coherent and consistent public information in case of an emergency situation.

3. EXPRESSIONS AND DEFINITIONS

3.1 Basic expressions

In this document the following basic expressions are used;

a. *Intervention;* any actions aiming at reducing or averting human exposure to radiation in nuclear or radiological emergencies. This can be done either by removing radiation sources from the living environment, influencing people's living conditions so that their exposure to radiation is reduced, or by reducing the number of people being exposed to radiation.
b. *Protective action;* a single action in order to reduce the radiation exposure of workers or members of the public.
c. *Averted dose;* an individual dose that can be averted by a single protective action.
d. *Operational intervention level;* any measurable quantity of radiation or radioactivity above which a specific protective action is generally justified.
e. *Generic intervention level;* such an averted or avertable radiation dose above which a specific protective action is generally justified and which is used in emergency planning.

3.2 Basic protective actions

There are a few protective actions that should be considered in any nuclear or radiological emergency situation where there is a risk of radioactive releases into the environment. These are;

a. *Sheltering;* in the area at risk, people are advised to seek shelter indoors, to close and seal up doors and windows, and to turn off ventilation systems in the house. Sheltering will reduce exposure to external gamma radiation and internal exposure to inhaled radioactivity. Further advise will be provided inter alia in radio and television.
b. *Iodine prophylaxis;* if outdoor air is expected to contain notable amounts of radioactive iodine, people are advised to take a tablet of stable iodine according to the dosage guide. This action will effectively block radioactive iodine from drifting into the thyroid.
c. *Precautionary evacuation;* displacement of the population, or a part of the population, and small animals, from the near zone of domestic nuclear power plants before any radioactive releases into the environment. Precautionary evacuation shall be implemented on the basis of assessments of accident severity and of the possibility of environmental releases of radioactivity.
d. *Evacuation;* displacement of the population, or a part of the population, and small animals, from the area contaminated with radioactive substances after the dispersion phase of radioactivity or, subject to the situation, even earlier. Evacuation should not last longer than a few days.
e. *Temporary relocation;* displacement of the population, or a part of the population, from the contaminated area for time period of several weeks, months or even over a year. Removal of cattle and other domestic animals should also be considered.
f. *Permanent resettlement;* permanent resettlement of the population in new locations if their home environment is badly contaminated and, in spite of decontamination actions, is not able to be restored to habitable condition.

4. NUCLEAR AND RADIOLOGICAL EMERGENCIES

In an intervention situation, an uncontrolled source of radiation is already in the living or working environment of people or it is in danger of spreading to their environment. In this kind of situation, special actions are needed to reduce individuals' exposure to radiation. Typical intervention situations are those resulting from accidents in connection with use of radiation and production of nuclear energy.

An accident resulting in dispersion of radioactive substances to the environment could occur in nuclear power plants, nuclear vessels or submarines, at nuclear fuel cycle facilities, in facilities utilising radiation sources, or in transportation of radioactive materials. Also a nuclear powered satellite reentering the atmosphere could result in wide dispersion of radioactive materials.

Consequences will be specific to each type of accident, in both nature and degree, and there is unlikely to be a unique accident sequence upon which to base emergency response plans. It is easier to plan for emergencies in a large, centrally controlled facility, e.g. a nuclear power plant, than for those at an application facility, in transport or in the case of a satellite descent. However, planning for these latter categories should not be neglected. For planning purposes, accident scenarios should therefore be considered in advance. The scenarios should cover those being unlikely to require off-site actions, or for which the off-site consequences are expected to be minor, and those having significant consequences off the site, even though these accidents may have an extremely low probability of occurrence.

A great radiation risk to a large population group will be caused by a nuclear explosive launched intentionally or unintentionally near ground level. Also crime and terrorism being connected with nuclear or radioactive materials should be taken into consideration in emergency response plans.

5. OBJECTIVES OF INTERVENTION AND HEALTH GROUNDS FOR PROTECTIVE ACTIONS

All protective actions and countermeasures of intervention in a nuclear or radiological emergency aim at keeping the radiation exposure to individuals as low as reasonably achievable. The first objective in all emergency situations is to ensure that all serious deterministic health effects of radiation are prevented. This means that all possible efforts shall be made to keep individual absorbed doses to the whole body, which will be received during a relative short time period, below 0,5 Gy. Bone marrow is then the critical tissue.

