Nuclear Accidents

Intervention Levels for Protection of the Public

NUCLEAR ENERGY AGENCY

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Intervention Levels for Protection of the Public

A report by
an NEA Expert Group

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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- *encouraging harmonisation of national, regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;*
- *assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;*
- *developing exchanges of scientific and technical information particularly through participation in common services;*
- *setting up international research and development programmes and joint undertakings.*

In these and related tasks, NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

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POUR LA PROTECTION DU PUBLIC

FOREWORD

Following the Chernobyl accident in 1986, a critical review was undertaken, under the aegis of the NEA Committee on Radiation Protection and Public Health (CRPPH), of the radiological principles and procedures used to establish and apply intervention criteria for the protection of the public in the event of a nuclear accident.

This report was prepared by the Expert Group on Intervention Levels for Nuclear Emergencies. It includes guidance on specific questions related to emergency response planning and the establishment and application of intervention criteria. It also identifies those aspects of international guidance on emergency response planning where expansion or clarification is needed.

The report is intended to assist national authorities and international organisations in their examination of the issue of emergency response planning and intervention levels. The report, which represents the views of the Expert Group, is published under the authority of the Secretary-General of the OECD and does not commit Member countries.

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EXECUTIVE SUMMARY

Following the Chernobyl accident of April 1986, the NEA Committee on Radiation Protection and Public Health (CRPPH) decided to conduct a critical review of the radiological principles and procedures for the establishment and application of intervention criteria for the protection of the public in the event of a nuclear accident. The Expert Group on Intervention Levels for Nuclear Emergencies was established to consider such issues. This report has been prepared by the Expert Group to document the status of their discussions.

Section 2 of the report outlines the status of international guidance and recommendations on emergency response planning prior to the Chernobyl accident. A brief review of the radiological impact and the emergency responses in Member countries following the accident, including deposition patterns, estimated doses, protective measures and intervention criteria adopted, estimated effectiveness of the measures, and consequent issues and problems, is presented in Section 3.

Section 4 provides the Expert Group's review of the radiological principles and procedures underlying intervention criteria, primarily in the context of the issues and problems which have been raised by the Chernobyl accident. These primarily involve:

a) the need for additional clarification or expansion of international guidance and recommendations on emergency response planning and intervention criteria;

b) the need for harmonisation of methodologies and parameter assumptions used in accident impact assessment and the establishment of derived intervention levels (DILs); and

c) the need for specific guidance on control levels for the international trade of food.

Where appropriate, guidance from the Expert Group on specific questions related to emergency response planning and the establishment and application of intervention criteria is provided. As well, the Expert Group identifies those aspects of the international guidance and recommendations where a need for expansion or clarification exists.

The Expert Group is of the opinion that a strong potential exists for international harmonisation of intervention levels through development of criteria at the planning stage. Such predetermined intervention criteria would be most useful in providing internationally accepted values for intervention in the event of accidents having transboundary impacts, as well as interim values for intervention immediately following an accident.

The Expert Group has concluded that aspects of the current international guidance and recommendations on emergency response planning and intervention criteria need to be expanded or clarified, with the objective of providing more comprehensive and harmonised advice and a clearer explanation of the rationale for the recommended intervention criteria and protective measures.

Explicit attention needs to be given to areas beyond the accident site, giving particular consideration to the implications of severe accidents having widespread, transboundary and long-term impacts. Greater consideration of the spatial aspects of such accidents, particularly in terms of the types of protective measures required, is expected to enhance the applicability and interpretation of the international guidance on emergency response. To facilitate discussion on the far-field issue, the Expert Group has distinguished two impact conditions: a) that where interventions are required primarily to control exposures arising from deposition of contaminants (i.e., the far-field with direct impact); and b) that where interventions are required only to control exposures arising from contaminated food imported from other countries (i.e., the far-field with indirect impact).

The meaning and applicability of principles (b) [risk to individuals] and (c) [collective detriment] of ICRP-40 [2] in the far-field need to be clarified, particularly with respect to controls on food. The Expert Group is of the opinion that a process of optimisation of radiological protection [i.e., use of principle (c)] may be useful as a decision-aiding tool in the general development of predetermined intervention criteria for protection of public health. Some members of the Group are of the opinion that this process of optimisation should be conducted between two constraints: an upper level of individual dose above which the protective measure should almost certainly be applied, and a lower level of individual dose below which the protective measure would not likely be warranted. While the Expert Group considers that the upper level could be established on the basis of maximum acceptable risk to individuals, no consensus has been reached by the Group on the appropriateness of specifying a lower bound for the optimisation process. The Expert Group recommends that further effort should be made towards developing a consistent set of dose constraints.

The Expert Group considered the need for modification of principles (b) and (c) of ICRP-40, with the objective of making them appropriate for application to the far-field, and to the long term. The rationale for any such modification involves the need to provide justification for implementing protective measures, to establish an individual-related criterion based on acceptable risk and to place greater emphasis on control of the collective detriment in the far-field. The Expert Group recommends that these aspects be given further consideration by the relevant international organisations.

The Expert Group concluded that several practical issues require the formulation of derived intervention levels (DILs). However, it was also concluded that the safety factors introduced into the methodologies and parameter assumptions used in the definition of DILs and accident impact assessments can potentially introduce a substantial degree of subjectivity into the results. Because of this, the Expert Group notes that there is considerable potential for differences to arise in developing DILs, even when they have been determined from the same intervention level. Therefore, the Expert Group recommends that increased international attention be devoted to examining DIL modelling techniques and approaches, and developing a more systematic and harmonised approach to the definition of DILs.

Some guidance from the Expert Group on this issue is provided in the report, and can be summarised as follows:

a) Unnecessary discrepancies in the modelling of environmental transfer processes need to be reduced to the extent possible.

b) There is a need for further consideration of the development of DILs for routes of exposure, in the far-field, not related to ingestion of food.

c) Planning for emergency response should be based on a defined reference group of individuals, or a reference population, to which protective measures would be applied in the event of an accident.

d) The Expert Group considers that it would be useful to obtain a consensus on an accepted value for a food contamination factor, which can be used in the development of predetermined DILs.

e) With respect to control measures for food, the Expert Group is of the opinion that a system which requires full additivity of exposures from all foods would, in practice, require an assessment and control mechanism perhaps too complex to be pragmatic or useful. Thus, particularly for the far-field, the Group is of the opinion that DILs should be developed only for major components of the diet, and that additivity should be considered only if the contributions to the ingestion dose from different foods are of a similar degree of importance and, individually, represent a significant fraction of the corresponding intervention level.

The Expert Group observes in the report that the issue of establishing appropriate intervention criteria for controls on the international trade of food contaminated as a result of an accident has dominated post-Chernobyl discussions on intervention criteria. The Group notes that factors other than those typically considered in radiological protection assessments are relevant to decision making, and recommends that the organisations examining this issue attempt to explicitly identify and define the role of these various factors in the decision-making process. Nevertheless, the Expert Group is of the opinion that the intervention criteria established for controls on the consumption of food, on the basis of radiological protection and public health considerations, should be the initial focus of decisions on control levels for the international trade of food. Therefore, the Expert Group suggests that the numerical value selected for the lower intervention level should be adopted as the general level for use in calculating DILs for controls on imported food.

1. INTRODUCTION

1.1 BACKGROUND

On the 26th April 1986, a major accident occurred at Unit 4 of the Chernobyl nuclear power facility, located in the Ukraine Republic (USSR), which resulted in a prolonged release to the atmosphere of large quantities of radioactive material. The specific characteristics of the release, particularly its relatively long duration and the altitude reached by the radioactive plumes, led to a widespread distribution of activity, mainly across Europe. Activity transported by the multiple plumes was measured not only in northern and in southern Europe but also, to a lesser extent, in Canada, Japan and the United States. The spatial pattern of ground contamination was uneven due to the variation of meteorological conditions, wind patterns and precipitation during the passage of the airborne radionuclides.

The NEA Committee on Radiation Protection and Public Health (CRPPH) held a special session on the 1st-2nd September 1986 to review the impact of the Chernobyl accident in OECD Member countries and to consider the radiological issues which had arisen. One such issue which was identified by the CRPPH concerned the observed differences in the emergency responses and intervention criteria adopted by Member countries.

The progressive spread of contamination at large distances from the accident site caused considerable concern in Member countries, particularly with respect to contamination of food and the environment, and the consequent radiation doses received by the public. The reactions of national authorities were varied, ranging from a simple intensification of the normal environmental monitoring programmes, without adoption of any specific protective measures, to compulsory restrictions on the marketing and consumption of food. This variety of responses was accompanied by significant differences in their timing and duration of application. In addition, there appeared to be considerable differences in the derivation and use of intervention criteria, even with the recognition of understandable differences in contamination levels, environmental features, living habits and diets, and national regulatory approaches.

This apparent disharmony caused considerable concern and confusion amongst the public and national authorities. Thus, the CRPPH believed that it would be appropriate to undertake a critical review of the emergency response actions and intervention criteria adopted in Member countries, with the <u>goal of directing effort towards achieving a better international harmonisation of the principles and criteria for the protection of the public</u> in the event of a nuclear accident. On this basis, the CRPPH established an <u>Expert Group on Intervention Levels for Nuclear Emergencies</u> to consider such issues.

1.2 STUDY APPROACH

The Expert Group on Intervention Levels for Nuclear Emergencies was composed of experts in the field of radiological protection from eight Member countries, as well as representatives from the International Commission on Radiological Protection (ICRP), the International Atomic Energy Agency (IAEA), the Commission of the European Communities (CEC), the World Health Organisation (WHO) and the Food and Agriculture Organisation (FAO). Representation of the international organisations was provided specifically to ensure a degree of international co-ordination and communication. A list of participants at the Expert Group meetings is provided in Annex I.

The terms of reference of the Expert Group are provided in Annex II. The primary objectives of the study were to:

a) critically review the emergency responses and corresponding intervention criteria adopted in Member countries in response to the Chernobyl accident;

b) examine the potential and means for generic derivation and application of intervention criteria for protection of the public in the event of an accidental release of radionuclides from nuclear facilities; and

c) provide guidance on the means for enhancing international harmonisation of the derivation and application of such intervention criteria.

The formulation of numerical derived intervention levels (DILs) was beyond the scope of the Expert Group's activities.

Because of the nature of the impact of the Chernobyl accident in Member countries, emphasis was placed on an examination of principles and criteria applicable to the control of exposures in the "far-field", that is, at considerable distances from an accident site. Thus, primary consideration has been given to principles and criteria for the control of public exposures arising from ingestion of contaminated food.

Section 2 of this report from the Expert Group outlines the status of international guidance and recommendations on emergency response planning prior to the Chernobyl accident. A brief review of the radiological impact and the emergency responses in Member countries following the Chernobyl accident, including deposition patterns, estimated doses, protective measures and intervention criteria adopted, estimated effectiveness of the measures, and consequent issues and problems, is presented in Section 3. Some of this material has been summarised from a more detailed review of these subjects published by the OECD/NEA as a separate report [1].

Section 4 provides a critical review of the principles and procedures for the establishment and application of intervention criteria for emergency response, primarily in the context of the issues and problems which have been raised by the Chernobyl accident. Where appropriate, guidance from the Expert Group on specific questions is provided. As well, the Expert Group identifies those aspects of the international recommendations where a potential need for expansion or clarification exists.

Section 5 provides a synthesis of the discussions contained in the preceding section, and outlines the status of the deliberations of the Expert Group.

A Glossary has been provided to facilitate a common and clearer understanding of the key terms used in the Expert Group's discussions.

2. INTERNATIONAL BASIS FOR EMERGENCY RESPONSE PLANNING

2.1 INTRODUCTION

The basic ICRP recommendations of 1977 [3] and the "Basic Safety Standards of Radiation Protection" issued by the IAEA, ILO, NEA and WHO in 1982 [4] stipulate that the establishment of emergency response criteria for the protection of the public is the responsibility of national authorities, due to the variety of administrative, social and environmental conditions existing in the various countries. As a consequence, differences in practices have developed between Member countries, leading to potential problems in the event of accidents having transboundary consequences.

A significant effort to develop an international consensus on criteria and measures for the protection of the public in the event of a nuclear accident had been made in recent years by several international organisations active in this field, particularly the ICRP, the IAEA, the WHO and the CEC. As a result, a set of recommendations had been developed which provided a reasonably well-developed international basis for accident response [2, 5, 6, 7, 8]. In particular, ICRP Publication No. 40 (ICRP-40) outlines principles for planning for protection of the public in the event of major radiation accidents, including guidance on intervention levels. Subsequent to the Chernobyl accident, many of these international recommendations are being examined for their applicability to Chernobyl-type accident scenarios.

This section of the report briefly reviews the basic international recommendations and guidance for emergency response planning.

2.2 OBJECTIVES AND NATURE OF EMERGENCY RESPONSE PLANS

The accidental release of radionuclides from a nuclear facility to the environment may entail risks to the public which extend beyond those considered acceptable, and therefore which require mitigation by authorities. Emergency response plans exist to provide guidance to the authorities in the event of such an accident although, given the unique character of each potential accident situation, the authorities may be called upon to respond with ad-hoc corrective actions. Thus, it is essential that adequate procedures are available for the authorities to quickly ascertain the consequences (both actual and predicted) of any accidental release from any source, and to respond to such a release in an appropriate manner.

The decision-making process in an emergency response system generally involves an evaluation of the consequences of an accident in the context of decision criteria and constraints, an identification and evaluation of alternative actions, and the selection of appropriate responses. The primary bases for these evaluations are intervention criteria. The use of radiological intervention criteria can provide a good quantitative basis for the selection of emergency responses. An intervention level is the value of radiation dose which, if exceeded or predicted to be exceeded in the event of an accident, may require the application of a given protective measure. Intervention levels (ILs) specify values of radiation dose to individuals projected over a given period of time, and are used as a threshold for initiating a given set of protective measures. Derived intervention levels (DILs) are secondary criteria, usually specified as the concentration or time-integrated activity of a given radionuclide within a given food or environmental medium (air, soil, water, vegetation) which, on the basis of specific assumptions on transfer to humans, corresponds to the relevant IL. Measurements of activity in the environment or in food can be compared directly to DILs to provide timely determination of the need for implementing protective measures.

The outcome of the decision-making process is represented by the set of protective measures, or interventions, enacted by authorities with the primary objective of restricting or minimising exposures of the public. Interventions commonly considered in emergency response planning include sheltering, stable iodine administration, evacuation, control of access, relocation, decontamination (people, land, buildings) and controls on the distribution and consumption of food and water. The interventions may be characterised with respect to their temporal and spatial application, and also with respect to the particular exposure pathway being considered.

External exposures may arise from irradiation from radionuclides in the plume (or "cloud"), and irradiation from material deposited on the ground or on clothing and skin. Specific protective measures for control of such exposures include sheltering, evacuation, control of access and decontamination. Internal exposures may arise from internal contamination as a result of inhalation of radionuclides in the plume, inhalation of resuspended radionuclides or ingestion of contaminated food and water. Control of inhalation exposures from the plume can be attempted through the use of sheltering, stable iodine administration, evacuation and control of access, while protective measures for control of exposures resulting from inhalation of resuspended radionuclides include evacuation, relocation, control of access and decontamination. Ingestion-related exposures may be mitigated through controls on food and water, and by the use of stored (uncontaminated) animal feed.

All international recommendations have been reasonably uniform in advocating a temporal classification of accidents for the development of radiological protection principles and criteria for emergency response planning. Accidents have been categorised into three sequential time phases, namely the early, intermediate and late (or recovery) phases. Such a categorisation has been viewed as providing a useful framework for decision-making, under the assumption that exposure pathways may differ in each phase, and that these differences may require the introduction of different protective measures.

The Early Phase involves the period of time during which there is a threat of a significant release, and extends into the first few hours of the occurrence of any such release. Although some environmental monitoring information may be available to aid decisions on the introduction of protective measures, this information would be of limited value for calculating projected doses. Rather, emergency response decisions would be based upon specific facility and local meteorological conditions. Protective measures appropriate for the early phase include sheltering, stable iodine administration, evacuation and control of access.

The Intermediate Phase covers the period of time from the first few hours to a few days or weeks after commencement of a release. For planning purposes, it is assumed that the majority of the release will have occurred by the beginning of this phase, with significant ground deposition of released materials focussing attention on the exposure pathways arising from the deposited activity (external exposure, internal exposure from ingestion of contaminated food and water, inhalation of resuspended activity). The ICRP-40 recommendations [2] do envision, for severe accidents and extensive ground contamination, temporal extension of this phase involving protective measures at greater distances and for larger populations. During the intermediate phase, it is anticipated that monitoring information on food and environmental media would be available to enable calculation of projected doses for the principal exposure pathways, and to make decisions on the implementation of applicable interventions.

The Recovery (or Late) Phase may extend for a considerable period of time following an accident, depending upon the specific release characteristics. Decisions on the return to normal living conditions are made in this phase. Decisions on the withdrawal of protective measures may be based on monitoring information on environmental media and food, and on a process similar to that of optimisation of radiological protection.

The international recommendations adopt, as a general philosophy for decision-making, the concept that the social cost and risk associated with the implementation of interventions should be less than that of the radiation dose averted. Adoption of a given protective measure, therefore, should involve a consideration of the balance between the degree of public protection to be achieved and the extent of social and economic disruption (entailing residual risks and costs) that is introduced by the implementation of that measure.

2.3 BASIC PRINCIPLES FOR INTERVENTION

Controls on public exposures arising from normal operations of nuclear facilities are generally based on the ICRP system of dose limitation [3]. On the assumption that the source of exposure in an accident situation is not under control, international recommendations [2,6,7,9] are in general agreement that the ICRP system of dose limitation [3] is not directly applicable. Nevertheless, the general principles which underlie these ICRP recommendations can form the basis for planning intervention in the event of an accident, giving consideration both to criteria for the limitation of individual risk and for the limitation of collective detriment. As well, part of the methodology recommended in the general system of radiological protection, namely optimisation, can be adopted to aid decision-making following an accident [2].

The basic principles recommended by the ICRP and other international organisations for planning intervention are the following:

"(a) Serious non-stochastic effects should be avoided by the introduction of countermeasures to limit individual dose to levels below the thresholds for these effects.

(b) The risk from stochastic effects should be limited by introducing countermeasures which achieve a positive net benefit to the individuals involved.

This can be accomplished by comparing the reduction in individual dose, and therefore individual risk, that would follow the introduction of a countermeasure with the increase in individual risk resulting from the introduction of that countermeasure.

(c) The overall incidence of stochastic effects should be limited, as far as reasonably practicable, by reducing the collective dose equivalent.

This source-related assessment may be carried out by cost-benefit analysis techniques and would be similar to a process of optimisation in that the cost of a decrease in the health detriment in the affected population is balanced against the cost of further countermeasures." [2, para. 10].

All three principles apply to all phases of an accident, but their relative importance changes with time and distance as the potential for acute exposures decreases, as individual risk becomes smaller and as larger populations are affected. Interventions based on the limitation of individual risk have been intended to be applicable to the most highly exposed individuals, generally within a relatively short distance from the accident source and within a short time from occurrence of the accident . Principle (a) calls for the implementation of protective measures to avoid high levels of dose which could produce non-stochastic health effects. Below these dose levels, principle (b) would be implemented to establish an intervention level appropriate for protection of the individual from stochastic effects. Principle (c) implies that collective detriment is also an important consideration for accident management, with decisions on withdrawal of protective measures and allowing the resumption of normal living conditions depending partly on a process similar to that of the optimisation of radiological protection.

2.4 INTERVENTION CRITERIA

All international organisations are in agreement on the need for the establishment of intervention levels of dose (ILs) as the reference point for decisions on implementing protective measures. The international recommendations acknowledge that the risks, difficulties and socio-economic disruptions that are associated with the implementation of the various interventions vary widely in relation to the particular protective measures, and thus the level of dose at which a given measure should be introduced is considered to be influenced by such considerations, as well as by other national and site-specific factors.

Consequently, the international recommendations call for a dose range to be established, for each intervention, between two levels of dose - a lower level, below which introduction of the protective measure is not likely to be warranted on the basis of radiological protection, and an upper level, above which the protective measure should almost certainly be implemented. Actual intervention levels for the various protective measures are recommended to be established within this range, according to local conditions and requirements. All recommendations agree that the level of dose at which action is to be taken should be that projected if a particular measure is not introduced. Intervention levels which have been suggested or recommended for implementing various protective measures are provided in Table 1.

The recommendations also recognise the necessity of specifying derived intervention levels (DILs), particularly for facilitating the interpretation of monitoring results for environmental media and food. Several Member countries (for example, the United Kingdom [11]) had, prior to the Chernobyl accident, established DILs for various environmental media and food for use in the event of a radiological emergency resulting from an accident at a domestic nuclear facility. Still other countries had developed other secondary levels, not necessarily based on radiological protection criteria, for the control of radioactive contamination in domestic and imported food.

Prior to the Chernobyl accident, the IAEA had been preparing a guide on DILs for radiological emergencies. That document was published in 1986 [12], and is currently being reviewed in the context of new information arising from post-Chernobyl studies.

Table 1. International Guidance on Intervention Levels
PRIMARY INTERVENTION LEVELS (mSv)

Protective Measure	Whole Body or Effective Dose Equivalent		Single Organ	
	Lower	Upper	Lower	Upper
Sheltering	5	50	50	500
Stable Iodine Administration	-	-	50	500
Evacuation	50	500	500	5000
Relocation	50	500	-	-
Control of Food	5	50	50	500

Source: References [2], [6] and [9].

3. REVIEW OF THE RADIOLOGICAL IMPACT AND THE EMERGENCY RESPONSE IN MEMBER COUNTRIES FOLLOWING THE CHERNOBYL ACCIDENT

3.1 INTRODUCTION

As part of its programme of work related to the evaluation of the Chernobyl accident, the OECD/NEA prepared an assessment of the radiological impact of the accident and a preliminary review of the emergency response in Member countries [1]. The assessment was prepared under the direction of the CRPPH on the basis of information supplied by Member countries. A summary of the relevant parts of the assessment is provided in this section, including discussion of the contaminant deposition patterns, the estimated doses, the protective measures and intervention criteria adopted, the effectiveness of the protective measures, and consequent issues and problems.

3.2 RADIOLOGICAL IMPACT

3.2.1 Contaminant Deposition

The major part of the release of radioactive material from the damaged Chernobyl reactor occurred over a period of about ten days. During this time, the prevalent meteorological conditions dispersed the airborne radioactivity over a wide area throughout Europe, and eventually the Northern Hemisphere. Deposition of radioactivity was complex and uneven, largely due to the varying distances from the release source, and to the presence of unstable air masses and extensive, localised heavy rainfall which resulted in sporadic, enhanced deposition of contaminants. Of the OECD Member countries, only Australia did not detect enhanced environmental radioactivity which could be attributed to the Chernobyl accident.

In the Member countries, only a few radionuclides were deposited in quantities considered to be radiologically significant, with the three most important nuclides being iodine-131, caesium-134 and caesium-137. Tables 2 and 3 depict, respectively, average and maximum recorded levels of deposition of these nuclides for each Member country (levels provided for caesium are for caesium-134 and -137 combined). In general, those countries such as Austria, the Federal Republic of Germany, Italy and some Nordic countries which experienced very heavy regional rainfall in the presence of contaminated air masses, recorded the highest levels of deposition.

The ratios of maximum to average deposition levels for the Member countries are also provided in Table 3. For most, the maximum levels are no more than a few times the average levels, although for a few, such as the

United Kingdom and Sweden, the range is very large. This inhomogeneity of deposition is reflected in differences between average and critical group doses, discussed below in Section 3.2.2.

3.2.2 Dose Estimates

The following estimates of doses received in Member countries as a result of the Chernobyl accident are preliminary and subject to a degree of uncertainty. They have been based on environmental measurements, assumed dietary and living habits, and models of the behaviour of radionuclides in the environment and in man. Results of in-vivo, whole-body measurement programmes in several Member countries have indicated that the dose estimates presented for the ingestion pathway may be high (by factors of approximately 2 to 5). Reference should be made to the OECD/NEA radiological impact study [1] for a detailed review of the sources of uncertainty and the assumptions used in the dose assessments.

The exposure pathways arising from the Chernobyl accident which were relevant for Member countries were direct external gamma irradiation from the cloud, direct inhalation from the cloud, external gamma irradiation from material deposited on the ground and ingestion of contaminated food. For those Member countries which experienced deposition, doses are mainly due to ingestion of contaminated food and external irradiation by deposited activity (Table 4), and iodine-131, caesium-134 and caesium-137 are considered to be the most significant contributors to dose.

Average Individual Doses

Average individual effective dose equivalents resulting from exposure and intake during the first year following the accident are provided in Table 5. Corresponding average individual thyroid dose equivalents are also provided in Table 5. These doses have been calculated by dividing the total collective effective dose equivalent estimates by the respective populations, and thus cannot be applied to a particular age group of the population (see reference [1]). These estimates take account of the reductions in dose achieved by any protective measures adopted.

The average effective doses range from a few mSv or less for Portugal and most of the countries outside of Europe, to about 0.7 mSv for Austria, and generally correspond in relative magnitude to the amount of caesium deposition. The thyroid doses range from a few mSv to between 2 and 3 mSv for Greece, Austria and Italy, with there appearing to be little correspondence between the amount of iodine-131 deposition and the dose (see reference [1]).

Collective Doses

Collective doses committed from the first year of exposure and intake following the accident were estimated for three representative age groups: infants, children and adults. The collective dose estimates take account of the reductions in dose achieved by any protective measures adopted. The collective effective dose equivalent estimates for each country and age group are displayed in Table 6, with the corresponding collective thyroid dose equivalent estimates provided in Table 7.

The total collective effective dose equivalent is estimated to be about 70 000 manSv, with the total collective thyroid dose equivalent estimated at about 300 000 manSv. Although the influence of the size of the population on the collective doses is clear, the impact of the variation of deposition between countries is also evident (comparing, for example, the collective effective doses for the UK and Italy). Of significance, the OECD/NEA dose assessment [1] concluded that differing assumptions used in predictive modelling (e.g., diets; living conditions) had an important influence on the calculated doses.

Critical Group Doses

Although the assumptions used in the calculation of average individual and collective doses led to probable differences in dose estimates between Member countries of factors of three or so, the influence of the assumptions made on estimates of critical group doses was considered to be even greater [1].

The committed effective dose equivalent estimates for individuals of the critical group are provided in Table 8, for each age group. The effect of any protective measures introduced is accounted for in these estimates, and the assumptions made regarding the nature of the critical group are identified.

The dose estimates display two primary groupings: those with values of about 1 mSv or more, and those with values of about 0.1 mSv or less. Generally, those countries which recorded the highest levels of total caesium deposition displayed the highest critical group dose estimates. There is no uniformity in the relative sizes of the dose estimates for each age group, due both to the influence of protective measures adopted and to differences in the assumed habits of each age group [1].

3.3 EMERGENCY RESPONSE

3.3.1 Protective Measures

The results of a survey of the interventions adopted in Member countries in response to the Chernobyl accident have been discussed in reference [1]. A summary of that information is presented in Table 9 of this report. Annex III provides a detailed compilation of the response information.

Emergency responses in Member countries ranged from the application of no specific protective measures up to comprehensive bans on the consumption, marketing and importing of food. In general, the most widespread measures adopted were those which were not expected to impose any significant social or economic burden (e.g., advice to wash food before consumption, advice not to use rainwater). However, in practice, significant impacts did occur as a result of many of these measures (see Section 3.5). Other protective measures, having a significant socio-economic impact, included restrictions or prohibitions on the consumption and marketing of milk, dairy products, fresh vegetables and meat, controls on agricultural practices (e.g., outdoor grazing of livestock) and advice on travel to potentially contaminated areas.

The implementation of monitoring programmes was complicated due to considerable initial uncertainty as to the nature and spatial distribution of the contamination, and also because existing emergency monitoring protocols appear to have been tailored to respond to a well-defined, local release source, which was not the case for the Chernobyl accident. Thus, considerable initial effort had to be made to identify areas of elevated deposition of contaminants prior to determining whether the actual activity levels required some form of intervention.

Protective measures typical of those required in the early phase of an accident (sheltering, stable iodine administration, evacuation) were not required nor adopted in Member countries to control exposures. Some advice was issued in some countries to restrict certain activities (e.g., outdoor bathing), presumably to avoid external exposures, but this advice may not have been based on radiological health criteria.

The principal consideration of intervention in most Member countries was the control of public exposures arising from consumption of contaminated food. Widespread initial concern over contamination of fresh milk, arising from the consumption of contaminated grass by dairy animals, led to the adoption of controls on outdoor grazing by livestock. In addition, a variety of protective measures were adopted relating to consumption of milk and dairy products. Such measures ranged from <u>advice</u> on consumption, to <u>restrictions</u> on the levels of contamination acceptable in food to be consumed, to <u>prohibitions</u> on consumption by specific groups (e.g., infants and children) in more heavily contaminated regions. In some cases, contaminated milk was destroyed, but in others, milk was converted into dairy products (cheese, butter) which were then stored with the objective of having sufficient radioactive decay of the short-lived radionuclides occur over the period of storage to enable release of the food to consumer markets. Activity deposition on fresh vegetables was also an initial source of concern, as reflected in Table 9 by the extent of interventions adopted relating to consumption and marketing of vegetables.

The initial concerns and adoption of protective measures related to milk, dairy products and vegetables were primarily in response to high levels of iodine-131 activity. With the subsequent decrease in levels of the short-lived iodine-131, attention focussed on the presence of longer-lived nuclides in food, in particular caesium-134 and -137. Environmental monitoring activities were focussed to assess the accumulation and impact of the longer-lived contaminants,and controls on consumption and marketing were extended to stored milk products, grains and cereals, meat and fish, reindeer, game and other specific food.

Protective measures concerning the control of contaminated food were adopted in virtually all Member countries, and had a significant socio-economic impact on international trade. Initially, several countries placed prohibitions on the import of food from the Soviet Union and several Eastern European countries, largely in response to uncertainty over actual levels of contamination. Later, restrictions on imports from both Member and non-Member countries were implemented, although there were variations in the relevant intervention criteria used by the different countries.

3.3.2 Intervention Criteria

A survey of the intervention criteria adopted in Member countries in response to the Chernobyl accident was conducted by the OECD/NEA in support of the work of the Expert Group. Preliminary results of that survey were provided in the OECD/NEA evaluation of the radiological impact of the accident [1], and are presented in detail in this report.

The general radiological protection principles which provided the basis for the actions taken in most Member countries were found to be very similar. However, some differences arose amongst Member countries in the assessment of the situation, and in the adoption and application of radiological protection criteria.

One of the principal aspects of the use of intervention criteria in the various countries was the diversity of values adopted for derived intervention levels (DILs) and other secondary control levels. A distinction can be made between DILs and other control levels (e.g., action levels), particularly for food-related interventions adopted in various countries following the Chernobyl accident. DILs, by definition, are derived from an established dose level (i.e., the IL) by means of a defined model. Other control levels, on the other hand, may not be directly related to a selected intervention level of dose. In many cases, the secondary intervention criteria used following the Chernobyl accident were actual DILs, but in several cases, no such direct calculational link to a selected intervention level of dose is apparent.

A compilation of the information available on intervention criteria is provided in Annex IV. A summary of the secondary intervention criteria adopted by each Member country for iodine-131 and radio-caesium (caesium-134 and -137) is provided in, respectively, Tables 10 and 11. The information in these tables has been provided by the competent authorities in the Member countries [1]. The criteria have been tabulated for drinking water, milk/ dairy products, vegetables, meat and other exposure pathways (fruit, cereals, forage, sewage sludge used in agriculture, etc).

The secondary criteria for the various exposure pathways were identical in certain countries but significantly different in others, even when environmental and dietary and living habits may not have been substantially different. For example, the levels for radio-iodine, adopted to control exposures resulting from the consumption of milk, varied between 125 and 2 000 Bq L^{-1} (Table 12). In one country, a "screening level" as low as 10 Bq L^{-1} was adopted for restricting imports of milk. For radio-caesium in milk, values ranged from 50 to 3600 Bq L^{-1}. Similar broad ranges were observed in the adoption and application of secondary criteria for vegetables and meat.

Part of these differences can be explained by differences in the intended application of the DILs. Some of the higher values represented maximum activity concentration levels applicable to short periods of time. On the other hand, lower DILs were adopted in some countries to apply as average values over extended periods. Some values were intended to be applied to the most exposed age category of a critical group (often infants), while others were intended for application to adults of an average population.

In some cases, differences in the secondary criteria can be accounted for in terms of objective diversities in environmental characteristics and dietary and living habits. However, dissimilarities in assessment methodology, including environmental transfer and dosimetric modelling, as well as the influence of non-radiological decision criteria, also played a substantial role in creating the perception of unwarranted differences in the adoption and application of intervention criteria.

A particular problem raised by the transboundary character of the Chernobyl accident concerned its impact on the international trade of goods, particularly food. Shortly after the deposition of contaminants in Member countries, concern was expressed regarding acceptable levels of activity in imported and exported food. Secondary intervention criteria were provisionally established by the CEC for the import and export of food between CEC Member countries [13]. Relatively low values were selected for radio-caesium, namely 370 Bq L^{-1} in milk and infant food, and 600 Bq kg^{-1} in other food. It is recognised, however, that these values were not adopted solely on the basis of radiological protection criteria, but that their choice was influenced by other, non-radiological factors. The retention of these secondary criteria has been prolonged [14] due to the issue of the future marketing of food contaminated as a result of the Chernobyl accident. However, other intervention criteria have been recently adopted by the CEC to apply to control of food placed on the market in the CEC Member countries following any future nuclear accident or other type of emergency which may lead to significant radioactive contamination of foods [15].

The impact of this transboundary issue was not limited to countries directly affected by the deposition of radioactivity. Many other countries were concerned with the possible risks to their population from food imported from Europe, and established controls and limitations on these imports. Many of these countries adopted levels of activity for the screening of imported foods which were similar to those recommended by the CEC, but other countries chose to use more restrictive limits. This situation resulted in some socio-economic disruptions and difficulties in trade. In order to overcome these difficulties, several international organisations have attempted to achieve an international consensus on a set of secondary intervention criteria to be used to control the international trade of food which has been accidentally contaminated with radionuclides. In particular, the FAO and the WHO are attempting to develop joint recommendations on a system that can be uniformly and simply applied by authorities, and which achieves an adequate level of public health protection.

Other international agencies, such as the IAEA and the ICRP, are examining the validity of their respective recommendations on emergency response planning and intervention criteria in the light of the issues which have arisen from the Chernobyl accident. Still other international agencies, in particular the WHO [16] and the OECD/NEA, have examined the potential and means for international harmonisation of the development and application of intervention criteria for protection of public health.

3.4 EFFECTIVENESS OF PROTECTIVE MEASURES

It is useful to examine the relationship between the protective measures adopted and the consequent reductions in dose (that is, the dose averted). Basically, a protective measure may be adopted primarily to reduce either individual dose or collective dose, although in practice it will influence both. International recommendations [2, 6] stress the importance of individual dose reduction in the implementation of protective measures. The OECD/NEA report on the radiological impact of the Chernobyl accident [1] presented estimates of the effectiveness of protective measures adopted in Member countries. Estimates of the percentage of the dose averted by the measures which were implemented are presented in Table 13 for the critical group dose estimates, and in Table 14 for the collective dose estimates.

Austria, the Federal Republic of Germany and Norway have estimated the highest collective effective dose reductions, with a reduction in total dose of between 30% and 50%. Austria also estimated the highest critical group dose reduction (64 - 80%), and the highest collective thyroid dose reduction (68 - 85%). The high dose reduction estimates for both critical group doses and collective doses would appear to indicate that, although some interventions were targeted specifically at preventing exposures of individuals most at risk, they may have had a broader effect. The percent dose reductions estimated by Greece, Luxembourg and the Netherlands were also similar for collective and critical group effective doses, while for Sweden, the percent collective dose reduction was estimated to be significantly higher than that for the critical group. However, other Member countries, such as the United Kingdom, estimated considerably higher percent reductions for the critical group doses than for the collective doses.

Reference [1] concluded that the assumptions made concerning the character of the critical group would have a significant influence on the selection of protective measures and the estimates of the effectiveness of the measures in terms of dose averted, and that the choice of whom to protect when implementing protective measures is strongly influenced by the pattern of environmental contamination. Where the contamination levels vary substantially within a given country, the potential arises for one group of individuals to be significantly more at risk than the general population. In such circumstances, the need to protect the critical group is clear. However, in the case of relatively uniform environmental contamination of a small country, the adoption of protective measures designed to reduce the collective dose potentially is more appropriate and effective.

3.5 ISSUES AND PROBLEMS

Several issues and problems relevant to the derivation and application of intervention criteria have arisen due to the occurrence of the Chernobyl accident. These primarily involve:

a) the nature of the accident;

b) international guidance on emergency response planning and intervention criteria;

c) methodologies and parameter assumptions used in accident impact assessment and the development of DILs;

d) the role of non-radiological factors in the decision-making process;

e) public understanding and acceptance of emergency response measures, and the capability of public authorities for communicating adequate and appropriate information;

f) residual (unintended) impacts arising from the adoption of certain interventions; and

g) international trade of food.

3.5.1 Nature of the Accident

The nature of the Chernobyl accident (i.e., severe failure; prolonged release; long-range, transboundary transport of contamination) gave rise to several problems related to emergency response. For example, the emergency response systems, in particular the monitoring programmes, in many Member countries have been developed on the basis of a well-defined release source characterised by relatively local and short-term impacts. Such conditions were not relevant to Member countries in the case of the Chernobyl accident, and considerable uncertainty as to the spatial distribution of contamination arose. The consequent uncertainty in the extent or degree of intervention deemed necessary led many countries to take additional measures, mostly in the form of precautionary advice, to compensate for this higher level of uncertainty.