Another objective of protective actions is to restrict stochastic health effects of radiation exposure in the affected population. The stochastic health effects have no threshold levels of exposure. For that reason, every protective action aims at restricting stochastic health effects in all population groups to as low a level as reasonably achievable.

Cancer is the most significant stochastic health effect of radiation. Risk of severe hereditary effects is clearly lower than that of cancer. The total individual cancer risk in emergency situations, where dose rates could be relatively high, is about 10 % per Sv effective dose (2). This means that a person receiving an effective dose of 100 mSv at a high dose rate will have a 1-% increase in the

probability of developing cancer. Respectively, if 1000 persons will each receive 100 mSv dose at high dose rates, ten excess cancers can be expected to occur in that population group.

There will be mental distress and anxiety associated with any radiological emergency, regardless of whether an actual radiation dose has been received or not. Because these effects are independent of the actual physical radiation doses received, they have not been taken into account in setting the values of intervention levels recommended here. However, these health effects are factors to be taken into consideration in decision making on countermeasures in an actual situation.

6. PRINCIPLES OF INTERVENTION

Dose limits or dose constraints can not be used in intervention in the same way as in controlled use of radiation or production of nuclear energy. Individual and collective doses, which still can be considered tolerable in nuclear or radiological emergencies, always depend on the situation. In severe and wide extending accidents it may be necessary to accept relatively high individual doses because of limited possibilities of reducing these or of limited resources, whereas in mild and regionally limited accidents it may be reasonable to undertake countermeasures with lower individual or collective doses.

Before introducing any protective action, care should be taken that the protective action is **justified** and **optimised**. In doing so;

- the protective action should do more good than harm, i.e. the reduction in detriment resulting from reduction of radiation dose should be sufficient to justify the harm and costs, including social costs, of the protective action (justification principle), and
- the form, scale and duration of the protective action should be optimised so that the net benefit of the protective action is maximised, i.e. the benefit of the protective action, less the detriment associated with the protective action, is as great as possible (optimisation principle).

The introduction of any particular protective action entails some risk to the individuals affected and some harm to society in terms of financial costs and of social and economic disruption. Public anxiety, which can be either relieved or increased by the protective action, is another factor to be considered within decision making. For emergency situations where the projected dose from any specific pathway or combination of pathways may approach thresholds for serious deterministic health effects, protective actions are always justified *a priori*.

7. APPLICATION TO EXPOSURE OF MEMBERS OF THE PUBLIC

Several intervention criteria have been dealt with in international recommendations and basic safety standards. The important reasons for a joint Nordic approach on these questions have been pointed out, and the basic foundation for such an approach was drawn up in the first chapter.

In this chapter these basic principles are used to form a joint Nordic application for members of the public in case of a nuclear or radiation emergency. The protective actions themselves are very much the same as pointed out in earlier policy documents, but here a joint Nordic set of generic

intervention levels together with these actions is defined. These are determined on the basis of present knowledge of the effects of ionising radiation.

This chapter opens with a summary of the factors influencing the decision on intervention. Furthermore, the different urgent and longer term protective actions given in the flowchart in Figure 1 are discussed and tied together for a generic strategy including specified intervention levels. This is substantially different from for example the application to exposure of workers, which will be addressed in the next chapter. In the last part of this chapter this generic approach and intervention levels are considered together with operational levels.

The primary aim of protective actions is to avoid all serious deterministic health effects and to reduce the probability of stochastic health effects. This means justification and optimisation of any protective action to be taken into account in the actual situation. However, the final decision on intervention may also depend on other factors not directly related to radiological protection, such as those of a political and social nature. All together these factors may be grouped in the following list.