It has been demonstrated by the Chernobyl accident that the occurrence of accidental releases and deposition of contaminants in relation to the time of year, or seasonality, can have an important influence on the transfer of radionuclides in foodchains, and thus on the determination of interventions. For example, the growing season in northern European countries was just beginning at the time of the Chernobyl accident, while in southern Europe, many agricultural crops were ready for harvesting and dairy cattle were grazing on new forage. Thus, initially, there were some differences in the extent of grazing and crop-harvesting controls implemented by Member countries. The need for such controls, particularly those relating to radio-iodine, would have been greatly reduced had the accident occurred during the winter season. Thus, it is evident that accident scenarios (including the timing of accidents and seasonality effects) are of some importance to emergency response planning, and partly explain differences in emergency response measures taken in the Member countries.

3.5.2 International Guidance on Emergency Response Planning and Intervention Criteria

Although the international guidance is based on sound principles, it is apparent that further explanation is required in order to enable the guidance to be appropriately interpreted and applied. There would appear to be a need for a critical review of the existing recommendations, with the objective of providing more comprehensive and harmonised guidance, and a clearer explanation of the rationale for the recommended intervention criteria and protective measures. Particular emphasis should be placed on examining international guidance on the spatial aspects of accident categorisation, the applicability of the intervention levels to areas remote from the accident source, the applicability of the recommendations to controls on food, and clarification of the meaning and applicability of principle (b) [risk to individuals] and principle (c) [collective detriment] in areas well beyond the accident site.

3.5.3 Methodologies and Parameter Assumptions

The use of different methodologies and parameter assumptions in accident impact assessment and in the establishment of DILs is significant in the explanation of the diversity of responses and intervention criteria observed in Member countries following the Chernobyl accident. Different assumptions on environmental processes and characteristics of the affected populations have been noted in the various dose assessment models (including environmental transfer and dosimetric modelling), often resulting in significantly different conclusions as to the need for specific protective measures.

Several parameters influential in the determination of derived intervention levels and the assessment of impacts arise from the dietary and living habits of the individuals exposed to the accidental releases of radionuclides. Such parameters include the food source, the dietary habits, the age of the individuals, the activities of the exposed group and the particular practices of food distribution and processing. In the case of the Chernobyl accident, the wide range observed in these parameters amongst the affected population groups has made it difficult to generalise and assess actual impacts, even within individual countries [1].

It is not readily apparent that such diversity of assumptions was warranted, given that differences in intervention criteria and protective measures between countries were observed even when environmental contamination and dietary and living habits may not have been substantially different. In addition, the extensive use of safety factors in the assumptions used in impact assessment modelling appears to have resulted in the adoption of restrictive measures having, in some cases, a substantial socio-economic impact.

An important factor involved in the assessment of the response to the Chernobyl accident concerns the effectiveness of food distribution and processing procedures in decreasing or modifying exposures. Initial intervention criteria and protective measures were aimed at restricting exposures from the consumption of fresh milk and vegetables. However, where amenable, many fresh products were converted into products which could be stored for a period of time, and introduced to the consumer market at a later date following radioactive decay of short-lived nuclides. Such procedures were aimed at reducing the economic impacts which would arise by destroying the fresh produce. Such processing and storage procedures are normally followed to a given extent for some products (e.g., milk to cheese; fresh vegetables to frozen vegetables), but the Chernobyl accident appears to have increased the extent to which such conversion and storage activities have occurred. This has had the effect of delaying potential impacts from longer-lived radionuclides (such as, for example, caesium-137), and has created a need for continuation of appropriate controls on preserved and stored food. Similarly, harvested animal fodder, which may contain elevated levels of longer-lived contaminants such as caesium-137, may create a prolonged situation of potential exposure (for example, through contamination of milk and milk products from domestic animals fed with the fodder), for which suitable protective measures and DILs may need to be developed. The effects of decontamination of food due to the particular aspects of processing need to be assessed to determine the consequent safety factors introduced into impact assessment and the definition of derived intervention levels.

3.5.4 Role of Non-Radiological Factors

The emphasis placed on non-radiological factors or constraints in the decision-making process for the implementation of protective measures is generally believed to have contributed to the apparent lack of a harmonised response to the Chernobyl accident in Member countries. These non-radiological factors included regulatory, social, political and economic considerations, most of which differed substantially between countries. In many cases, the distinction between radiological criteria and non-radiological factors generally was not appreciated or understood by the public and by the decision-makers. This led to the adoption of protective measures which, although not justified on the basis of radiological protection, may have been portrayed as such to the public.

3.5.5 Public Comprehension and Communication

Problems also arose from public understanding and acceptance of the protective measures adopted by authorities. These problems were based, in part, on the public perception of discrepancies in response amongst the various national and local authorities, as well as on a more basic level of lack of understanding of the complex technical and scientific aspects of radiation and radiological protection. As well, limits on the capability of authorities to effectively communicate information to the public were observed.

3.5.6 Residual Impacts

Authorities' instructions were issued in a variety of ways, ranging from providing simple advice up to the adoption of compulsory bans. Often, the public did not appreciate such differences in degree intended by the authorities, thus leading to confusion over what constituted "safe" protective measures. In other words, a lack of understanding of the information being provided by authorities led to distrust by the public. For example, the use of "prudent advice" measures, not necessarily based on the excedence of given intervention criteria or on the presence of a significant risk, was often misinterpreted by the public to represent actions based on the actual presence of dangerous levels of contamination. In several cases, for example, it was apparent that the issuance of advice to wash leafy vegetables prior to consumption led to public avoidance of consumption of vegetables altogether. Similarly for milk, advice or restrictions against milk consumption by infants, perhaps reasonably justified by the use of very conservative assumptions, often led to the avoidance of milk consumption by all age groups. The resulting implications of this situation included additional residual impacts on individuals and society which were not originally intended by the introduction of the measures.

3.5.7 International Trade of Food

Finally, a particular problem raised by the transboundary character of the Chernobyl accident was its impact on the international trade of goods, primarily food. Concern expressed regarding acceptable levels of activity in imported and exported food led to a diversity of secondary intervention criteria being adopted in various countries as the basis for control of contaminated food, and to some disruption in trade relations between countries. As previously discussed, several international organisations have attempted to provide a basis for international harmonisation of criteria for controls on the trade of food, but many problems still remain in defining acceptable values.

3.5.8 Summary

In summary, those problems most relevant to the derivation and application of intervention levels and derived intervention levels primarily involve:

a) the need for additional clarification or expansion of international guidance on emergency response planning and intervention criteria;

b) the need for harmonisation of methodologies and parameter assumptions used in accident impact assessment and the development of DILs; and

c) the need for specific guidance on control levels for the international trade of food.

Table 2. Average Levels of Deposition

Country[a]	Approximate Distance from Chernobyl (km)	Average Deposition (kBq/m2)	
		Total Caesium[b]	Iodine-131
Austria	1000-1500	23	120
Norway	1500-2500	11	77
Finland	1000-2000	9.0	51
Sweden	1000-2000	8.2	44
Switzerland	1500-2000	8.0	37
Italy	1500-2500	6.5	32
FRG	1000-1500	6.0	16
Greece	1000-2000	5.3	23
Ireland	2500-3000	5.0	7.0[c]
Luxembourg	1500	4.0	19
Netherlands	1500-2000	2.7	21
France	1500-2500	1.9	7.0
Denmark	1000-1500	1.7	1.7
UK	2000-2500	1.4	5.0
Belgium	2000	1.3	3.9
Japan	9000	0.13	1.2
Turkey	1000-2000	0.08	0.88
Iceland	3000-3500	0.05	small
US	8000-12000	0.04	0.15
Canada	6000-13000	0.04	0.10
Spain	2500-3500	0.004	0.010
Portugal	3000-3500	0.003	0.005
Australia	16000	N.D.[d]	N.D.[d]

a) Countries are listed in order of decreasing average deposition of total caesium.
b) Caesium-137 plus caesium-134.
c) Based on a limited number of measurements.
d) N.D. - not detected.

Source : Reference [1], Table 3.1.

Table 3. Maximum Levels of Deposition

Country[a]	Maximum Deposition (kBq/m^2)		Ratio of Maximum to Average Deposition	
	Total Caesium[b]	Iodine-131	Total Caesium	Iodine-131
Sweden	190	950	23	22
Norway	>100	not given	>9	-
Italy	N 100	N 500	N 15	N 16
FRG	65	160	11	10
Austria	N 60	700	N 2.6	5.8
Switzerland	41	180	5.1	4.9
Finland	N 30	190	N 3.3	3.7
Greece	28	60	5.3	2.6
Ireland	22	16	4.4	2.3
UK	20	40	14	8.0
Netherlands	N 9	26	N 3.3	1.2
France	7.6	not given	4.0	-
Luxembourg	7.3	N 40	1.8	N 2.1
Denmark	4.6	4.2	2.7	2.5
Belgium	3.0	10	2.3	2.6
Turkey	0.90	8.0	11	9.1
Japan	0.41	3.8	3.2	3.2
Iceland	0.10	small	2.0	-
Canada	0.065	0.24	1.5	2.4
Spain	0.041	0.09	10	9
Portugal	0.012	0.013	4	2.6
US	small	>1.9	-	>13
Australia	N.D.[c]	N.D.[c]	-	-

a) Countries are listed in order of decreasing maximum deposition of total caesium.
b) Caesium-137 plus caesium-134.
c) N.D. - not detected.

Source: Reference [1], Table 3.2.

Table 4. Percentage Contributions to Average Individual Dose Estimates (First Year)

Country[a]	Percentage Pathway Contribution (%)			
	Inhalation	External (Deposited)	Ingestion	External (Plume)
Austria	7	19	74	<1
Norway	---------------- not assessed ------------------			
Finland	3	25	72	<1
Sweden	5	47	47	<1
Switzerland	2	23	74	<1
Italy	7	17	77	<1
FRG	12	47	40	<1
Greece	15	7	78	<1
Ireland	<1	14	84	<1
Luxembourg	8	29 [b]	63	-
Netherlands	7	53	40	<1
France	-	30 [b]	70 [c]	-
Denmark	3	7	91	<1
UK	3	14	82	<1
Belgium	35	46	18	<1
Japan	13	68	19	<1
Turkey	3	30	65	3
Iceland	--------------- not assessed ------------------			
US	--------------- not assessed ------------------			
Canada	1	38	60	<1
Spain	--------------- not assessed ------------------			
Portugal	-	-	100	-
Australia	-	-	-	-

a) Countries are listed in order of decreasing average deposition of total caesium.
b) Includes contribution from external (plume) pathway.
c) Includes contribution from inhalation pathway.

Source: Reference [1], Table 3.7.

Table 5. Average Individual Dose Estimates (First Year)[a]

Country	Effective Dose Equivalent (mSv)	Thyroid Dose Equivalent (mSv)
Australia	-	-
Austria	0.65	2.3
Belgium	0.04	0.31
Canada	0.0025	0.0037
Denmark	0.027	0.064
Finland	0.50	0.92
France	0.023	0.13
FRG	0.30	1.5
Greece	0.37	2.8
Iceland	0.01	N.A.[b]
Ireland	0.11	0.52
Italy	0.49	2.0
Japan	0.0065	0.068
Luxembourg	0.12	0.43
Netherlands	0.066	0.40
Norway	0.17	0.43
Portugal	0.0062	0.017
Spain	N.A.[b]	N.A.[b]
Sweden	0.20	0.42
Switzerland	0.22	1.3
Turkey	0.016	0.10
UK	0.037	0.19
US	N.A.[b]	0.013

a) Doses are calculated by dividing total collective dose equivalents by the respective populations, and thus cannot be applied to a particular age group.
b) N.A. - not assessed.

Source : Reference [1],Tables 3.7 and 3.8.

Table 6. Collective Effective Dose Equivalent Estimates (First Year)

Country	Population	Collective Effective Dose Equivalent (manSv)			
	($x10^6$)	Total	Infants	Children	Adults
Australia	16	-	-	-	-
Austria	7.4	4900	42	490	4400
Belgium	10	400	22	85	290
Canada	25.5	63	0.49	8.4	54
Denmark	5.2	140	4.9	27	110
Finland	4.9	2500	44	320	2100
France	55	1300	67	280	920
FRG	61	18000	--- 4000[a] ---		14000
Greece	9.8	3600	48	630	3000
Iceland	0.24	not assessed	---- not assessed ----		
Ireland	3.5	370	55	37	280
Italy	56.6	28000	300	4100	23000
Japan	120	780	17	160	600
Luxembourg	0.37	45	0.50	4.7	40
Netherlands	14.5	950	40	150	750
Norway	4.2	700	72	130	500
Portugal	9.3	58	2.0	12	44
Spain	37.7	not assessed	---- not assessed ----		
Sweden	8.3	1700	33	160	1500
Switzerland	6.5	1400	13	130	1300
Turkey	52	830	20	150	660
UK[b]	56.6	2100	120	510	1800
US	239	not assessed	---- not assessed ----		
TOTAL	N 795	N 68000	-- N 12000[a] --		N 55000

a) Total for infants and children.
b) The sum of collective doses for the age groups does not equal total collective dose indicated, for reasons outlined in reference [1].

Source : Reference [1], Table 3.4.

Table 7. Collective Thyroid Dose Equivalent Estimates (First Year)

Country	Population ($x10^6$)	Collective Thyroid Dose Equivalent (manSv)			
		Total	Infants	Children	Adults
Australia	16	-	-	-	-
Austria	7.4	17000	680	2600	14000
Belgium	10	3100	190	820	2100
Canada	25.5	95	6.8	45	43
Denmark	5.2	330	18	75	240
Finland	4.9	4500	130	900	3400
France	55	7400	670	2100	4600
FRG	61	91000	--- 33000[a] ---		58000
Greece	9.8	27000	760	8000	19000
Iceland	0.24	not assessed	----- not assessed -----		
Ireland	3.5	1800	810	250	790
Italy	56.6	120000	2400	28000	85000
Japan	120	8200	210	2400	5600
Luxembourg	0.37	160	3.7	31	120
Netherlands	14.5	5800	350	1300	4100
Norway	4.2	1900	78	160	1600
Portugal	9.3	150	9.0	43	100
Spain	37.7	not assessed	----- not assessed -----		
Sweden	8.3	3500	57	410	3000
Switzerland	6.5	8500	120	1400	7000
Turkey	52	5300	310	1800	3300
UK[b]	56.6	11000	1900	5300	9400
US	239	3000	----- not assessed -----		
TOTAL	N 795	N 320000	-- N 97000[a] --		N 22000

a) Total for infants and children.
b) The sum of collective doses for the age groups does not equal total collective dose indicated, for reasons outlined in Reference [1].

Source : Reference [1], Table 3.5.

Table 8. Critical Group Effective Dose Equivalent Estimates (First Year)

Country[a]	Critical Group Effective Dose Equivalent (mSv)			Assumed Critical Group
	Infants	Children	Adults	
Sweden	2.3	2.6	2.5	Identified Group of 2000-4000
Norway	2.5	2.3	2.1	Not Known
Italy	3.2	3.2	2.6	Hypothetical Group
FRG	1.2	0.8	0.8	Identified Group of 200 000
Austria	0.82	0.98	1.2	Identified Group of 200 000
Switzerland	1.4	1.7	2.0	Identified Group of 10 000
Finland	0.92	0.93	0.95	Identified Group of 670 000
Greece	0.27	0.44	0.36	Whole Population
Ireland	0.37	0.32	0.32	Hypothetical Group
UK	1.2	1.1	1.0	Hypothetical Group
Netherlands	0.16	0.10	0.06	Whole Population
France	0.21	0.087	0.049	"East France"
Luxembourg	0.12	0.12	0.12	Whole Population
Denmark	0.081	0.050	0.023	Whole Population
Belgium	0.26	0.20	0.12	Hypothetical Group
Turkey	0.19	0.12	0.081	Identified Group of 40 000
Japan	0.057	0.038	0.020	Hypothetical Group
Iceland	------------------------	----	not assessed	------------------------
Canada	0.0042	0.0053	0.0066	Residents in Vancouver
Spain	0.071	0.053	0.034	Hypothetical Group
Portugal	0.030	0.020	0.010	Hypothetical Group
US	0.020	0.0050	0.0050	Residents in Washington State
Australia	-	-	-	-

a) Countries are listed in order of decreasing maximum deposition of total caesium.

Source : Reference [1], Table 3.9.

Table 9. **Summary Matrix of Responses to the Chernobyl Nuclear Accident in OECD Member Countries**

RESPONSE[b]	COUNTRY[a] AUS	A	B	CND	DK	SF	F	FRG	GR	IS	IRL	I	J	L	NL	N	P	E	S	CH	TR	UK	US
A. ENVIRONMENTAL MONITORING																							
1. Intensify/expand monitoring activities	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
B. PUBLIC INFORMATION																							
1. Establish means for issuance of public information	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
C. OUTDOOR PUBLIC ACTIVITIES																							
1. Control outdoor activities		A		X		A		A[c]												X	A		
2. Monitor people/vehicles from contaminated areas		Y			Y	Y	Y	Y	Y		Y			Y	Y		Y	Y	Y		Y	Y	Y
3. Control travel to contaminated areas		A				A		A			A			A	A	A		A	A			A	A
4. Clean transport vehicles at border points		A			A	A		A							A						A		
D. WATER																							
1. Control rainwater use for drinking or household purposes		A		A		A		A	A			A	A	A	A	A			A	A	A	A	A
2. Control rainwater use for watering cows		A				A															A		
3. Filter rainwater before drinking													A										
4. Control rainwater use in saunas						A																	
E. MILK AND DAIRY PRODUCTS																							
1. Control grazing of dairy cattle		P	A		P	A		A	A			P		P	P				A		P/A[d]		
2. Control marketing & consumption of cow milk/dairy products		R/A[e]			R		R	R			R			R/A[e]		R			R	A	R		
3. Control marketing & consumption of sheep/goat milk		R/A[f]						A			R			R	A				A	A			
4. Control marketing & consumption of sheep/goat cheese		P							P			P			P	R			R	A	P/A[g]		
5. Control import of milk/dairy products	h	R	R[i]	R	R[i]	R	R[i]	R[i]	R[i]	R	R[i]	R[i]	R	R[i]	R[i]	R	R[i]	R[i]	R[i]	R	R[i]	R[i]	R
F. VEGETABLES, FRUIT AND GRAINS																							
1. Control consumption of fresh leafy vegetables		A						A[c]	A			A			A				A	A	A		
2. Wash fresh vegetables prior to consumption		A	A		A			A	A		A	A	A	A	A				A	A	A		

3. Control consumption of non-cultivated plants & mushrooms		A				A		A							A				A					
4. Control domestic marketing of leafy vegetables		P					P[j]	R				P		P	R/P	P			R					
5. Control import of vegetables, fruit and grains	h	R	R[i]	R	R[i]	R	R[i]	R[i]	R[i]		R[i]	R[i]	R[k]	R[i]	R[i]	R	R[i]	R[i]	R[i]	R	R[i]	R[i]	R	
6. Control agricultural practices						A													A					

G/ MEAT AND FISH

1. Control domestic marketing of animal thyroids									P			P		P	P									
2. Control domestic marketing of lamb/sheep		R							R						R	R			R	R		R		
3. Control domestic marketing of beef/horse meat		R														R								
4. Control domestic marketing of reindeer meat						A										R			R					
5. Control domestic marketing of game						A									A				R					
6. Control consumption of freshwater fish						A									A	P			A	R[l]				
7. Control hunting of game											A				A			A	A					
8. Control imports of meat	h	R	R[i]	R	R[i]	R	R[i]	R[i]	R[i]	R[i]	R[i]	R[i]	R	R[i]	R[i]	R	R[i]	R[i]	R[i]	R	R[i]	R[i]	R	

H. OTHERS

1. Government compensation for agricultural losses		Y				Y		Y	Y			Y			Y	Y			Y		Y	Y		
2. Controls on the changing of industrial air filters		A	A			A		A	A			A		A	A				A	A				
3. Control the use of sewage sludge for soil amendment		P				R								R					R	R				
4. Administer stable iodine		X		X		X[m]	X	X	X					X	X			X	X	X	X			X

Matrix Key:

A = Advice
R = Restriction
P = Prohibition
X = Explicit advice against need for specific action.
Y = Action taken

Notes:

a) See Glossary, Part A, for key to Member country acronyms.
b) For detailed description of responses, see Annex III.
c) Some States gave advice; No official national advice.
d) Prohibition progressively phased-out; Followed by advice; Limited to Trace region.
e) Including advice not to drink fresh cow milk from farms.
f) Restriction on marketing of sheep/goat milk; Advice to avoid consumption of sheep/goat milk.
g) Prohibition on consumption (1 week); Advice against marketing goat cheese (8 weeks).
h) Surveillance of imports; No specific restrictions imposed.
i) Including a temporary prohibition on imports from several Eastern European countries.
j) Temporary measure in one department (Haut Rhin), for spinach only.
k) Restriction limited to vegetables only.
l) Concerned only Lake Lugano.
m) Except for nationals travelling to within 50 km of Chernobyl.

Table 10. Summary of Secondary Intervention Criteria (DILs): Iodine-131[a]

	PATHWAY (Bq/L or Bq/kg)					
Country[b]	Drinking Water	Milk/Dairy Products	Vegetables	Meat	Other	Date Adopted
A		370[c]	185			2/5/86
N		1000	1000	1000		
SF	2000	2000				2/5/86
S		2000	300;5000[d]	300		2/5/86
CH[e]						
I		560[f]	560[f]	560[f]		1971
GR		125[g]	90[h]			26/5/86 (CEC)
NL		500[i]	1000[j]			2/5/86
L		500	250			
FRG		500	250			
F[e]						
IRL[e]						
UK	11000[k]	2000[l]	110000[m]		160000[m,n]	3/86 (NRPB-DL10)
B		500[o]	1000[p]			2/5/86
DK[e]						
J	110	220	7400			
TR[e]						
US	1.5[q]	56[r]; 296[s]	56[r]; 296[s]	56[r]; 296[s]	56[r]; 296[s]	16/5/86
CND	10	10;40[t]	70	70	70[u]	5/86 (all but water)
E		125[g]	90[h]		90[h,u]	26/5/86 (CEC)
P		125[g]	90[h]		90[h,u]	26/5/86 (CEC)
IS[e]						
AUS[e]						
CEC		125[g]; 500[v]	90[h]; 2000[v]	2000[v]	90[h,u]; 2000[v]	26/5/86 (g,h); 22/12/87 (v)

Notes on Table 10:

a) For detailed description of intervention criteria, see Annex IV.
b) Member countries are listed in order of decreasing average deposition of radio-iodine (see Table 2); See Glossary, Part A, for key to Member country acronyms.
c) Value replaced by 185 Bq/L on 21/5/86.
d) Value stated as import limit (2-15 May).
e) No official DILs.
f) Attention Level, based on activity over a 7-day period; Emergency Level cited as 10 times the Attention Level.
g) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 250 Bq/L (kg), which had replaced the 6 May recommendation of 500 Bq/L (kg); For control of imports/exports.
h) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 175 Bq/kg, which had replaced the 6 May recommendation of 350 Bq/kg; For control of imports/exports.
i) Value replaced by 125 Bq/L on 23/5/86.
j) Value replaced by 250 Bq/kg on 23/5/86.
k) Lower Derived Emergency Reference Level (DERL), based on activity over a 2-day period; Value of 3700 Bq/L used for activity over a 7-day period.
l) Lower DERL (peak concentration), for fresh milk only.
m) Lower DERL (peak concentration).
n) Lower DERL (peak concentration), for fruit.
o) Initial value (2-15 May); Was 250 Bq/L from 16-25 May, and 125 Bq/L after 25 May.
p) Initial value (2-15 May); Was 500 Bq/kg from 16-25 May, and 250 Bq/kg after 25 May.
q) US EPA derived level for the Chernobyl accident.
r) Level of concern for imported infant food.
s) Level of concern for imported adult food.
t) Manufactured dairy products (Bq/kg).
u) Fruit (fresh weight).
v) CEC Regulation of 22 December 1987; Maximum permitted levels for radioactive contamination of food following a future nuclear accident or any other case of radiological emergency.

Table 11. Summary of Secondary Intervention Criteria (DILs): Total Caesium (Caesium-134 and -137)[a]

	PATHWAY (Bq/L or Bq/kg)					
Country[b]	Drinking Water	Milk/Dairy Products	Vegetables	Meat	Other	Date Adopted
A		185[c];300	110[c];175	185[c,d];300[e]		
N		370[f]	600[f]	600[f];6000[g]	370[h]	20/6/86
SF		1000[c]		1000[i]	1000[j]	22/5/86
S		300[k]	300[k];10000[l]	300[k]	300[m]	15/5/86
CH		370[n]	600[n]	600[n]	600[n]	8/9/86
I		250[o];370[p]	250[o];600[p]	250[o];600[p]		1971; 31/5/86(CEC)
FRG		370[p]	600[p]	600[p]		31/5/86 (CEC)
GR		370[p]	600[p]	600[p]		31/5/86 (CEC)
IRL		370[p]	600[p]	600[p]		31/5/86 (CEC)
L		370[p]	600[p]	600[p]		31/5/86 (CEC)
NL		370[p]	600[p]	600[p]		31/5/86 (CEC)
F		370[p]	600[p]	600[p]		31/5/86 (CEC)
DK		370[p]	600[p]	600[p]		31/5/86 (CEC)
UK	51000[q]	3600[r];370[p]	190000[s];600[p]	1000[t];600[p]	280000[u]	3/86 (DERL); 31/5/86 (CEC)
B		370[p]	600[p]	600[p]		31/5/86 (CEC)
J[v]						
TR		370	600	600		31/5/86
IS[v]						
US	90[w]	370[x]	370[x]	2780[x]; 370[y]	370[x]	16/5/86 (x); 24/10/86 (y)
CND	50	50;100[z]	300	300	300[aa]	5/86 (Except Water)
E		370[p]	600[p]	600[p]		31/5/86 (CEC)
P		370[p]	600[p]	600[p]		31/5/86 (CEC)
AUS		100[t]	100[t]	100[t]	100[t,bb]	5/86
CEC		370[p]; 1000[cc]	600[p]; 1250[cc]	600[p]; 1250[cc]	370[h,p]; 1250[cc]	31/5/86 (h,p); 22/12/87 (cc)

Notes on Table 11:

a) For detailed description of intervention criteria, see Annex IV.
b) Member countries are listed in order of decreasing average deposition of total caesium (caesium-134 and -137) (see Table 2); See Glossary, Part A, for key to Member country acronyms.
c) For caesium-137 only; For Finland, refers to peak concentration.
d) Pork and poultry; Applicable value for other types of meat is 370 Bq/kg.
e) Value for pork and poultry; Value of 600 Bq/kg for other meat.
f) Replaced original value of 300 Bq/L (kg) on 20/6/86.
g) Reindeer and game meat (20/11/86).
h) Infant food (Bq/kg).
i) Beef and pork (peak concentration).
j) Grains and cereals (anticipated peak concentration).
k) Replaced the 2/5/86 value of 1000 Bq/L (kg).
l) Value stated as import limit (2-15 May).
m) Marketing limit for game; Level raised to 1500 Bq kg^{-1} after first year.
n) Notification levels only; Protective measures dependent on dose assessment.
o) Attention Level, for 1-year period of exposure; Emergency Level cited as 10 times the Attention Level.
p) CEC Regulation, for control of imports/exports.
q) Lower Derived Emergency Reference Level (DERL), based on activity over a 2-day period; Value of 15000 Bq/L (caesium-137) used for activity over a 7-day period.
r) Lower DERL (peak concentration), for fresh milk only.
s) Lower DERL (peak concentration).
t) Screening reference level for consumption and marketing.
u) Lower DERL (peak concentration), for fruit.
v) No official DILs.
w) US EPA derived level for the Chernobyl accident.
x) US Department of Agriculture (USDA) initial value (16 May 1986).
y) USDA value adopted on 24/10/86.
z) Manufactured dairy products (Bq/kg).
aa) Fruit (fresh weight).
bb) Cereals, fruit, nuts/seeds, fish.
cc) CEC Regulation of 22 December 1987; Maximum permitted levels for radioactive contamination of food following a future nuclear accident or any other case of radiological emergency.

Table 12. Range of Secondary Intervention Criteria (DILs) for Controls on Food Adopted in OECD Countries Following the Chernobyl Accident

	PATHWAY (Bq/L or Bq/kg)			
Nuclide	Drinking Water	Milk/Dairy Products	Vegetables	Meat
Iodine-131	1.5 - 11 000	10 - 2 000	56 - 110 000	56 - 1 000
Caesium-134 and -137	50 - 51 000	50 - 3 600	100 - 190 000	100 - 6 000

Note:

In many cases, the large range in values is due to the differing assumptions used in their derivation and in their application. Detailed observations are outlined in Annex IV, and in Tables 10 and 11.

Table 13. Percent of the Critical Group Effective Dose (First Year) Averted by Protective Measures

Country	Individual Effective Dose Equivalent (Percent Averted)		
	Infants	Children	Adults
Austria	80	72	64
Finland	16	2.1	5.0
France	-----------	not given	----------
FRG	--------	N50[a] --------	not given
Greece	25	17	23
Italy	36	27	10
Luxembourg	12	13	6.9
Netherlands	36	23	14
Norway	33	15	19
Sweden	0	1.9	2.7
Switzerland	38	0	0
Turkey	0	37	9.0
UK	14	19	23

a) Average for infants and children.

Source: Reference [1], Table 3.13.

Table 14. Percent of the Collective Dose (First Year) Averted by Protective Measures

Country	Collective Effective Dose Equivalent (Percent Averted)				Collective Thyroid Dose Equivalent (Percent Averted)			
	Total	Infants	Children	Adults	Total	Infants	Children	Adults
Austria	50	53	50	50	70	85	70	68
Finland	7.2	12	11	6.3	58	71	57	58
France	---------- very small ----------				--------- very small ----------			
FRG	30[a]	-	-	-	60[a]	-	-	-
Greece	23	25	17	24	36	39	22	40
Italy	18	53	33	15	55	81	66	47
Luxembourg	7.5	17	13	6.6	38	39	39	38
Netherlands	15	43	23	12	24	30	23	23
Norway	32	29	28	33	19	28	47	14
Sweden	15	0	3.0	17	8.1	0	1.2	9.1
Switzerland	1.0	50	0	0	4.5	77	0	0
Turkey	12	0	18	11	19	0	16	22
UK	1.0	< 1.0	1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0

a) Overall estimates; No information is available on dose averted for different age groups, but it is assumed that protective measures adopted for infants and children have been fully implemented.

Source : Reference [1], Tables 3.11 and 3.12.

Table 15. Values of Age-Dependent Ingestion Dose Conversion Factors Used in Development of Predetermined DILs

Radionuclide	Committed Effective (or Organ) Dose Equivalent (Sv/Bq)[a]			Organisation[b]
	Infant (1 yr)	Child (10 yr)	Adult	
Plutonium-239	$(1.7 \times 10^{-5})^c$	-	-	FAO
	2.4×10^{-6}	1.4×10^{-6}	1.3×10^{-6}	CEC[d]
	4.7×10^{-8}	2.1×10^{-8}	1.4×10^{-8}	IAEA
	4.9×10^{-8}	2.2×10^{-8}	1.4×10^{-8}	NRPB
	6.7×10^{-8}	2.7×10^{-8}	1.6×10^{-8}	ISH
	2.4×10^{-6}	1.4×10^{-6}	1.3×10^{-6}	WHO
Strontium-90	$(1.9 \times 10^{-6})^c$	-	-	FAO
	1.1×10^{-7}	4.0×10^{-8}	3.6×10^{-8}	CEC
	1.2×10^{-7}	4.6×10^{-8}	3.3×10^{-8}	IAEA
	1.2×10^{-7}	4.6×10^{-8}	3.3×10^{-8}	NRPB
	1.1×10^{-7}	4.0×10^{-8}	3.5×10^{-8}	ISH
	1.1×10^{-7}	4.0×10^{-8}	3.6×10^{-8}	WHO
Iodine-131	$(2.9 \times 10^{-6})^e$	-	-	FAO
	1.1×10^{-7}	2.8×10^{-8}	1.4×10^{-8}	CEC
	$(3.7 \times 10^{-6})^e$	$(1.2 \times 10^{-6})^e$	$(4.4 \times 10^{-7})^e$	IAEA
	1.1×10^{-7}	3.6×10^{-8}	1.3×10^{-8}	NRPB
	$(3.7 \times 10^{-6})^e$	$(1.2 \times 10^{-6})^e$	$(4.4 \times 10^{-7})^e$	NRPB
	1.1×10^{-7}	2.8×10^{-8}	1.3×10^{-8}	ISH
	$(3.5 \times 10^{-6})^e$	$(8.5 \times 10^{-7})^e$	$(4.3 \times 10^{-7})^e$	ISH
	$(3.6 \times 10^{-6})^e$	$(1.0 \times 10^{-6})^e$	$(4.4 \times 10^{-7})^e$	WHO
Caesium-134	-	-	2.0×10^{-8}	FAO
	1.2×10^{-8}	1.2×10^{-8}	2.0×10^{-8}	CEC
	1.7×10^{-8}	1.7×10^{-8}	1.7×10^{-8}	IAEA
	1.7×10^{-8}	1.7×10^{-8}	1.7×10^{-8}	NRPB
	1.2×10^{-8}	1.2×10^{-8}	2.0×10^{-8}	ISH
	1.2×10^{-8}	1.2×10^{-8}	2.0×10^{-8}	WHO
Caesium-137	-	-	1.4×10^{-8}	FAO
	0.9×10^{-8}	0.9×10^{-8}	1.4×10^{-8}	CEC
	1.3×10^{-8}	1.2×10^{-8}	1.2×10^{-8}	IAEA
	1.3×10^{-8}	1.2×10^{-8}	1.2×10^{-8}	NRPB
	0.9×10^{-8}	0.9×10^{-8}	1.4×10^{-8}	ISH
	1.0×10^{-8}	1.0×10^{-8}	1.3×10^{-8}	WHO

Table 15 (cont'd)

Radionuclide	Committed Effective (or Organ) Dose Equivalent (Sv/Bq)[a]			Organisation[b]
	Infant (1 yr)	Child (10 yr)	Adult	
Americium-241	-	-	-	FAO
	3.4×10^{-6}	1.7×10^{-6}	1.2×10^{-6}	CEC
	1.9×10^{-6}	1.1×10^{-6}	9.8×10^{-7}	IAEA
	2.1×10^{-6}	1.2×10^{-6}	9.8×10^{-7}	NRPB
	1.7×10^{-6}	8.6×10^{-7}	5.9×10^{-7}	ISH
	-	-	-	WHO

a) Values in brackets signify organ dose equivalent.

b) Source of values used by each organisation are as follows:
   (1) FAO - Published in reference [23]; Values taken from reference [28].
   (2) CEC - Values selected by the CEC Group of Experts set up pursuant to Article 31 of the Euratom Treaty [22].
   (3) IAEA - Published in reference [12]; Values taken from reference [29], as updated by reference [30].
   (4) NRPB - Reference [31].
   (5) ISH - Reference [24], [25] and [26].
   (6) WHO - Reference [16].

c) Bone surface dose equivalent.

d) The assessments of the CEC for the gastro-intestinal absorption of plutonium have been based on a value higher, by a factor of 10, than that outlined in ICRP-30 [27], and also, on the recommendation from the OECD/NEA Expert Group on Gut Transfer, on an additional factor of 10 times higher gastro-intestinal absorption for members of the public in comparison to reference man.

e) Thyroid dose equivalent.

4. CRITICAL REVIEW OF THE PRINCIPLES AND PROCEDURES FOR THE ESTABLISHMENT AND APPLICATION OF INTERVENTION CRITERIA

4.1 INTRODUCTION

This section provides a critical review of the principles and procedures for the establishment and application of intervention criteria for the protection of the public in the event of a nuclear accident, primarily in the context of the issues and problems which have been raised by the Chernobyl accident. Where appropriate, specific guidance from the Expert Group is identified. In particular, consideration is given to the applicability of the current international guidance and recommendations to areas remote from an accident site, and to long-term contamination problems.

As outlined in Section 3, a variety of protective measures were implemented following the Chernobyl accident to control exposures to the public and to workers. However, due to time constraints, the Expert Group only examined in detail the basis for intervention criteria for controls on food.

4.2 BASIS FOR ESTABLISHMENT OF INTERVENTION LEVELS

4.2.1 General Issues

The ICRP-40 [2] approach to preparation of emergency response plans is viewed as reasonable and appropriate when planning considerations are limited to the vicinity of the accident. However, the Expert Group is of the opinion that the existing basis for development of emergency response plans should be examined for areas beyond such zones, giving particular consideration to the implications of severe accidents having widespread, transboundary and long-term impacts. The current international guidance and recommendations for emergency response plans and intervention criteria appear to have been formulated in the context of accidents of relatively short duration, where intervention would mainly be contemplated over an area close to the site of the accident. Experience during and after the Chernobyl accident has shown that it is necessary to give more consideration to prolonged releases and to those where intervention may be required over large surface areas, at great distances and for extended periods of time.