- Plant condition
- Plant condition + weather
- Plant condition + weather + early measurements and prognosis
- Measurements + dose assessments + economic factors + social factors

7.1. Early phase protective actions

Early phase protective actions are measures taken in an early and intermediate phase of a radiological or nuclear emergency based primarily on the best possible assessment of the type of accident, the time being available and weather forecasts. Protective actions may be applied differently depending on the kind of emergency and the distance to the accident site itself. The principal characteristic of such actions is the lack of time available in which to make decisions and implement them successfully. The urgent protective actions in the immediate vicinity of domestic nuclear accidents need to be applied promptly to be most effective. For that reason prompt precautionary actions in near zones of domestic nuclear power plants are described separately.

7.1.1 Prompt precautionary actions in near zones of domestic nuclear facilities

Prompt decisions for protective actions in the near zones of domestic nuclear facilities have to be made in the case of an accident. In emergency planning, near zones around nuclear power plants are separated from the rest of the country. In the near zones, a prompt precautionary measure is an urgent protective action initiated at the mere *indication* of a possible release of radioactivity. The prompt precautionary actions sketched in the flowchart of Figure 1 are the following:

- preventive sheltering
- iodine prophylaxis
- precautionary evacuation

These preventive actions must be handled as one entity and decisions on actions shall be made immediately. The indication might be an alarm or any other predefined signal, or an expert

assessment. It is important that the chosen protective action(s), regardless of the type of action, should be implemented before any radioactive release into the environment. Because implementation of these protective actions will always be based on very limited information about the accident, it is not reasonable to set any intervention levels for these actions in terms of radiation dose.

7.1.2 Sheltering

After a release of radioactivity, the decision concerning protective evacuation is very dependant on the possibilities for efficient sheltering. In this situation sheltering means staying inside, closing doors, windows and other openings, which represent a risk for pulling radioactive material from the outside air, and turning off ventilation systems. After the radioactive plume has passed it is essential to open the windows and restart the ventilation systems. The competent authorities will give information about the situation and further guides on radio and television.

Sheltering might be an efficient urgent protective measure in an acute situation. However, when considering sheltering it is important to note the significance of timing according to the phase of the accident, the possibilities for displacement of people during continuous releases, and people's ability to stay indoors for a longer period of time. Sufficient means of communication are essential to assure that the recommendations are followed and provide essential information after sheltering has been cancelled.

7.1.3 Iodine prophylaxis

The administration of stable chemical compounds can block or reduce the intake by specific organs of certain toxic agents including radioactive nuclides. Stable iodine compounds are an important example here in connection with emergencies and possible releases of radioiodine from nuclear installations. As a protective measure administration of stable iodine will rarely be used as a stand-alone action, and is normally recommended together with sheltering or evacuation. The risk associated with administration of stable iodine is considered to be very low for most population groups below the age of 40-45. Iodine prophylaxis is only recommended as a protective action to prevent or reduce the exposure to the thyroid from radioiodine in the air. Protective actions against radioiodine in foodstuffs, especially in milk, should be based on food controls and not on the use of stable iodine.

The maximum benefit from stable iodine is obtained by taking the tablets before exposure to radioiodine, or as soon as possible afterwards. Because of the short timescale available, distribution of stable iodine may present a practical problem, especially if large populations groups are involved. Therefore the extent (populations groups, distance to nuclear power plants, accident scenarios, planning levels etc.) of the possible use of iodine prophylaxis in an emergency situation should be decided and planned beforehand. In this decision the overall costs of maintaining this protective action as an operative part of the emergency plan should be taken into account. These costs could be different in the Nordic countries due to different national circumstances. The maintenance costs will include the cost to ensure, e.g. every 5 years, that the selected population groups in an