The general philosophy which forms the rationale for the existing international guidance and recommendations on emergency response planning is that the social cost and detriment associated with the implementation of protective measures should be less than that which could be avoided with the use of the measures. The Expert Group is of the opinion that this philosophy is sound and well-established. The Expert Group also believes that the existing international guidance and recommendations provide a reasonable conceptual basis for the establishment of radiological protection criteria for accident management, particularly for the establishment of intervention levels. However, it is believed that the scope of applicability of the three basic principles of ICRP-40 (see Section 2.3), and their relative roles in accident management, require some clarification and expansion. This issue is discussed in Section 4.2.3 below.

A key issue in international guidance on emergency response planning is that the control of exposures resulting from accidental releases of radionuclides is conceptually distinct from the control of exposures resulting from normal situations or operational releases (e.g., [2]). In the latter case, control is applied to the source of exposure in planning and operational phases by such means as the ICRP system of dose limitation [3]. In an accident situation, the source of exposure is not subject to control, so that any subsequent exposure can be limited in amount, if at all, only by some form of remedial action or intervention. Thus, the dose limitation system is not viewed as applicable.

The Expert Group accepts the distinction made by the ICRP between situations in which the exposure is foreseen and can be limited by control of the source, and those in which the source is not under control, such as in accidents. It is recognised, however, that following the Chernobyl accident there was some confusion over the role of the ICRP dose limits in the establishment of intervention criteria, particularly in areas remote from the accident site. There was also some confusion concerning what was intended by the term "source of exposure", that is, whether the term referred to the source of the release or to the environmental contamination. The Expert Group is of the opinion that these two issues need to be clarified.

4.2.2 Temporal and Spatial Aspects of Intervention

Existing international guidance suggests that the development of radiological protection principles and intervention criteria for emergency response planning can be related to three sequential time-phase categories: early, intermediate and recovery (or late). It is apparent that this guidance has been developed primarily for accident situations having a well-defined source term (with a short-duration release), and a relatively local and short-term impact. However, the Chernobyl accident, characterised by an ill-defined source term, a long-duration release and a widespread, transboundary impact over an extended period of time, highlighted the potential short-comings of such a basis for accident management.

Therefore, the Expert Group is of the opinion that characterisation of an accident in terms of temporal dependencies alone is not completely adequate for developing a set of emergency responses, there being some difficulty in separating the spatial and temporal aspects of an accident. Rather, it is preferable to relate emergency response criteria to a combination of the spatial and temporal components of the accident. As well, more emphasis needs to be placed on assessing accident situations in terms of the appropriateness of specific protective measures.

It is recommended that the existing accident phase categorisation system be amended accordingly. Such a revised categorisation would involve distinguishing between two primary spatial components, the near-field and the far-field, with the far-field being further sub-divided on the basis of the type of intervention required. The Near-Field would be defined as the area in the vicinity of the release source, where the primary short-term focus of public protection concerns immediate measures taken to avoid acute health effects and to reduce the risk to individuals arising from external irradiation and inhalation of radioactive material from the release. Beyond the short term in this area, additional measures may be required to control exposures, in particular those arising from ingestion, and to return the area to normal living conditions. The near-field zone could encompass an area up to a few tens of kilometres. The Far-Field would be defined as the area affected by the accidental release beyond the near-field zone, where the primary focus of public protection measures is on restricting exposures and health effects arising from ingestion of food and from external irradiation by deposited contaminants. The far-field can be sub-divided into two zones: (1) that where potential impacts may arise from external irradiation and ingestion of locally contaminated food (direct impact); and (2) that where potential impacts may arise essentially from imported food (indirect impact). In this revised system, "short-term" would be considered to be days or weeks, while "long-term" would involve time periods of months or years.

The Expert Group is of the opinion that consideration of such spatial aspects of accidents, particularly in terms of the types of protective measures required, would enhance the applicability and interpretation of international recommendations and guidance on emergency response.

As a result of an accident having transboundary impacts, countries may have to implement emergency response plans to mitigate and control exposures of the public. The emergency response system would need to be directed to both the control of exposures arising from deposition of contaminants within the country (or additional controls if a near-field situation exists) and the control of exposures arising from contaminated food, or other goods, imported from other areas or countries directly affected by the same accident. This accident situation could be classified as a Type I condition, or the far-field with direct impact.

It is reasonable to assume that, even under conditions of a severe accident having a transboundary impact, there may be far-field areas which are not affected by the deposition of contaminants from that accident. Such unaffected countries may be normal trading partners with countries who are in a Type I situation, and food imported from these countries may be contaminated with radionuclides. In such a situation, potential exposures from ingestion of the contaminated food would represent the sole source of accident-related exposure to an importing country. This situation could be classified as a Type II condition, or the far-field with indirect impact.

In reality, of course, there may not be sharp boundaries between Type I and Type II conditions. Nevertheless, this classification may prove useful in highlighting different far-field situations in an accident having transboundary impacts. Following the Chernobyl accident, it is clear that, in many cases, ad-hoc measures and criteria were implemented to manage these two situations. In some cases, attempts were made to apply criteria developed for near-field conditions. In other cases, there was a lack of clarity over what criteria should be applied. As has been demonstrated by transboundary problems arising subsequent to the Chernobyl release, there is a need, firstly, to ensure the compatibility of emergency response systems for managing both types of exposure situations within a given country or between adjacent countries and, secondly, to ensure compatibility of control systems for the international trade of food amongst a group of countries. A critical review of the applicability of the basic ICRP-40 emergency response principles to the far-field is provided in Section 4.2.3 below.

4.2.3 Basic Principles for Intervention

As previously outlined, three internationally accepted principles form the basis for development of criteria for planning intervention in the event of an accident. From the first two, known as principle (a) and principle (b) in ICRP Publication 40 [2], it is apparent that individual dose has been viewed as the primary criterion in deciding upon the introduction of protective measures. However, and as particularly demonstrated by the radiological impact of the Chernobyl accident, all three basic principles need to be fully considered in the development of comprehensive emergency response plans.

Existing international guidance on the application of principle (a), concerning avoidance of non-stochastic effects, is reasonably explicit and is considered adequate by the Expert Group. Measures for the control of non-stochastic effects are not viewed as being applicable to the far-field, due to the relatively small doses likely to be encountered beyond the near-field zone of the accident. Following the Chernobyl accident, some concern has been raised in a few countries about the possible role of "hot particles", highly radioactive particulates transported at great distances from the source of the accidental release, in creating acute individual health risks in the far-field. However, the Expert Group notes that the occurrence of these "hot particles" has not resulted in any documented significant exposures to individuals in Member countries.

Implementation of protective measures on the basis of principle (a) considerations was not required in Member countries. However, although beyond the scope of the Expert Group's study, review of the emergency response measures implemented by the Soviet authorities in the near-field zone of the Chernobyl accident could provide useful insights into the applicability of international guidance on principle (a).

Limitation of the risk to individuals, the basis of principles (a) and (b), has primarily been applied to the most highly exposed individuals of a population. These principles have also been viewed as being applicable primarily within short distances from the accident site, and over relatively short periods of time following an accident. In the near-field, it is appropriate that concerns relate to the risks to individuals of the local population. Protective measures are introduced to prevent health effects in such a way that there is a net benefit to the individuals involved. This approach is considered satisfactory by the Expert Group since the individuals receiving the risk from the protective measures will, in general, be the same as those receiving the benefit from the measures. It is, therefore, reasonable to focus attention, at least in the early to intermediate phases of an accident, on the level of individual dose in deciding on the introduction of protective measures. The application of principle (c) to the near-field is considered to be limited. The largest portion of the collective dose is likely to arise over a much larger area in the long term, and would not, therefore, be likely to be relevant to the establishment of intervention levels for protective measures in the near-field.

However, the particular release and dispersion characteristics of the Chernobyl accident have demonstrated the need to consider measures for limitation of individual risk at large distances from the source and over greatly extended periods of time. Although considered of little relevance to principle (a), this extension in space and time has greatly influenced the potential role of principle (b) in deciding upon protective measures, and has given rise to several issues with respect to its application. For example, beyond the near-field, the distributions to individuals and to society of costs and benefits associated with the introduction of any intervention are likely to diverge and consideration needs to be given to whether the same principles apply as in the near-field. As such, the Expert Group is of the opinion that there is a need for provision of more explicit, practical international guidance on the application of principle (b) in the far-field, particularly for the control of exposures arising from ingestion of contaminated food.

Although both principles (b) and (c) can be considered to be complementary in their application to the far-field, particularly for the introduction of protective measures to control exposures resulting from ingestion of contaminated food, their relative importance is considered to vary with distance and time, with principle (c) becoming more important as distance and time increase. With this increase, in fact, very low levels of average individual dose would be expected, and the adoption of protective measures would likely entail very little risk for individuals. In such a situation, the establishment of intervention criteria on the basis of principle (b) would be expected to correspond to very low values of individual dose. However, the application of protective measures on this basis would involve a large population and a significant cost (to governments, food producers and consumers). In such cases, use of principle (c) would perhaps be the more appropriate basis for the establishment of intervention levels, and the role of principle (b) would be limited, in the far-field, to specific circumstances. Thus, there exists a need to develop guidance on achieving an appropriate balance in the application of principles (b) and (c) for the establishment of intervention levels for the various protective measures, particularly food controls, to be implemented in the far-field.

In an attempt to resolve the issue of the relative importance of principle (b) and principle (c) in establishing protective measures, international discussions have examined the feasibility and value of using a process of optimisation based on cost-benefit analysis to assess the optimised level of individual dose at which controls on food could be implemented [17]. Such a concept had been developed to a certain degree prior to the Chernobyl accident (see, for example, reference [18]). Application of a process of optimisation of radiological protection to the determination of intervention levels for controls on food consumption has yielded a range of values between 1 mSv and 10 mSv [18]. Differences in the intervention levels thusly determined result from differing assumptions on food production costs and the assigned cost per manSv (i.e., alpha values, as defined in ICRP Publication 37 [19]). Application of the optimisation process can be extended to determine derived intervention levels, through the use of appropriate dose conversion factors for each relevant radionuclide or group of radionuclides, and through assumptions on food consumption rates.

Such a process of optimisation may be characterised by the existence of constraints, an important one being the limitation of individual risk as expressed by an upper level of individual dose. This level of dose should be selected to correspond to the maximum individual risk considered acceptable under the particular circumstances. It should be noted that this individual dose constraint has a different meaning from that of the individual dose level considered under principle (b), the latter resulting from a balance between the radiological risk and the risk associated with introducing a protective measure.

Some members of the Expert Group are of the opinion that optimisation should be conducted between two constraints: a) an upper level of individual dose above which the protective measure should almost certainly be applied; and b) a lower level of individual dose below which the protective measure would not likely be warranted. While the Expert Group considers that the upper level could be established on the basis of maximum acceptable risk to individuals, no consensus has been reached by the Group on the appropriateness of specifying a lower bound for the optimisation process.

The Expert Group notes that there is a potential risk for protective measures to be implemented in an arbitrary or inappropriate manner when decisions are made under pressure or in conditions of uncertainty, such as may be the case in the early stages of an accident. Therefore, the Expert Group is of the opinion that predetermined intervention criteria (ILs and DILs) are of considerable value to emergency response planning. Furthermore, the Expert Group is of the opinion that a process of optimisation may be useful as a decision-aiding tool in the general development of such predetermined intervention criteria for protection of public health. However, it is recognised that some difficulties may exist in applying this approach, particularly with respect to controls on the international trade of food. For example, decisions on the acceptability of the quality of food imports in various countries may differ according to prevailing social, regulatory and political circumstances. The Expert Group also notes that the approaches to optimisation of radiological protection in accident situations being considered by various national and international organisations have not been uniform, particularly with respect to the values of individual dose used as constraints for the process. Therefore, the Expert Group recommends that further effort should be made towards developing a consistent set of dose constraints for the process of optimisation.

Due to the difficulties and uncertainties associated with applying principles (b) and (c) of ICRP-40 to the far-field, some doubts have been raised as to whether these principles provide an adequate basis for developing intervention criteria in areas well beyond the vicinity of the accident site. The Expert Group considered the need for modification of the basic principles for planning, with the objective of making them appropriate for application to the far-field. The rationale for any such modification involves the need to provide justification for implementing protective measures, to establish an individual-related criterion based on acceptable risk and to place greater emphasis on control of the collective detriment in the far-field. The Expert Group recommends that these aspects be given further consideration by the relevant international organisations.

4.2.4 Application of Intervention Levels

In the previous section, the basic principles for the establishment of intervention levels have been discussed. This section discusses aspects of the application of the intervention levels to decisions on the implementation of protective measures.

All international recommendations concur with the need for defining intervention levels in terms of individual dose. In general terms, the dose to be compared with the relevant intervention level in order to decide if a given protective measure is required is the total dose which can be affected by that measure, including the contribution from all the related exposure pathways. For evacuation, for example, this is the total dose from all exposure pathways that can be modified by the evacuation, such as inhalation and external irradiation from airborne radionuclides and ground deposition. The Expert Group is of the opinion that the effective dose equivalent (or organ dose equivalent) integrated to the age of 70 is the most relevant dose type to use as the basis for emergency response. The time period of exposure or intake used as the basis for making dose projections depends on the particular protective measures and their duration of application, as well as the time evolution of the radiological impact. For evacuation, this period can be hours or days, while for food control it can be months or years.

It has been recommended by the ICRP [2] that the numerical intervention levels to be applied to decisions on the introduction of each protective measure should be selected from within a range of values between a lower intervention level and an upper intervention level. Although the numerical values suggested by the ICRP [2] for lower and upper intervention levels are considered to be adequate for the near-field, using current risk factors, the Expert Group is of the opinion that their applicability to the far-field and to long-term situations should be discussed further. The Expert Group notes that the issue of establishing numerical intervention levels for controls on food is still under consideration within various international organisations. Substantial benefits would result from international harmonisation in this area.

The review of actions taken following the Chernobyl accident has indicated that many countries imposed controls on food below the lower intervention level of 5 mSv in a year suggested by the ICRP [2]. In some cases, this was due to the incorporation of additional safety factors on the part of the national authorities. In other cases, some authorities regarded the level of individual risk associated with 5 mSv to be too high.

The Expert Group discussed the appropriateness of establishing, for the far-field with indirect impact, a lower intervention level for controls on food below that adopted in the near-field or the far-field with direct impact (for example, 1 mSv rather than 5 mSv as suggested by ICRP [2]). Consideration was also given to the possible need to reduce the lower intervention level for controls on food after the first year following the accident (for example, from 5 mSv in the first year to 1 mSv in subsequent years). The Expert Group notes, however, that the use of two different lower intervention levels at different times and distances from the accident could add unnecessary complexity to control systems and create undue public confusion. It is also to be recognised that doses to the public in the far-field and in the long term following a major accidental release are likely to be substantially lower than in the near-field and in the short term. The Expert Group is of the opinion, therefore, that it may be adequate for most circumstances to specify only one value for the lower intervention level, that is, the value applicable to the first year.

Decisions on the withdrawal of protective measures will need to be made at some point in time following their introduction. The withdrawal of the measures and the return to normal living conditions will be dependent upon the specific characteristics of the accidental contamination and on specific social and economic considerations. Therefore, the Expert Group is of the opinion that it cannot be assumed that the criteria used to withdraw a particular protective measure will necessarily be the same as those used for its introduction. The Expert Group recommends that further consideration be given to defining the criteria for withdrawal of protective measures.

4.3 PROCEDURES FOR ESTABLISHMENT OF DERIVED INTERVENTION LEVELS

4.3.1 Utility of Derived Intervention Levels

Consideration was given to the issue of whether decisions on protective measures should be made on the basis of DILs expressed as the activity concentration in environmental media or food, or whether they should be expressed solely on the basis of intervention levels of dose. For example, it had been noted that at least one country did not specify formal DILs in response to the Chernobyl accident, but rather took action on the basis of calculations of projected dose to critical groups.

The sole use of intervention levels of dose potentially offers a considerable degree of flexibility in controlling public exposures, although the approach can be complex to monitor and is not readily transparent to those other than the decision makers. Nevertheless, it is the opinion of the Expert Group that several practical issues, particularly in the areas of monitoring and food control actions, require that DILs be formulated and used as the basis for decisions on implementing many types of protective measures, notably controls on consumption of food and on the international trade of food.

Establishing DILs implies starting with an intervention level of dose, and calculating corresponding activity concentrations in food or environmental media. In doing so, there is a need to consider a broad range of processes and parameters that link the two types of values. Inherent to the calculations, therefore, are a considerable number of assumptions on processes and a wide variation in possible parameter values, which may introduce a substantial degree of uncertainty or subjectivity. The application of safety factors in modelling approaches sometimes results in an unnecessary degree of conservatism being introduced into predictions of dose impacts or calculation of derived intervention levels. It is noted that dose estimates based on food-intake predictive modelling of the Chernobyl impact have exceeded more recent dose estimates based on in-vivo, whole-body measurements by factors of approximately 2 to 5.

Because of this, the Expert Group notes that there is considerable potential for differences to arise in defining DILs, even when they have been developed from the same intervention level. The Expert Group recommends, therefore, that increased international attention be devoted to examining DIL modelling techniques and approaches, and developing a more systematic and harmonised approach to the definition of DILs.

The remainder of Section 4.3 is devoted to a brief examination of some of the parameters used in the derivation of DILs, and some guidance, where appropriate, is provided on how a greater degree of harmonisation could be achieved.

4.3.2 Exposure Pathways

In the early stages of an accident, decisions on the implementation of measures to protect public health depend significantly on predictions of potential doses, often on the basis of minimal environmental monitoring data. In the later stages of an accident, when a more complete database is available, more informed decisions can be made on the basis of the modelling of environmental transfer processes.

Characterisation of the accident source term is a first step in understanding and assessing the consequences of an accidental release of radionuclides to the environment, including the contamination of food. Factors of importance to the source term include the relevant radionuclides, the release characteristics, and atmospheric or aquatic dispersion and deposition processes. For nuclear facility accidents, plant safety analyses are used as the basis for identifying possible accident scenarios and estimating the characteristics of potential releases. The particular radionuclides of concern following an accident are dependent upon the type of facility and the severity of the accident. References [20] and [21] provide a review of the important radionuclides and pathways relevant to severe accidents at nuclear facilities. In the far-field, following a release of radionuclides other than noble gases, the primary concerns will relate to the incorporation of radionuclides into food-chains, and to external irradiation from deposited radionuclides.

The potential wide variations in many of the parameter and process assumptions used in accident consequence assessment, or environmental transfer modelling, may place some limitations on the extent to which international harmonisation can be achieved. The Expert Group is of the opinion that unnecessary discrepancies in the modelling of environmental transfer processes, not justified on the basis of objective differences in environmental conditions, need to be reduced to the extent possible. Emphasis needs to be placed on developing international harmonisation of realistic assumptions, rather than worst-case assumptions. The use of an overly conservative approach is not considered to be appropriate for application to quantitative risk assessment.

In the event of a major accident involving dispersal of radioactive material at large distances from the accident site, there may exist a number of routes of exposure to the public and workers which are not related to ingestion of food. Some examples of potential exposure problems resulting from these other pathways include:

a) contamination of surfaces and large areas (e.g., fields, buildings, roads), requiring extensive decontamination;

b) contaminated sewage sludge resulting from processes of concentration of radionuclides in sewage treatment plants, which may require special considerations related to its handling, disposal and use as fertiliser;

c) contaminated industrial air filters, resulting in occupational exposure problems as well as waste disposal problems;

d) contaminated wood, peat or other materials used for heating or energy production, resulting in problems related to activity released in stack emissions and disposal of ash containing concentrated activity; and

e) contaminated tools and equipment used in industry and agriculture, resulting in potential exposures to workers.

While not discussed in detail by the Expert Group, there is a need for further consideration of the development of DILs for these and other routes of exposure.

4.3.3 Reference Group or Population

Planning for emergency response should be based on a defined reference group of individuals, or a reference population, to which protective measures would be applied in the event of an accident. It is considered that the reference group should consist of individuals who are likely to be exposed at a higher level than the rest of the population, and should also be the group of individuals whose dose can most be affected by the particular intervention. Important parameters involved in the definition of the reference group include the group's age distribution, its source of food, dietary intakes and living habits.

However, as demonstrated by the response to the Chernobyl accident in Member countries, there can be a wide range in interpretation of the nature and characteristics of this group. This can have a significant influence with respect to creating differences between countries in the establishment and application of derived intervention levels. The Expert Group is of the opinion that the appropriate reference group is similar to what is commonly known as the "critical group" when the corresponding intervention level has been derived on the basis of principle (a) or principle (b) of ICRP-40. In this case, the dose to be compared with the intervention level is the average individual dose in the reference group. Attempts should be made to ensure selection of a relatively homogeneous group for this purpose, but not at the expense of being too narrow in terms of group size or living habits. On the other hand, when principle (c) of ICRP-40 determines the choice of the intervention level and the decision for application of a protective measure, the reference group would be a much larger population (i.e., a "reference population") whose collective dose has been used to apply principle (c), and the individual dose to be compared with the intervention level is the average individual dose in that population.

Apart from such reference groups or populations, it is recognised that there may exist some individuals whose extreme dietary and living habits, or specific radio-sensitivities, may cause them to have potentially higher risks or exposures in the event of an accident (e.g., unusually high consumers of reindeer meat). The Expert Group is of the opinion that any additional need for consideration of these individuals (e.g., provision of advisory information) should be addressed on an ad-hoc basis.

4.3.4 Parameters for Dose Calculations

Two particular issues of relevance to the calculation of DILs for controls on consumption of food involve the selection of food intake data, and selection of dose conversion factors.

The value of the DIL for a particular food may be given, in simple terms, by:

$$DIL = \frac{IL}{m \cdot d}$$

where m is the mass or volume of food consumed annually (kg/year), and d is the relevant dose per unit intake value, or dose conversion factor Sv/Bq. Additionally, one may wish to include another term to the numerator of the DIL equation which would take into account the extent of contamination of the food being consumed. Such a contamination factor would be equivalent to the fraction of an individual's intake of the particular food that can be considered to be uniformly contaminated to the full value of a selected DIL for an entire year. A factor of 1 is considered to be a conservative approach to calculation of DILs. The CEC Group of Experts established under Article 31 of the Euratom Treaty assumed, in their calculation of secondary intervention criteria [22], that an individual's annual intake of radionuclides would be equivalent to the consumption of 10 percent of the relevant dietary component contaminated to the full value of the DIL for one entire year (i.e., a contamination factor of 0.1). This assumption has been supported by measurements, made in various regions of the Federal Republic of Germany, of different levels of environmental contamination following the Chernobyl accident. However, the approach adopted by an FAO Group of Experts [23] assumed a contamination factor of 1 in the calculation of secondary intervention criteria for controls on food traded internationally.

The distribution of activity concentration in the particular type of food being considered depends on several factors, including distance from the site of the accident, the time elapsed since its occurrence, the season of the year and whether the accident impact situation is Type I or Type II. Because of the complexity of environmental transfer mechanisms, it is not possible to make any precise estimate of the effect of these variations in time and space. Nevertheless, the Expert Group recognises that some subjective judgements are necessary to develop predetermined intervention criteria, particularly for long-lived radionuclides.

In the interest of international harmonisation, the Expert Group considers that it would be useful to obtain a consensus on an accepted value for the contamination factor, which can be used in the development of predetermined DILs. The Expert Group suggests that a value of 10 percent (i.e., a factor of 0.1) would be appropriate for both Type I and Type II situations. Of course, this assumption could be modified, <u>if necessary</u>, following a particular accident on the basis of detailed measurements and information. For example, in the near-field where food may be both produced and consumed locally, values approaching 1 may be necessary. In Type I situations (i.e., far-field with direct impact), it is conceivable that values higher than 0.1 also may be required. However, in Type II situations, it is considered most unlikely that values higher than 0.1 will be required.

With respect to m, the annual food consumption rate, the Expert Group supports the international efforts (e.g., [16]) aimed at determining appropriate assumptions for food consumption rates for use in the calculation of predetermined DILs.

The Expert Group also supports efforts to achieve international agreement on age-dependent dose conversion factors, for ingestion, for members of the public. Table 15 compares the sets of age-dependent ingestion dose factors which have been published and used by various national and international organisations in the development of predetermined DILs. <u>The Expert Group is of the opinion that the age-dependent dose conversion factors developed by the Institut für Strahlen Hygiene (ISH) of the Federal Republic of Germany [24, 25, 26] (see Table 15) should be accepted as appropriate interim values until formal international review of this subject has been completed</u>. These values are considered to be consistent with values proposed by most other organisations. It is also advisable to consider the use of values for the thyroid dose equivalent.

<u>The Expert Group is of the opinion that</u>, with respect to the relevant radionuclides, <u>practical application of an intervention system may be facilitated by specifying DILs on the basis of groupings of radionuclides rather than for individual nuclides</u>. Nuclides may be grouped on the basis of comparable radiotoxicity, and the most restrictive dose conversion factors in each group, for the most restrictive age group, should be selected as the basis for calculation of predetermined DILs. The Expert Group suggests that four groupings of nuclides can be made on this basis:

a) iodine isotopes (e.g., iodine-131);

b) caesium isotopes (e.g., caesium-134 and -137);

c) other long-lived nuclides (e.g., strontium-90); and

d) alpha-emitting nuclides (e.g., plutonium-239, americium-241).

4.3.5 Additivity

With respect to the additivity of exposures from different pathways, the Expert Group is of the opinion that the approach taken in ICRP-40 [2] remains applicable, whereby all exposure pathways are not grouped but rather are assessed in relation to the particular protective measure being considered. In the far-field, it is not considered likely that there will be a need to implement multiple protective measures, each requiring control at the designated intervention level. It is recognised that impact assessments can be based on a limited number of key, or indicative, pathways and nuclides. Any problems associated with the potential need to specifically evaluate the total, summated dose over all pathways and nuclides should not arise.

Nevertheless, there remains some ambiguity in the intent of ICRP-40 [2] with respect to control measures for food. The Expert Group has made the interpretation that the ICRP-40 intervention levels refer to the total ingestion dose due to all food, to be used as the collective criterion for action on control of food. This, therefore, suggests that full additivity of exposures from all individual foods would, in principle, be necessary. However, the Expert Group notes that, in practice, this would require an assessment and control mechanism perhaps too complex to be pragmatic or useful. Thus, particularly for the far-field, the Expert Group is of the opinion that DILs should be developed only for major components of the diet, and that additivity should be considered only if the contributions to the ingestion dose from different foods are of a similar degree of importance and, individually, represent a significant fraction of the corresponding intervention level.

4.4 INTERNATIONAL TRADE OF FOOD

As previously noted, a particularly complex problem which has developed from the transboundary impact of the Chernobyl accident involves attempts to establish appropriate intervention criteria for controls on the international trade of food contaminated as a result of an accident. This issue has dominated post-Chernobyl discussions on the derivation and application of intervention criteria. The issue is particularly difficult to address in that considerations are introduced into the decision-making process which transcend those typically addressed in radiological protection assessments. These additional considerations include a variety of social, economic, regulatory and political factors. It was not within the mandate of the Expert Group to examine these aspects of the issue. However, the Expert Group recommends that the organisations examining this issue attempt to explicitly identify and define the various factors involved in the decision-making process, and the relative roles of these factors. Although this issue applies to all aspects of public protection, it particularly applies to the international trade of food. Nevertheless, the Expert Group is of the opinion that the intervention criteria established for controls on the consumption of food, on the basis of radiological protection and public health considerations, should be the initial focus of decisions on control levels for the international trade of food.

As previously mentioned, the CEC and the FAO have made specific attempts to develop secondary intervention criteria for the international trade of food. The CEC approach has been based on the specific need to harmonise controls on the trade of food amongst its Member states. While the impetus has primarily been provided by social and economic factors of relevance to radiological protection, it also must be recognised that other considerations, including economic, regulatory and political factors, may have played a role in the decision-making process. The focus of the FAO approach has been on the development of "non-intervention levels" [23] for control of imports of contaminated foods. Emphasis has been placed on developing criteria which would be characterised by substantial margins of safety, and by ease of derivation and application by customs and regulatory officials. As such, considerable safety factors have been introduced into the assumptions on which these proposed intervention criteria have been based. Currently, the FAO and the WHO are attempting to develop joint recommendations on criteria which would be applicable to controls on the international trade of food. Descriptions of the CEC and the FAO approaches are provided in, respectively, references [22] and [23]. The details will not be addressed further in this report, other than to note that the two approaches are characterised by sets of assumptions which correspond reasonably in some cases, and which differ in others.

The Expert Group is of the opinion that approaches to harmonisation of intervention criteria for controls on the international trade of food should give consideration to the distinction between Type I and Type II conditions (see Section 4.2.2). Under Type I conditions, or the far-field with direct impact, it will be necessary to ensure that the approaches adopted to control deposition-related exposures and to control import-related exposures are compatible. In this respect, the Expert Group is of the opinion that the ICRP-40 accident management approach would be applicable to controls on exposures, including those arising from ingestion of contaminated food, although there is a need for clarification of the role of principles (b) and (c) in far-field situations (see Section 4.2.3).

In those countries subject to Type II conditions, or the far-field with indirect impact only, the primary source of exposure is through the import of contaminated food originating from countries directly affected by deposition. In this situation, exposures may be controlled by placing restrictions on the maximum levels of contamination of the imported food. Such restrictions can be implemented by the importing country through appropriate measurements on the food at the point of entry, or by requesting certificates of compliance with the appropriate standards from the exporting country.

The Expert Group notes the problems to the international trade of food which were caused by countries which imposed strict controls on food originating from countries directly affected by deposition of radionuclides from the Chernobyl accident. Such restrictions were apparently undertaken in the interest of maintaining public exposures at negligible levels, there being no immediately obvious risks or other costs associated with seeking alternative food supplies. However, the Expert Group is of the opinion that there may be hidden costs associated with such actions, not only for the exporting country (e.g., lost production), but also for the importing country (e.g., risks associated with changes in diet, particularly for infants being fed on powdered milk; damage to trade relations). In order to foster international harmonisation in the trade of food, the Expert Group suggests that the numerical value selected for the lower intervention level should be adopted as the general level for use in calculating DILs for controls on imported food.

5. SUMMARY OF CONCLUSIONS

5.1 INTRODUCTION

The nature of the Chernobyl accident gave rise to several unique issues and problems related to emergency response and public health protection in OECD Member countries. The Expert Group has noted that those relevant to the derivation and application of intervention criteria primarily involve:

a) the need for clarification or expansion of international guidance on emergency response planning and intervention criteria;

b) the need for harmonisation of methodologies and parameter assumptions used in accident impact assessment and the establishment of DILs; and

c) the need for specific guidance on control levels for the international trade of food.

To provide a better understanding of the reasons for the occurrence of these issues and problems, the Expert Group undertook a critical review of the radiological principles and procedures for the establishment and application of intervention criteria. This report has documented the status of the Expert Group deliberations and, where appropriate, guidance has been provided on the potential and the means for achieving international harmonisation of emergency response criteria, particularly in the context of questions raised by the Chernobyl accident.

5.2 INTERNATIONAL GUIDANCE ON EMERGENCY RESPONSE PLANNING AND INTERVENTION CRITERIA

The Expert Group is of the opinion that predetermined intervention criteria (ILs and DILs) are of considerable value to emergency response planning. The predetermined intervention criteria would be most useful in providing an internationally accepted basis for intervention in the event of accidents having a transboundary impact, as well as an interim basis for intervention immediately following an accident. However, the Expert Group notes that any such approach adopted must ensure a clear link between the philosophical basis for emergency response and the operational intervention criteria, and that the intervention criteria should be specified in terms of levels for actions and not as inflexible limits.

The Expert Group has concluded that several aspects of the current international guidance on intervention criteria need to be expanded or clarified, with the objective of providing more comprehensive and harmonised guidance and a clearer explanation of the rationale for the recommended intervention criteria and protective measures. The conclusions of the Expert Group with respect to the international guidance is summarised as follows:

1. The existing basis for development of emergency response plans needs to be further examined for areas beyond the accident site, giving particular consideration to the implications of severe accidents having widespread, transboundary and long-term impacts. In particular, there is a need to more clearly develop the rationale for distinguishing the control of exposures in the far-field resulting from accidental releases of radionuclides, from the control of exposures resulting from normal situations or operational releases.

2. A simple characterisation of an accident in terms of temporal dependencies is not completely adequate for emergency response planning. Rather, it is preferable to relate emergency response criteria to a combination of the spatial and temporal components of an accident, involving the "near-field" and the "far-field". Consideration of such spatial aspects of accidents, particularly in terms of the types of protective measures required, may enhance the applicability and interpretation of international guidance on emergency response.

3. There is a specific need to clarify the application of emergency response criteria in the far-field. To facilitate discussion on the far-field issue, the Expert Group has distinguished two impact conditions: a) Type I, where interventions are required primarily to control exposures arising from deposition of contaminants (direct impact); and b) Type II, where interventions are required only to control exposures arising from contaminated food imported from other countries.

4. The scope and applicability of the three basic principles of ICRP-40, and their relative roles in accident management, require some clarification and expansion, particularly with respect to the far-field. Existing international guidance on the application of principle (a) of ICRP-40, concerning avoidance of non-stochastic effects, is reasonably explicit and is considered adequate.

5. There is a need to clarify the meaning and applicability of principle (b) [risk to individuals] and principle (c) [collective detriment] in areas well beyond the accident site, particularly with respect to controls on food.

6. The Expert Group is of the opinion that a process of optimisation of radiological protection [i.e., use of principle (c) of ICRP-40] may be useful as a decision-aiding tool in the general development of predetermined intervention criteria for protection of public health. Some members of the Group are of the opinion that this process of optimisation should be conducted between two constraints: an upper level of individual dose above which the protective measure should

almost certainly be applied, and a lower level of individual dose below which the protective measure would not likely be warranted. While the Expert Group considers that the upper level could be established on the basis of maximum acceptable risk to individuals, no consensus has been reached by the Group on the appropriateness of specifying a lower bound for the optimisation process. The Expert Group recommends that further effort should be made towards developing a consistent set of dose constraints.

7. The Expert Group considered the need for modification of principles (b) and (c) of ICRP-40, with the objective of making them appropriate for application to the far-field and to the long term. The rationale for any such modification involves the need to provide justification for implementing protective measures, to establish an individual-related criterion based on acceptable risk and to place greater emphasis on control of the collective detriment in the far-field. The Expert Group recommends that these aspects be given further consideration by the relevant international organisations.

8. Although the numerical values suggested by the ICRP [2] for lower and upper intervention levels are considered to be adequate for the near-field, using current risk factors, the Expert Group is of the opinion that their applicability to the far-field and to long-term situations needs to be discussed further.

9. The Expert Group is of the opinion that it cannot be assumed that the criteria used to withdraw a particular protective measure will necessarily be the same as those used for its introduction. It is recommended therefore that further consideration be given to defining the criteria for withdrawal of protective measures.

5.3 PROCEDURES FOR ESTABLISHMENT OF DERIVED INTERVENTION LEVELS

The Expert Group concluded that several practical issues, particularly in the areas of monitoring and food control actions, require the formulation of derived intervention levels (DILs). However, it was also concluded that the safety factors introduced into the methodologies and parameter assumptions used in the definition of DILs and in accident impact assessments can potentially introduce a substantial degree of subjectivity into the results. Because of this, the Expert Group notes that there is considerable potential for differences to arise in developing DILs, even when they have been determined from the same intervention level.

Therefore, the Expert Group recommends that increased international attention be devoted to examining DIL modelling techniques and approaches, and developing a more systematic and harmonised approach to the definition of DILs. Some guidance from the Expert Group on this issue is identified as follows:

1. Unnecessary discrepancies in the modelling of environmental transfer processes need to be reduced to the extent possible. Emphasis needs to be placed on developing international harmonisation of realistic assumptions, rather than worst-case assumptions.

2. It is recognised that, in a far-field accident situation, there may exist a number of routes of exposure to the public and workers which are not related to ingestion of food. While not discussed in detail by the Expert Group, there is a need for further consideration of the development of DILs for these routes of exposure.

3. Planning for emergency response should be based on a defined reference group of individuals, or a reference population, to which protective measures would be applied in the event of an accident. The reference group should consist of individuals who are likely to be exposed at a higher level than the rest of the population. Such a group is considered to be similar to what is commonly known as the "critical group" when the corresponding intervention level has been derived on the basis of principles (a) or (b) of ICRP-40. The reference population, generally of a much larger size than the reference group, should be considered when principle (c) of ICRP-40 is used to establish intervention criteria on the basis of its collective dose. Apart from such reference groups and populations, there may exist individuals whose extreme dietary and living habits, or specific radio-sensitivities, may cause them to have potentially higher risks or exposures in the event of an accident. The Expert Group is of the opinion that any additional need for consideration of these individuals should be addressed on an ad-hoc basis.

4. The Expert Group supports the international efforts aimed at determining appropriate assumptions for food consumption rates for use in the calculation of predetermined DILs. In the interest of international harmonisation, the Expert Group also considers that it would be useful to obtain a consensus on an accepted value for a food contamination factor, which can be used in the development of predetermined DILs. The Expert Group suggests that a contamination factor of 0.1 would be appropriate for far-field situations, and that this assumption should be modified, if necessary, following a particular accident on the basis of detailed measurements and information. The Expert Group also supports efforts to achieve international agreement on age-dependent dose conversion factors, for ingestion, for members of the public. As a step towards harmonisation, the Expert Group considers that the age-dependent dose conversion factors developed by the Institut für Strahlen Hygiene (ISH) of the Federal Republic of Germany should be accepted as appropriate interim values until formal international review of this subject has been completed.

5. With respect to control measures for food, the Expert Group is of the opinion that a system which requires full additivity of exposures from all foods would, in practice, require an assessment and control mechanism perhaps too complex to be pragmatic or useful. Thus, particularly for the far-field, the Group is of the opinion that DILs should be developed only for major components of the diet, and that additivity should be considered only if the contributions to the ingestion dose from different foods are of a similar degree of importance and, individually, represent a significant fraction of the corresponding intervention level.