Flow chart for protective actions

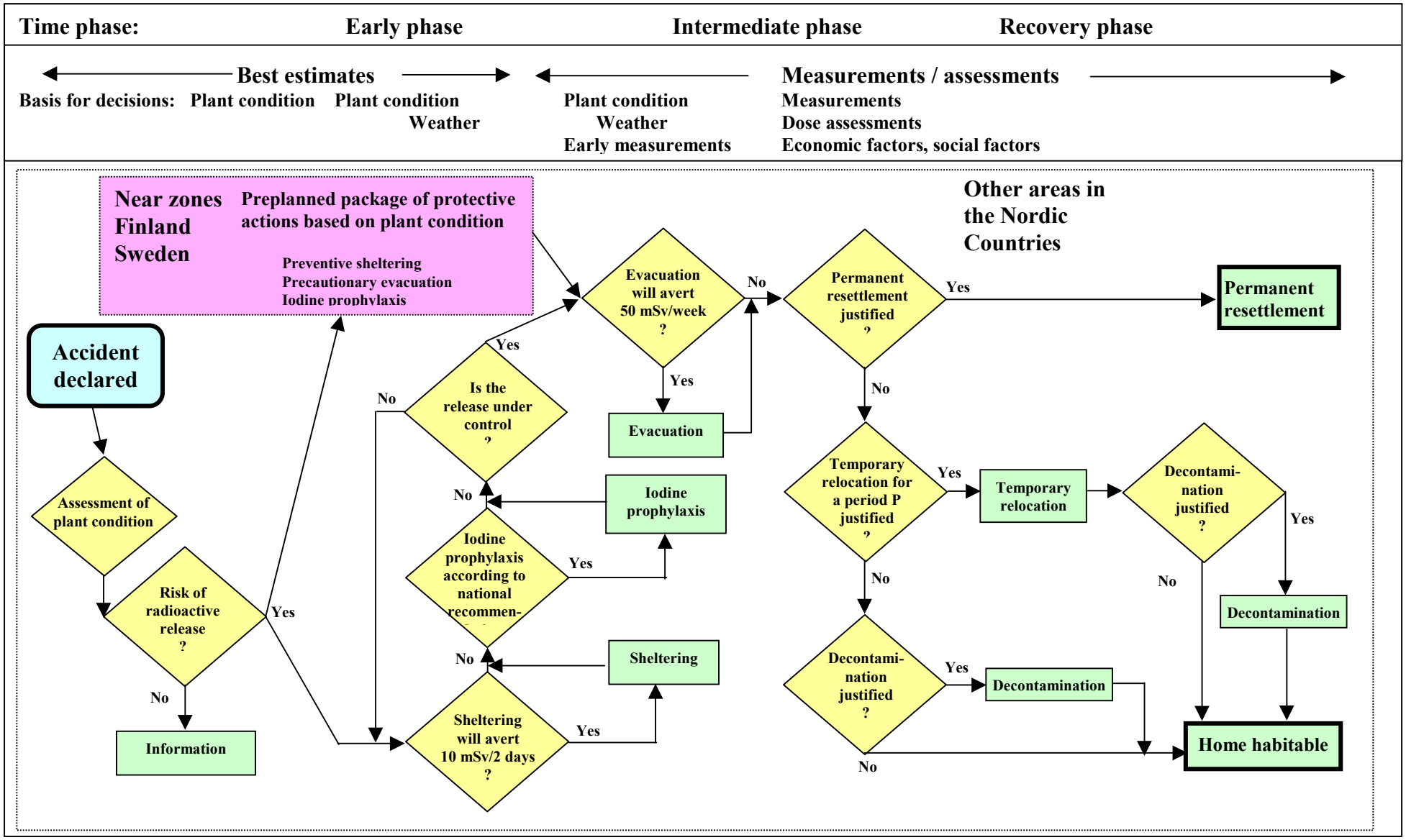

Figure 1. Flow chart of the protective actions for members of the public and the generic intervention levels to be used in emergency planning.

Legend to Figure 1:

Near Zone *is an area around nuclear power plants in Finland and Sweden where prompt preventive actions should be undertaken before any radioactive release to the environment. These actions are based on plant conditions and expert assessments.*

Other areas *are areas outside the near zones in all the Nordic countries.*

Best estimates *mean that all protective actions are mainly based on assessments on development of the accident and on forthcoming radiation situation. Results of off-site measurements may not yet be available.*

Measurements *mean that all protective actions are mainly based on off-site radiation measurements.*

Risk for radioactive release? *means that expert assessment on the possibility of environmental release of radioactivity is needed. If there is no risk of releases, no protective actions are needed. If there is any risk of radioactive releases, preventive sheltering, iodine prophylaxis and precautionary evacuation in the near zone should be undertaken. No intervention levels, in terms of radiation dose, are recommended because of insufficient information available.*