5.4 INTERNATIONAL TRADE OF FOOD

The Expert Group has observed that the issue of establishing appropriate intervention criteria for controls on the international trade of food contaminated as a result of an accident has dominated post-Chernobyl discussions on intervention criteria. The Group notes that factors other than those typically considered in radiological protection assessments are relevant to decision making, and recommends that the organisations examining this issue attempt to explicitly identify and define the role of these various factors in the decision-making process.

Nevertheless, the Expert Group is of the opinion that the intervention criteria established for controls on the consumption of food, on the basis of radiological protection and public health considerations, should be the initial focus of decisions on control levels for the international trade of food. Therefore, the Expert Group suggests that the numerical value selected for the lower intervention level should be adopted as the general level for use in calculating DILs for controls on imported food.

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7. GLOSSARY

PART A: OECD/NEA MEMBER COUNTRY ACRONYMS

The following acronyms have been used to identify Member countries:

AUS	Australia	J	Japan
A	Austria	L	Luxembourg
B	Belgium	NL	Netherlands
CND	Canada	N	Norway
DK	Denmark	P	Portugal
SF	Finland	E	Spain
F	France	S	Sweden
FRG	Federal Republic of Germany	CH	Switzerland
GR	Greece	TR	Turkey
IS	Iceland	UK	United Kingdom
IRL	Ireland	US	United States
I	Italy		

In addition, the following acronyms for various national and international organisations have been used in the report:

CEC	Commission of the European Communities
EEC	European Economic Community
IAEA	International Atomic Energy Agency
WHO	World Health Organisation
FAO	Food and Agriculture Organisation
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
ICRP	International Commission on Radiological Protection
NRPB	National Radiological Protection Board (UK)
ISH	Institut für Strahlen Hygiene (FRG)
EPA	Environmental Protection Agency (US)
FDA	Food and Drug Administration (US)
USDA	Department of Agriculture (US)

PART B: QUANTITIES AND UNITS

Special measurement units for quantities of interest in radiological protection (röntgen, rad, rem, curie) have, in recent years, been superseded by a new set of units associated with the International System of Units (SI). These new units - the gray for absorbed dose, the sievert for dose equivalent and the becquerel for activity - have been progressively adopted in Member countries. The relationship between the SI units and the previously used units are shown in the following table.

QUANTITY	SI NAME, SYMBOL AND BASE	OLD NAME AND SYMBOL	CONVERSION FACTORS
Exposure	- ; C kg^{-1}	röntgen (R)	1 C kg^{-1} = 3876 R 1 R = 2.5 x 10^{-4} C kg^{-1}
Absorbed Dose	gray (Gy); J kg^{-1}	rad (rad)	1 Gy = 100 rad 1 rad = 10^{-2} Gy
Dose Equivalent	sievert (Sv); J kg^{-1}	rem (rem)	1 Sv = 100 rem 1 rem = 10^{-2} Sv
Activity	becquerel (Bq); s^{-1}	curie (Ci)	1 Bq = 2.7 x 10^{-11} Ci 1 Ci = 3.7 x 10^{10} Bq

In addition, factors of the above units are commonly used, as follows:

SI Unit Prefixes:

Factor	Prefix	Symbol	Factor	Prefix	Symbol
10^{12}	tera	T	10^{-3}	milli	m
10^{9}	giga	G	10^{-6}	micro	m
10^{6}	mega	M	10^{-9}	nano	n
10^{3}	kilo	k	10^{-12}	pico	p

Dose equivalent:

1 Sv	=	100 rem
1 mSv	=	100 mrem
1 mSv	=	0.1 mrem

Activity:

1 Bq	=	2.7 x 10^{-11} Ci	= 27 pCi
1 kBq	=	2.7 x 10^{-8} Ci	= 27 nCi
1 MBq	=	2.7 x 10^{-5} Ci	= 27 mCi
1 GBq	=	2.7 x 10^{-2} Ci	= 27 mCi
1 TBq	=	27 Ci	

PART C: EXPLANATION OF TERMS

Note: Some of the terms explained here have well-established meanings, while others have not. The definitions provided here pertain to the use of the terms in this report, and are not necessarily applicable to the terms as they may be used generally.

Absorbed Dose: The quantity of energy imparted by ionising radiation to a unit mass of matter such as tissue. It is measured in grays (Gy), where 1 Gy equals 1 joule per kilogram. One Gy produces different biological effects on tissue depending on the type of radiation.

Accident: Any event which results in loss of control of a nuclear facility or radiation source, and which gives rise to abnormal exposures to ionising radiation, in excess of those anticipated for normal conditions.

Accident Management: The measures taken to control the course of an accident in progress, and to mitigate the consequences of an accident during and after its occurrence.

Activity: The rate at which spontaneous nuclear transformations (i.e. radioactive decay) occur in a quantity of a radionuclide in a given time interval. It is measured in becquerels (Bq) where 1 Bq equals 1 nuclear transformation per second.

Acute Doses: Those received within a relatively short period of time.

ALARA: An acronym for "as low as reasonably achievable", a concept meaning that the design and use of sources, and the associated practices, should be such as to ensure that exposures are kept as low as is reasonably achievable, economic and social factors being taken into account.

Chronic Doses: Those received over a prolonged period of time.

Collective Dose Equivalent: The total dose over a population group exposed to a given source of radiation. It is represented by the product of the average dose equivalent to the individuals in the group and the number of persons comprising the group. It can be expressed as collective organ dose equivalent or collective effective dose equivalent, and is measured in mansieverts (manSv).

Committed Dose: The total dose (expressed as organ dose equivalent or effective dose equivalent) gradually accumulated by an individual during a given period of time by the decay of a radionuclide, fixed within the individual, following its intake into the body. The integration time is usually taken as 50 years for workers and 70 years for members of the public.

Competent Authority: The authority designated or otherwise recognised by a government for specific purposes in connection with protection of public health and safety in the event of a radiation accident.

Containment: A structural envelope which completely surrounds a nuclear reactor system and is designed to confine releases from the design basis accidents with little or no release to the environment.

Contamination (radioactive): The presence of a radioactive substance or substances in or on a material or in a location where they are undesirable or could be harmful.

Core Melt: The term applied to the overheating of a reactor core as a result of the failure of nuclear reactor shutdown or cooling systems, leading to melting of the radioactive fuel and the structures which hold the fuel in place.

Cost-Benefit Analysis: A procedure for the optimisation of radiological protection used to determine the point at which exposures have been decreased so that any further decrease (benefit) is considered less than the additional cost required to achieve it.

Cost-Effectiveness Analysis: A procedure which is used to determine the most effective protection obtainable from fixed resources or, alternatively, to determine the least expensive option for a given level of protection.

Critical Group: A homogeneous group of the population which is representative of the more highly exposed individuals in that population exposed to a given source of radiation. May be synonymous with Reference Group.

Critical Pathway: The dominant environmental pathway through which members of the critical group are exposed to radiation. For example, iodine released in a gaseous discharge may contaminate pasture when deposited, be taken up by cows, be transferred to milk and consumed by individuals of the critical group.

Derived Intervention Level (DIL): A secondary intervention criterion, usually specified as the concentration or time-integrated activity of a given radionuclide within a given food or environmental medium (air, soil, water, vegetation) which, on the basis of specific assumptions on transfer to humans, corresponds to the relevant intervention level of dose.

Detriment: The mathematical expectation of the harm (damage to health and other effects) incurred from an exposure to radiation, taking into account not only the probability of each type of deleterious effect, but also the severity of the effect.

Dose: A general term denoting a quantity of radiation imported to organisms. It can be qualified as absorbed dose, dose equivalent or effective (or organ) dose equivalent.

Dose Equivalent (H): The quantity obtained by multiplying the absorbed dose by a factor representing the different effectiveness of the various types of radiation in causing harm to tissues. It is measured in sieverts (Sv), with 1 Sv producing the same biological effect irrespective of the type of radiation.

Effective Dose Equivalent (H_E): The weighted sum of the dose equivalents to the various organs and tissues. The weighting factor for each organ or tissue expresses the fractional contribution of the risk of death or serious genetic defect from irradiation of that organ or tissue, to the total risk from uniform irradiation of the whole body.

Exposure: The incidence of radiation on living or inanimate material (equivalent to irradiation). A distinction is made between:

(a) external exposure - irradiation by sources outside the body;

(b) internal exposure - irradiation by sources inside the body; and

(c) total exposure - the sum of the external and internal exposures.

Exposure Pathways:	The routes by which organisms can be exposed to external or internal irradiation.
Half-life (radioactive):	The time taken for the activity of a radioactive material to lose half its value by radioactive decay. The <u>biological half-life</u> is the time taken for half of a substance to be eliminated from a tissue, an organ or the whole body. The <u>effective half-life</u> is the time taken for a radioactive material in a living organism to be reduced to half of its original value by a combination of biological elimination and radioactive decay.
Intervention Level (IL):	The value of dose which, if exceeded or predicted to be exceeded in the event of an accident, may require the application of a given protective measure. ILs specify values of dose to individuals projected over a given period of time, and are used as a threshold for initiating a given set of protective measures. <u>Not</u> to be confused with <u>dose limit</u>.
Limit:	The value of a quantity which must not be exceeded.
Natural Radiation Exposure ("background" radiation exposure):	Exposure of persons resulting from naturally occurring radioactive substances inside the body and from natural sources of external radiation, including cosmic rays and sources of terrestrial origin (soils, rock).
Non-Stochastic Effects (radiation-induced):	Radiation effects for which a threshold exists, above which the severity of the effect varies with the dose.
Organ Dose Equivalent:	The dose equivalent imparted to a given organ or tissue. Measured in sieverts (Sv).
Risk:	For the purpose of radiological protection, the probability that a given individual will incur any given deleterious stochastic effect as a result of radiation exposure. Also known as the product of the probability of occurrence of an accident and the magnitude of the consequences given that occurrence.

Secondary Containment: An enclosure surrounding the primary containment of a reactor system which provides for the collection of leakage from the primary containment and filtering of the leakage before discharge to the atmosphere.

Severe Accident: An accident which exceeds the design basis sufficiently to cause failure of system components essential for core cooling by normal means. The degree of severity of a severe accident depends on the degree of fuel damage and on the degree of loss of containment integrity.

Source Term: A quantitative description of the release of radioactive material in a nuclear accident. The description includes the physical and chemical form of the nuclides released as well as other data relevant to the dispersion characteristics of the release, such as the energy of the release plume and the height and duration of release.

Stochastic Effects: Radiation-induced effects, the severity of which is independent of dose and the probability of which is assumed by the ICRP to be proportional to the dose without threshold, in the range of low doses of interest.

Annex I

EXPERT GROUP ON INTERVENTION LEVELS FOR NUCLEAR EMERGENCIES

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Annex II

TERMS OF REFERENCE

1. Critically review the emergency responses and corresponding primary and derived intervention levels adopted in Member countries, in terms of objective radiation protection criteria and in the context of transboundary impacts and prolonged consequences of an accident.

2. Identify the parameters involved in the definition of intervention levels, particularly with respect to distinguishing those aspects which are generic in nature from those which are situation-specific, and also with respect to distinguishing where radiation protection criteria are applied and where other, non-radiation protection factors may be of significance.

3. Examine the potential for a better harmonisation of the basic radiation protection criteria and the general rationale for establishment of primary intervention levels and, if possible, of their numerical values.

4. Examine the potential for harmonisation of assumptions, methodologies and radiation protection criteria used for the establishment of derived intervention levels.

5. Examine the criteria and approaches which would provide for flexible responses to accident situations, able to correlate required actions with the nature and severity of the radiological impact.

6. Examine the practical problems resulting from the presence of long-lived radionuclide contamination in foodstuffs and the environment, and for which harmonisation of management approaches would be useful.

Annex III

RESPONSE TO THE CHERNOBYL ACCIDENT IN OECD MEMBER COUNTRIES(a)

RESPONSE	COUNTRY(b)	NOTES
A. ENVIRONMENTAL MONITORING:		
1. Intensify/ expand monitoring activities	All countries Duration: Ongoing in some countries to a very limited extent	Initial monitoring was exploratory, followed by intensive monitoring where determined to be necessary. In general, monitoring activities have shifted to programmes designed to assess longer term impacts and accumulation of contaminants. Current focus is on caesium-137 in foodchains.
B. PUBLIC INFORMATION:		
1. Establish means for issuance of information to the public	All countries	News releases, tourist advisories, telephone 'hotlines'. Problems with overloading of telephone service, and public understanding of technical issues/facts.
C. OUTDOOR PUBLIC ACTIVITIES:		
1. Advice to stay indoors or avoid specific outdoor activities	A, SF, FRG (some States), TR Duration: A few days to 2 weeks Extent: Regional	Advice to stay out of rain, to keep children from playing in rainwater puddles, and to keep children from playing in sand and from engaging in dust-generating activities. CND, CH: Gave explicit advice against the need for such measures.

a) Information provided by the competent authorities in the Member countries, and updated until May 1987.

b) See Section 7, Glossary, Part A, for key to Member country acronyms.

RESPONSE	COUNTRY(b)	NOTES
2. Advice to take sanitary precautions when entering from outside	A, TR Duration: A few days Extent: Regional	Advice to wash hands and to clean shoes.
3. Monitoring of people and land vehicles travelling from potentially contaminated areas	A, DK, SF, F, FRG, GR, IRL, L, NL, P, E, S, TR, UK, US Duration: A few days to 2 weeks Extent: Points of entry	Basis: Avoid inadvertent spread of contamination; Assess exposures to nationals returning from the Chernobyl region. Vehicles found to be contaminated were generally required to be cleaned. SF: Monitoring of people travelling to or from the Kiev region still conducted on request.
4. Advice to clean transport vehicles at border points of entry/exit	A, DK, SF, FRG, NL, TR Duration: 1-4 weeks Extent: TR Bulgarian border	Basis: Avoid spread of contaminants collected from roads. FRG: Used a criterion of 100 kBq/m^2 for vehicles.
5. Advice to nationals not to travel to potentially contaminated foreign areas	A, SF, FRG, IRL, L, NL, N, E, S, UK, US Duration: 1-3 weeks	Basis: Avoid unnecessary exposure until contamination levels in affected areas were better understood. N: Press statement advising against travel to an area within 500 km of Chernobyl.
6. Monitoring of fishing boats	DK, NL, TR Duration: DK: 4-12 May; TR: May Extent: DK (Baltic Sea); TR (Black Sea); NL (cargo boats)	Basis: Surveillance of potential deposition on boats and consequent contamination of crew and fish catches.

RESPONSE	COUNTRY(b)	NOTES
D. WATER:		
1. Advice not to drink rainwater or to use for domestic purposes	A, CND, SF, FRG, GR, J, L, NL, N,S, CH, TR, UK, US (1 State) Duration: 2-4 weeks Extent: Limited to remote geographical areas, with exception of A	Basis: Minimise iodine-131 doses in remote areas where rainwater was primary source of drinking water. NL: Not to use rainwater for greenhouses.
2. Advice not to use rain-water for watering livestock	A, SF, TR Duration: TR: May Extent: Regional; TR (Trace Region)	
3. Advice not to use rain-water in the sauna	SF Duration: First 2 weeks of May	
4. Advice to filter rain-water through charcoal filters be-fore drinking	J	
E. MILK AND DAIRY PRODUCTS:		
1. Prohibition on allowing dairy cattle to graze outdoors	A, DK, I, L, NL, TR Duration: Generally 1-2 weeks; TR: 1-4 weeks Extent: Regional TR (Trace Region)	Basis: Deposition levels excessive with regard to potential for milk contamination. TR: Prohibition progressively phased-out; Followed by advice.

RESPONSE	COUNTRY(b)	NOTES
2. Advice to keep dairy cattle from grazing outdoors	B, SF, FRG, GR, S, TR Duration: 1-8 weeks; GR: 3 months Extent: Regional; TR (Trace region)	
3. Restrictions on marketing and consumption of cow milk and dairy dairy products	A, SF, FRG, GR, I, NL, N, S, TR Duration: 1-4 weeks Extent: Regional; N: One dairy closed for one month	I: Prohibition on consumption of fresh milk by children (< 10 years) and pregnant women; Based on precautionary reasons, considering emergency levels for food contamination had been exceeded in Northern Italy. TR: Limited to a few villages on the Bulgarian border. FRG: No milk to infants (1-14 May).
4. Advice to avoid consumption of cow milk and dairy products	A, NL, CH Duration: 2 weeks Extent: Regional	A, NL: Advice not to drink fresh milk directly from farms.
5. Advice to avoid consumption of milk from sheep and goats	A, GR, N, CH, TR Duration: A few weeks Extent: Regional	Basis: Precautionary measure; Higher levels in sheep and goat milk than in cow milk were observed N: In some areas, goat milk used as fodder instead of in cheese production.
6. Restrictions on marketing and consumption of milk from sheep and goats	A, I, NL Duration: A few weeks Extent: Regional	

RESPONSE	COUNTRY(b)	NOTES
7. Advice not to market fresh goat cheese	CH, TR Duration: CH: 3 weeks; TR: 8 weeks Extent: Regional	Basis: Elevated iodine-131 levels in goat milk.
8. Restrictions on marketing and consumption of fresh sheep/goat cheese	N, S Duration: A few weeks Extent: Regional	
9. Prohibition on marketing and consumption of fresh sheep/goat cheese	A, GR, I, NL, TR Duration: GR: 3 months; TR: 1 week; NL: 5 weeks Extent: Regional	Basis: Elevated iodine-131 levels in sheep and goat dairy products.
10. Restrictions on imports of milk and dairy products	Practically all countries Duration: Most Action Levels still valid, although surveillance of imports is minimal or terminated	Basis: Controls on contaminated foods not subject to domestic production and marketing controls.
11. Prohibition on imports of milk/dairy products from Eastern European countries	TR, CEC Member countries Duration: TR: 12-18 May; CEC: 1-12 May	Basis: Uncertainty on actual levels of contamination.