Sheltering will avert 10 mSv/2 days? *means that expert assessment of the effectiveness and applicability of sheltering is needed. If short-term sheltering will avert an affective dose of more than 10 mSv, then sheltering should be undertaken. Sheltering should not last more than 2 days.*

Iodine prophylaxis according to national recommendations *means that expert assessment of the effectiveness and applicability of iodine prophylaxis is needed. Implementation of iodine prophylaxis is based on national recommendation. No generic intervention level, in terms of radiation dose, is recommended due to national differencies in advance distribution of iodine tablets.*

Is the release under control? *means that expert assessment on the conditions of the accident site and weather is needed. If the release is not under control, as regards possible evacuation of a certain area, site-specific evacuation of that area should not be undertaken.*

Evacuation will avert 50 mSv/week? *means that expert assessment of the effectiveness and applicability of successful implementation of site-specific evacuation is needed. If evacuation can be implemented successfully and it will avert an effective dose of 50 mSv during the first week, then evacuation should be undertaken.*

Temporary relocation justified? *means that decision making on the temporary displacement of population to another area is needed. The decision should be based on the contamination level of the affected area and on possibilities of moving the population for a longer time to another area. Temporary relocation may last from weeks to several months depending on contamination levels, size of population, and socio-economic conditions. No intervention level is recommended.*

Decontamination justified? *means that expert assessment of the effectiveness of decontamination actions in the affected area is needed. If decontamination brings more good than harm, the decontamination actions should be undertaken.*

Permanent resettlement justified? *means that decision making on the permanent resettlement of the relocated population is needed. The decision should be based on the contamination level of the affected area and on the possibilities of resettling the population permanently in another area. No intervention level is recommended, but resettlement is always justified if living in the affected area would cause deterministic health effects.*

emergency situation will have easy access to iodine tablets that have not passed their approved shelf life.

If preplanned iodine prophylaxis is part of the emergency plan for some selected groups in the population, the implementation of this protective action for these groups is quite simple, cost effective and easily justified in a real emergency situation. The actual decision for this protective action would therefore probably be taken on a lower level of expected iodine exposure than the planning intervention level used in in the emergency plan.

7.1.4 Evacuation

Evacuation is the urgent removal of people to another area to avoid or reduce radiation exposure from air or surface deposits. The intention is to move people and small animals away for a period from some hours up to a week. Evacuation is planned to be taken after passage of the radioactive plume, but in some cases it may also be implemented during the release if it concerns a small amount of people and it can be performed safely. Domestic animals are not included. Under certain circumstances evacuation may be extended to temporary relocation, decontamination of the home habitat, or permanent resettlement. This will be more thoroughly discussed in connection with longer-term protective measures.

In an area further afield, evacuation during an accident release should not be considered because of the large uncertainty in relevant prognosis and the small risk of acute injuries. However, this is not the case in a more local area. The ultimate decision will always be founded on the common principle of radiation protection, i.e. the dose should be as low as reasonably possible. If evacuation of people in the local area close to the installation will represent a considerable chance of avoiding very large exposures, this should be done immediately.

Evacuation should not be recommended in connection with an accident in a nuclear installation in another country. Exceptions could be rare cases such as if the home habitat shows itself as unsuitable for a certain site-specific way of living.

7.2. Generic intervention levels for early phase protective actions

The prompt precautionary actions, preventive sheltering, preventive iodine prophylaxis and precautionary evacuation, will, in the case of a nuclear emergency in Sweden or Finland, be implemented without any predefined intervention levels due to a lack of available information and time. If there is any risk of environmental releases of radioactivity, preventive sheltering should be considered in the first place. If expert assessments show that there is also a risk of environmental release of radioactive iodine administration of stable iodine should be implemented. Furthermore, if the plant condition indicates that a major release of radioactivity is possible and there is enough time for evacuation, the precautionary evacuation of the population in the near zone should be implemented. In connection with evacuation one always has to remember that evacuation will take time and in itself contains some not insignificant risks.

No intervention levels, in terms of radiation dose, are recommended for these precautionary actions in near zones.