RESPONSE	COUNTRY(b)	NOTES
F. VEGETABLES, FRUIT AND GRAINS:		
1. Advice not to consume fresh leafy vegetables	A, FRG (some States), GR, I, NL, S, CH, TR Duration: Generally a few days to 3 weeks; GR: 3 months Extent: Regional	CH: For children (< 2 years), pregnant women and nursing mothers.
2. Advice to wash fresh vegetables prior to consumption	A, B, DK, FRG, GR, IRL, I, J, L, NL, S, CH, TR Duration: 1-2 weeks Extent: National	
3. Advice to delay planting of early vegetables	SF Duration: Early May Extent: Regional	Delay by 2 weeks. To minimize uptake of radioactivity.
4. Advice on consumption of non-cultivated plants and mushrooms	A, SF, FRG, NL, S Duration: SF: 7-16 May; FRG: May-September Extent: Regional	SF: Such plants and mushrooms should be boiled, and only eaten 1-2 times per week.
5. Restrictions on domestic marketing of fresh leafy vegetables	FRG, NL, S Duration: FRG: 3 weeks Extent: Regional	

RESPONSE	COUNTRY(b)	NOTES
6. Prohibition on domestic marketing of fresh leafy vegetables	A, F, I, L, NL, N Duration: 1-3 weeks Extent: Regional	NL: Destroyed fresh spinach (4-10 May). I: Precautionary measure; Lifted 13 May in Central and Southern regions, 18 May in Northern Italy. F: Spinach in Alsace region. N: Lettuce and parsley in Trondelag.
7. Restrictions on imports of vegetables, fruit and grains	Practically all countries Duration: Most Action Levels still valid, although surveillance of imports is minimal or terminated	Basis: Controls on contaminated foodstuffs not subject to domestic production and marketing controls.
8. Prohibition on imports of vegetables, fruit and grains from Eastern European countries	S, TR, CEC Member countries Duration: S: 30 April-5 May; TR: 12-18 May; CEC: 1-12 May	Basis: Uncertainty on actual levels of contamination.
9. Development of special harvesting methods for crops	S Duration: At least first year Extent: Regional; In areas of highest deposition	Leave a higher than normal stubble, to avoid or minimize contamination resulting from contact with active soil.

RESPONSE	COUNTRY(b)	NOTES
G. MEAT:		
1. Restrictions on domestic marketing of lamb/sheep	A, GR, NL, N, S, CH, UK Duration: GR: 3 months; UK: Ongoing; N: Ongoing Extent: Regional	Initiated in late June, with concern on levels of caesium-137. UK: Based on levels rising above the Action Level of 1000 Bq/kg recommended by the CEC Group of Experts on Article 31 of the Euratom Treaty. N: Meat classified as unfit for human consumption may be disposed of at selected sites, or may be used as animal fodder by fur producers.
2. Prohibitions on domestic marketing of animal thyroids	GR, I, L, NL Duration: A few months Extent: National	Meat packers advised to destroy thyroid glands.
3. Restrictions on domestic marketing of beef/horse meat	A, N Duration: Ongoing Extent: Regional	N: Only meat from animals that had been grazing in cultivated fields for at least 4 weeks, or that had been fed indoors for at least 4 weeks, approved for slaughter (8 September 1986).
4. Advice on domestic marketing of reindeer meat	SF Duration: Ongoing Extent: National	
5. Restrictions on domestic marketing of reindeer meat	N, S Duration: Ongoing; Initiated in June Extent: Regional	Concern on accumulation of caesium-137, and on future harvests.

RESPONSE	COUNTRY(b)	NOTES
6. Advice on consumption of freshwater fish	SF, NL, S Duration: Ongoing Extent: Regional	Advice to limit consumption to 1-2 times per week in areas of highest deposition. Concern on accumulation of caesium-137.
7. Prohibition on marketing of freshwater fish	N, CH Duration: Ongoing Extent: Regional	N: 29 municipalities (4/7/86); 8 additional municipalities (4/8/86). CH: Concerned only Lake Lugano.
8. Advice not to hunt certain game	IRL, NL, E, S Duration: Ongoing; Initiated in June Extent: Regional	Concern over elevated caesium-137 levels in woodcock. E: Advice not to hunt migratory birds.
9. Advice on domestic marketing of game	NL, SF Duration: Ongoing; Initiated in June Extent: National	
10. Restrictions on domestic marketing of game	S Duration: Ongoing Extent: National	Precautionary measure.
11. Restrictions on imports of meat	Practically all countries Duration: Most Action Levels still valid, although frequency of inspection and surveillance greatly reduced	Basis: Controls on contaminated foods not subject to domestic production and marketing controls. Current concern on longer-term accumulation of caesium-137.

RESPONSE	COUNTRY(b)	NOTES
12. Prohibition on imports of meat from Eastern European countries	IS, S, TR, CEC Member Countries Duration: S: 30 April-5 May; TR: 12-18 May; CEC: 1-12 May	Basis: Uncertainty on actual levels of contamination.
H. OTHERS:		
1. Provision of government compensation for agricultural losses	A, SF, FRG, GR, I, NL, N, S, TR, UK	A: Compensation to farmers allocated from Federal Disaster Fund. GR: Compensation for lost sheep and goat cheese production. NL: Compensation to spinach producers. N: Compensation to sheep, beef, dairy and reindeer farmers. S: Compensation to dairy farmers for milk losses and costs of stored feed, and potentially to reindeer owners. TR: Dairy farmers supplied with uncontaminated forage. UK: Compensation to sheep farmers.
2. Advice to take protective measures and special procedures in changing industrial air conditioning/ventilation filters	A, B, SF, FRG, GR, I, L, NL, S, CH Duration: 2-4 weeks	SF: Replace filters earlier than usual. I, CH: Delay cleaning and replacement of filters to let iodine-131 decay. All: Provide protective clothing to workers.

RESPONSE	COUNTRY(b)	NOTES
3. Restrictions/Prohibitions in the use of sewage sludge for soil amendment	A, SF, L, S, CH Duration: 1-3 weeks; A: May-July Extent: Regional	A: Prohibition on spreading sludge on agricultural lands. SF: Avoid application to cropland until August. S: Enacted activity limits. CH: Limit on quantities applied to cropland.
4. Advice not to administer stable iodine	A, CND, SF, F, FRG, GR, L, NL, E, S, CH, TR, US Extent: National	Basis: Avoid unnecessary risk of iodine poisoning. Deemed not necessary for radiological protection purposes.
5. Advice to administer stable iodine	SF Duration: 2 weeks (2-16 May)	Single dose of 200 mg of potassium iodide only if travelling to within 50 km of Chernobyl.

Annex IV

INTERVENTION CRITERIA APPLICABLE TO RESPONSE TO NUCLEAR ACCIDENTS

RADIONUCLIDE / PATHWAY									
Iodine-131 (Bq/L or Bq/kg)					Total Caesium (Caesium-134 and -137) (Bq/L or Bq/kg)				
Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
AUSTRALIA									
						100	100	100	100[a]

a) Cereals, fruit, nuts/seeds, fish.

Basis: Gives approximately 1 mSv/yr to adult males whose entire food intake is at this level, and is also detectable in bulk samples using hand-held monitors.

Application: Screening reference level for consumption and marketing.

Effective: May 1986.

Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
AUSTRIA									
	370[a]	185				185[b]; 300	110[b]; 175	185[b,c]; 300[d]	

a) Value replaced by 185 Bq/L on 21/5/86.
b) For caesium-137 only.
c) Pork and poultry; Applicable value for other types of meat is 370 Bq/kg.
d) Value for pork and poultry; Value of 600 Bq/kg for other meat.

Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
BELGIUM									
	500[a]	1000[b]				370[c]	600[c]	600[c]	

a) Initial value (2-15 May); Was 250 Bq/L from 16-25 May, and 125 Bq/L after 25 May.
b) Initial value (2-15 May); Was 500 Bq/kg from 16-25 May, and 250 Bq/kg after 25 May.
c) CEC Regulation for control of imports/exports (31/5/86).

RADIONUCLIDE / PATHWAY									
Iodine-131 (Bq/L or Bq/kg)					Total Caesium (Caesium-134 and -137) (Bq/L or Bq/kg)				
Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
CANADA									
10	10; 40[a]	70	70	70[b]	50	50; 100[a]	300	300	300[b]

a) Manufactured dairy products (Bq/kg).
b) Fruit (fresh weight).

Basis: Based on daily consumption for one year by an individual, to result in a lifetime risk of 5 per 1 million people for total caesium, and of 1 per 1 million people for iodine-131.

Application: All values are import screening limits.

Effective: May 1986.

DENMARK									
						370	600	600	

Basis: CEC Regulation for control of imports/exports (31/5/86).

FINLAND									
2000[a]	2000					1000[b]		1000[c]	1000[d]

a) For rainwater used for drinking or other household purposes (2/5/86).
b) Beef and pork.
c) Anticipated limit for grains/cereals.

Basis: Values are derived from a lower action limit of 5 mSv, individual effective dose equivalent (50 mSv for thyroid dose equivalent) and from Finnish data on consumption of food; Major foods considered to be milk, pork and grains; Caesium values refer to peak concentrations of caesium-137 only.

Application: Consumption and import limits.

Effective: 2 May for iodine-131 levels; 22 May for caesium-137 levels.

RADIONUCLIDE / PATHWAY

Iodine-131 (Bq/L or Bq/kg)					Total Caesium (Caesium-134 and -137) (Bq/L or Bq/kg)				
Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
FRANCE									
						370	600	600	
FEDERAL REPUBLIC OF GERMANY									
	500	250				370	600	600	
GREECE									
	125[a]	90[b]				370[c]	600[c]	600[c]	
ICELAND									
IRELAND									
						370	600	600	

FRANCE — Basis: CEC Regulation for control of imports/exports (31/5/86).

FEDERAL REPUBLIC OF GERMANY — Basis: Values for iodine-131 derived from postulated dose to thyroid of an infant of 30 mSv; Values for total caesium are from CEC Regulation for control of imports/exports (31/5/86).

GREECE:

a) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 250 Bq/L (kg), which had replaced the 6 May recommendation of 500 Bq/L (kg); Applied to control of imports/exports.
b) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 175 Bq/kg, which had replaced the 6 May recommendation of 350 Bq/kg; Applied to control of imports/exports.
c) CEC Regulation for control of imports/exports (31/5/86); Values are admissable control levels for domestic consumption.

ICELAND — No official derived intervention levels.

IRELAND — Basis: CEC Regulation for control of imports/exports (31/5/86).

RADIONUCLIDE / PATHWAY									
Iodine-131 (Bq/L or Bq/kg)					Total Caesium (Caesium-134 and -137) (Bq/L or Bq/kg)				
Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
ITALY									
	560[a]; 5600[b]	560[a]; 5600[b]	560[a]; 5600[b]			250[c]; 2500[d]; 370[e]	250[c]; 2500[d]; 600[e]	250[c]; 2500[d]; 600[e]	

a) Attention Level, based on activity over a 7-day period; Adopted in 1971.
b) Emergency Level, cited as 10 times the Attention Level for iodine-131 (1971).
c) Attention Level, based on a 1-year period of exposure (1971).
d) Emergency Level, cited as 10 times the Attention Level for total caesium (1971).
e) CEC Regulation for control of imports/exports (31/5/86).

JAPAN									
110	220	7400							

Basis: Values derived using parameters of food consumption, habits and metabolism characteristic of Japanese; Concentrations correspond to 5 mSv thyroid for infant of critical group for each item, totalling 15 mSv with 30 days continous consumption.

LUXEMBOURG									
	500	250				370[a]	600[a]	600[a]	

a) CEC Regulation for control of imports/exports (31/5/86).

NETHERLANDS									
	500[a]	1000[b]				370[c]	600[c]	600[c]	

a) Value replaced by 125 Bq/L on 23/5/86.
b) Value replaced by 250 Bq/kg on 23/5/86.
c) CEC Regulation for control of imports/exports (31/5/86).

NORWAY									
	1000	1000	1000			370[a]	600[a] 6000[b]	600[a];	370[c]

RADIONUCLIDE / PATHWAY									
Iodine-131 (Bq/L or Bq/kg)					Total Caesium (Caesium-134 and -137) (Bq/L or Bq/kg)				
Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other

NORWAY (continued)

a) Replaced the initial value of 300 Bq/L (kg) on 20/6/86.
b) Reindeer and game meat (20/11/86).
c) Infant food (Bq/kg).

PORTUGAL

Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
	125[a]	90[b]		90[b,c]		370[d]	600[d]	600[d]	

a) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 250 Bq/L (kg), which had replaced the 6 May recommendation of 500 Bq/L (kg); Applied to control of imports/exports.
b) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 175 Bq/kg, which had replaced the 6 May recommendation of 350 Bq/kg; Applied to control of imports/exports.
c) Fruit (fresh weight).
d) CEC Regulation for control of imports/exports (31/5/86).

SPAIN

Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
	125[a]	90[b]		90[b,c]		370[d]	600[d]	600[d]	

a) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 250 Bq/L (kg), which had replaced the 6 May recommendation of 500 Bq/L (kg); Applied to control of imports/exports.
b) CEC recommendation of 26 May 1986; Replaced the 16 May recommendation of 175 Bq/kg, which had replaced the 6 May recommendation of 350 Bq/kg; Applied to control of imports/exports.
c) Fruit (fresh weight).
d) CEC Regulation for control of imports/exports (31/5/86).

SWEDEN

Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other
	2000	300; 5000[a]	300			300[b]	300[b]; 10000[a]	300[b]	300[c]; 4000[d]; 20000[e]

a) Import limit, in effect from 2-15 May 1986.
b) Replaced the 2/5/86 value of 1000 Bq/L (kg) on 15/5/86.
c) Marketing limit for game; Level raised to 1500 Bq/kg after first year.

RADIONUCLIDE / PATHWAY									
Iodine-131 (Bq/L or Bq/kg)					Total Caesium (Caesium-134 and -137) (Bq/L or Bq/kg)				
Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other

SWEDEN (continued)

d,e) Activity limits (Bq/kg) for sewage sludge used as soil amendment: d - wet weight
e - dry weight

Basis: Values based on the annual food intake dose not exceeding 5 mSv for the next 2-3 years, and 1 mSv on a long-term basis; Levels to be applied to the most exposed group (young children); Assumed conversion factors between dose to 1-year olds and activity intake: 2×10^{-7} Sv/Bq (iodine-131), and 1×10^{-7} Sv/Bq (caesium-134 and -137); Assumed intake of 0.3 kg/day, yielding on activity limit of 300 Bq/kg (L) for caesium-137; For iodine, since activity concentrations diminish rapidly, an earlier guideline of 2000 Bq/kg (L) was accepted.

SWITZERLAND

Drinking Water (I-131)	Milk/ Dairy Products (I-131)	Vegetables (I-131)	Meat (I-131)	Other (I-131)	Drinking Water (Cs)	Milk/ Dairy Products (Cs)	Vegetables (Cs)	Meat (Cs)	Other (Cs)
						370	600	600	600

Basis/Application: Values represent Notification levels only; Protective measures dependent on dose assessment (8 September 1986).

TURKEY

Drinking Water (I-131)	Milk/ Dairy Products (I-131)	Vegetables (I-131)	Meat (I-131)	Other (I-131)	Drinking Water (Cs)	Milk/ Dairy Products (Cs)	Vegetables (Cs)	Meat (Cs)	Other (Cs)
						370	600	600	

Basis: Values adopted from CEC Regulation (31/5/86), and applied as import/export limits and domestic consumption limits.

UNITED KINGDOM

Drinking Water (I-131)	Milk/ Dairy Products (I-131)	Vegetables (I-131)	Meat (I-131)	Other (I-131)	Drinking Water (Cs)	Milk/ Dairy Products (Cs)	Vegetables (Cs)	Meat (Cs)	Other (Cs)
11000^{a}	$2000^{b,c}$	110000^{b}		160000^{d}	51000^{e}	$3600^{c,f}$; 370^{g}	190000^{f}; 600^{g}	1000^{h}; 600^{g}	280000^{i}

Note: Derived Emergency Reference Level (DERL) values listed for caesium are for caesium-137 only; Separate DERL values exist for caesium-134; Source: NRPB, March 1986, NRPB-DL10.

a) Lower DERL, based on activity over a 2-day period; Value of 3700 Bq/L used for activity over a 7-day period; Based on consideration of the yearly dose limit for individuals, and on avoiding individual thyroid doses of more than 50 mSv.
b) Lower DERL, based on peak concentrations; Suggests controls on food be considered if individual doses are predicted to exceed 5 mSv to the whole body, or 50 mSv to any individual organ.
c) Applicable to fresh milk only.

RADIONUCLIDE / PATHWAY

Iodine-131 (Bq/L or Bq/kg)					Total Caesium (Caesium-134 and -137) (Bq/L or Bq/kg)				
Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other	Drinking Water	Milk/ Dairy Products	Vegetables	Meat	Other

UNITED KINGDOM (continued)

d) Lower DERL, for fruit; Based on peak concentrations; As for b).
e) Lower DERL, based on caesium-137 activity over 2 days; Value of 15 000 Bq/L (caesium-137) used for activity over a 7-day period.
f) Lower DERL, based on peak concentrations; Based on effective dose to infants for caesium-137.
g) CEC Regulation for control of imports/exports (31/5/86).
h) Screening (safety) reference level for marketing and consumption; Consistent with reference level derived by an Expert Group convened under Article 31 of the Euratom Treaty; Viewed as a conservative reference level for food, based on an annual effective dose of 1 mSv.
i) Lower DERL, for fruit; Based on peak concentrations of caesium-137; As for f).

UNITED STATES

I-131 Drinking Water	I-131 Milk/ Dairy Products	I-131 Vegetables	I-131 Meat	I-131 Other	Cs Drinking Water	Cs Milk/ Dairy Products	Cs Vegetables	Cs Meat	Cs Other
1.5[a]	56[b]; 296[c]	56[b]; 296[c]	56[b]; 296[c]	56[b] 296[c]	90[a]	370[d]	370[d]	2780[d]; 370[e]	370[d]

a) US EPA derived level for the Chernobyl accident; Derived from dose of 0.5 mSv, but actual dose received not to exceed 0.1 mSv per day.
b) Level of concern for imported infant food.
c) Level of concern for imported adult food.
d) US Department of Agriculture (USDA) initial value (16 May 1986).
e) USDA value adopted on 24 October 1986.

CEC

I-131 Drinking Water	I-131 Milk/ Dairy Products	I-131 Vegetables	I-131 Meat	I-131 Other	Cs Drinking Water	Cs Milk/ Dairy Products	Cs Vegetables	Cs Meat	Cs Other
	125[a]; 500[b]	90[c]; 2000[b]	2000[b]	90[d]; 2000[b]		370[e]; 1000[b]	600[e]; 1250[b]	600[e]; 1250[b]	370[f]; 1250[b]

a) Recommendation of 26 May 1986; Replaced the 16 May recommendation of 250 Bq/L (kg), which had replaced the 6 May recommendation of 500 Bq/L (kg).
b) CEC Regulation of 22 December 1987; Maximum permitted levels for radioactive contamination of food following a future nuclear accident or any other case of radiological emergency.
c) Recommendation of 26 May 1986; Replaced the 16 May recommendation of 175 Bq/kg, which had replaced the 6 May recommendation of 350 Bq/kg.
d) Fruit; As for c).
e) Regulation of 31 May 1986, for control of imports/exports.
f) Infant food; As for e).

Basis: Aimed at harmonising diverse controls and commerce restrictions amongst the European Community member countries.

The impact of the 1986 Chernobyl accident called attention to the need to improve international harmonisation of the principles and criteria for the protection of the public in the event of a nuclear accident. This report provides observations and guidance related to the harmonisation of radiological protection criteria, and is intended to be of use to national authorities and international organisations examining the issue of emergency response planning and intervention levels.

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