Outside the immediate near zone, the Nordic radiation protection authorities have agreed on the generic intervention levels for early phase protective actions to be implemented. The recommended intervention levels are given in Table 2.

Table 2. Generic intervention levels for early phase protective actions

	Sheltering	**Iodine prophylaxis**	**Evacuation**
Avertable effective dose	10 mSv within two days	National recommendation	50 mSv within one week

In the case of an emergency situation with no prompt measures initiated, the possible choices are to recommend sheltering or evacuation. In both cases iodine prophylaxis has to be considered as an additional protective measure.

If there is limited time before possible releases, evacuation might not be possible, and sheltering is initiated. The averted effective dose of 10 mSv within no more than two days is recommended as a generic intervention level for sheltering. Sheltering might be initiated at lower levels for shorter periods, for example for the passing by of a geographically well-defined contaminated plume.

For evacuation, the averted effective dose of 50 mSv within no more than one week is recommended as a generic intervention level. Evacuation may be initiated at lower levels if it concerns small groups of people and it can be performed easily.

An emergency situation due to a nuclear or radiation accident changes gradually when the releases are under control and additional information, for example measurement results, are included in the decision-making. Then longer term protective measures such as temporary relocation, decontamination and resettlement have to be considered, and focus will progressively change with time.

7.3. Longer term protective actions

The emergency situation passes gradually from the acute phase to the intermediate and recovery phases. The results of environmental monitoring might be available when considering for example evacuation. Analyses of environmental samples and more extensive environmental monitoring will give a more accurate picture of extended evaluations relevant for longer term protective actions such as temporary relocation, decontamination and permanent resettlement.

The basis for withdrawing countermeasures will be that radioactive contamination has been reduced by the appropriate combination of radioactive decay, weathering and planned decontamination campaigns. There will also be a number of social, economic and technical inputs into decision making when considering these longer term protective actions. For example, serious health effects

have been identified in the population permanently or temporarily relocated from the Chernobyl zone because of considerable stress building up in the people affected.

7.3.1 Temporary relocation

Temporary relocation may take place over a period of several weeks, months and even over a year, and it is mainly distinguished from evacuation because of the possible long term perspective. It is important that an emergency or accident, where evacuation has not been initiated during the early phase, may lead on to a situation including use of temporary relocation in the later phase. This is due to the fact that time is a crucial factor when assessing radiation doses. A decision on temporary relocation is not merely a radiation protection matter. Decision making is more or less a political question including various socio-economic and socio-psychological aspects, in addition to radiological ones. Therefore it is not possible to define or even recommend in advance some intervention levels in terms of averted doses[2].

7.3.2 Permanent resettlement

A radioactive release from a nuclear accident consists of several short life and long life isotopes of different importance when considering radiation protection. Temporary relocation and decontamination are two important measures to avoid permanent resettlement. Resettlement on a permanent basis is a protective action which is hard to evaluate in a quantitative manner because of many negative socio-psychological effects related to such a process. As a protective action temporary relocation has a limited timespan. After a certain number of years, relocation effectively equals resettlement.

Permanent resettlement of the population due to radioactive contamination of their normal living environment is an extreme measure having far-reaching social, psychological and economic consequences. Permanent resettlement is always a political question to be decided at a governmental level. In the decision making there are so many influencing factors that is not possible to define or even recommend in advance any intervention levels in terms of radiation doses. However, if the projected doses in the contaminated area would cause deterministic health effects, even after exhaustive decontamination, the resettlement is always justified[3].

7.4. Operational intervention levels and decision-making models

This joint Nordic document has a generic approach. In addition to this, operational intervention levels are usually put forward in the form of easily measured quantities to optimise the protection of the public in connection with nuclear or radiological emergencies. Such a quantity might be dose rate and surface contamination density derived from a generic limit.

[2] The Nordic radiation protection authorities are aware of the international recommendations for generic intervention levels of 30 mSv/month for initiating and 10 mSv/month for terminating temporary relocation.

[3] The Nordic radiation protection authorities are aware of the international recommendation for generic intervention level of a projected lifetime dose of 1 Sv for permanent resettlement.

However, the operational intervention levels have their limits in practical use because the urgent protective actions have to be implemented before it is possible to measure the contamination or the actual dose rate. On the other hand, a straightforward derivation of operational intervention levels from the generic levels is not possible without knowing details of radioactive releases. If, however, operational intervention levels have been established from various assessments of accident scenarios, they should be included in national emergency plans.

8. APPLICATION TO EXPOSURE OF WORKERS

The principle difference between the exposures of workers and members of the public in the intervention situation is that workers undertaking an intervention will not be exposed until after the decision on starting the protective actions. On the contrary, members of the public will be exposed as far as their exposures will be diminished by the countermeasures. This means that radiation protection of workers undertaking an intervention has a closer connection with the occupational radiation protection in normal conditions.

As the exposure of workers in intervention situation is deliberate, it is reasonable to obey the normal radiation protection regulations if there is no imperative reason to deviate from them. Deviating from the occupational dose limits is normally justified in order to save human lives or to limit great population doses by bringing and maintaining the source of radiation under control. In the later phase of accident, when the situation is under control, a return to normal occupational radiation protection is justified.

Different radiological control regimes are appropriate for the various circumstances of exposure and categories of workers identified. These control regimes will become progressively more stringent as the need to depart from the normal regime of occupational exposure control becomes less acute. Emergency workers whose exposure to radiation might exceed one of the dose limits laid down for workers in normal practices shall be volunteers. Pregnant women shall not be directed to undertake these actions.

8.1. Urgent actions at the site of the accident

Immediately after the accident there might be a need for operations to save human lives, prevent serious injury or prevent individuals from incurring high doses beyond the thresholds for deterministic health effects or to prevent the development of catastrophic conditions. These workers are most likely to be plant personnel but may also be emergency service workers such as firemen. All these emergency actions are almost always justified although the radiation dose received by an individual worker could exceed the threshold level of deterministic health effects. However, every effort shall be made to keep doses below 500 mGy, in order to avoid deterministic health effects.

These workers shall be clearly and comprehensively informed in advance of the associated health risk, and shall, to a feasible extent, be trained in the actions that may be required. These workers should be given adequate protection, e.g. respiratory protection, protective clothing, iodine tablets etc. Their doses shall be monitored and recorded, and their medical surveillance shall be arranged.

8.2. Early protective actions

The workers engaged in taking urgent countermeasures to protect the public could include some workers from the affected site and will include many groups not normally employed as occupationally exposed workers. These groups will include police or others directing the public, manning road blocks and directing traffic, ambulance staff and other medical personnel handling casualties, drivers and crews of vehicles used for evacuation, and other workers. They should be properly trained for this work and should understand the risks of radiation.

The normal regime of occupational exposure control with dose measurements and dose limits should be applied to these workers, if it is possible. They should be given appropriate protection, e.g. personal protective equipment, iodine tablets etc. Their doses should be monitored and recorded, and their medical surveillance shall be arranged. By the end of their task, the doses they have received and risks should be explained to them.

8.3. Longer term recovery operations

The third group of workers includes people carrying out recovery operations that may take a relatively long period. These operations are likely to include decontamination, repairs to accident plant and buildings, waste disposal and all other industrial operations necessary either to restore the situation to normality or to leave the site in a state that may endure more or less indefinitely. This also includes the cleanup of the accident site and the surrounding areas.

All these operations can be planned and optimised in advance, so performing these operations is identical with normal practices and the normal regime of occupational exposure control with dose measurements and dose limits shall be applied.

8.4. Work not directly connected with an accident

If an accident gives rise to environmental contamination, the radiation exposure of all those who remain in or return to the area concerned to continue their normal occupations will be increased. Their work is not directly connected with the accident. These workers are regarded equally with members of the public, and the normal radiation protection regime for the public shall be applied. For some workers, however, exposure will be increased. Examples of such workers are farmers, forestry workers, workers handling industrial air filters, workers handling ash from burning peat and wood for energy production and workers handling sewage sludge from sewage treatment plants. These workers should receive detailed instructions on protective measures applicable to their particular work.

9. LIST OF REFERENCES

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