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APPLICATION OF INTERVENTION DOSE LEVELS AND DERIVED INTERVENTION LEVELS IN THE EVENT OF A MAJOR NUCLEAR ACCIDENT: REVIEW OF PRESENT STATUS

At the request of the IAEA Board of Governors, the Secretariat submitted to the Board, in February 1987, a report on intervention dose levels and related matters. In this report, the Secretariat reviewed the present status of the application of intervention dose levels and derived intervention levels in the event of a major nuclear accident. In view of the wide differences which currently exist between countries in their approach to setting levels for the control of potentially contaminated environmental materials and foodstuffs, the Secretariat considers that the information set out in the Attachment may be of interest to Member States wishing to obtain an overview of the development of intervention policy and the approach currently being pursued at the international and intergovernmental level. This information is based on the report submitted by the Secretariat to the Board, together with a summary of the advice and recommendations made by an IAEA Advisory Group which met in February 1987 to review the IAEA's existing guidance in the area of intervention dose levels and derived intervention levels.

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ATTACHMENT

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EMERGENCY RESPONSE PLANNING

1. The Agency's Basic Safety Standards for Radiation Protection (Safety Series No. 9, 1982 Edition), (Ref. 1), which reflect the recommendations of the International Commission on Radiological Protection, prescribe a formal system of dose limitation based on justification of the practice, optimizatio of the protection and compliance with specified dose limits. This is intende to apply whenever the source of radiation exposure is under control. However, the immediate impact of a major nuclear accident might result in a loss of control - albeit only temporarily - and it might no longer be possible to fully apply the principles of the dose limitation system to those workers or members of the general public who are involved. For such accident situations it might only be possible to limit exposure by taking protective actions the nature and timing of which would depend on the prevailing circumstances, including the extent of the potential hazard. Such protective action, termed "intervention", might necessitate decisions in which the risks taken to avoid a particular adverse consequence through protective measures need to be balanced against those that might prevail in the absence of such measures.

2. Formal emergency plans are a necessary prerequisite for ensuring that appropriate and timely protective measures can be implemented so as to prevent or mitigate the adverse effects of an accident. The scope of these plans and the arrangements for their implementation must encompass the spectrum of response action aimed at protecting both nuclear facility staff and the general public. An important prerequisite in emergency planning is the establishment of those intervention dose levels on which any decision to take protective measures during an accident will be based.

3. In addition to the formal emergency plan of the operating organization, those public authorities at the local, regional and national level which may need to respond in the event of an accident must ensure that they produce emergency plans and preparedness arrangements appropriate to their own response commitments. This must be done in consultation and co-ordination with the operating organization. The input from all participating organizations should be integrated into an overall national emergency plan and response infrastructure for ensuring that co-ordinated remedial action can be taken in the unlikely event of an accident involving potential off-site radiological consequences. For purposes of practical implementation, the national plan should include the specification of relevant intervention dose levels and, where appropriate, derived intervention levels.

INTERVENTION LEVELS

4. The decision to take a particular protective measure should be based on a balance of the risks avoided and disadvantages incurred by the individuals affected. Any form of intervention will carry with it risks, difficulties and costs, and these will vary in nature and degree as between protective measures. Nor will a particular protective measure have the same effect in all cases: the weighting of the risks and disadvantages associated with it will be influenced by, inter alia, the type of accident, the specific off-site characteristics, the time of day and the weather conditions. It is not possible, therefore, to set one generally applicable level at which a particular protective measure should always be taken. Moreover, the numerical values of the intervention dose levels adopted in different countries will not necessarily be the same, although, as experience after the accident at Chernobyl has shown, it is desirable that there should be a more uniform approach to their establishment. Even where a particular intervention level value has been adopted nationally, this may not result in the introduction of identical protective measures in different parts of the country. For radiological protection purposes, however, it is possible to define, for each protective measure, a dose level below which that measure would not be warranted and a - higher - dose level at which that measure should almost

certainly be taken. These two levels should be of use to national authorities when setting overall criteria on which to base the taking of protective measures. Nonetheless, judgement will be needed at the time of an accident in deciding whether or not to take a particular protective measure, and this will be influenced by many factors associated with the actual or potential release and the prevailing environmental conditions.

5. Intervention levels are set in terms of dose (sieverts), and in practice the dose which should be compared with the intervention level as the criterion for taking a particular protective measure is the 'projected' dose which would occur if the protective measure were not taken. If the value of this projected dose is such that it might produce serious non-stochastic (i.e. acute) effects on exposed individuals, the protective measure should almost certainly be taken. In general, the principle involved in deciding whether to take a particular measure is that the detriment to health and social life incurred if the measure is taken should be less than that of the radiation dose averted.

6. Because the ultimate responsibility for prescribing intervention levels for particular circumstances rests with competent national authorities, it is not surprising that differences have developed between countries as regards the levels adopted or, where a range rather than a single level has been adopted, the setting of the lower and upper boundary levels. This non-uniformity can give rise to problems, particularly if an accident results in the transport of radioactive material across several national frontiers. Unless neighbouring States have adopted a consistent approach in setting thei intervention dose levels, the transboundary release may cause unnecessary public concern and confusion and result in a loss of confidence in the arrangements made to protect those persons in each State who may be, or may consider themselves to be, potentially at risk. This problem may be aggravated by differences in the values of derived intervention levels, or in the procedures for their determination.

7. Some common ground of understanding in this area was achieved in 1982 with the publication of recommendations by the Commission of the European Communities to its Member States on reference dose levels as guidance for national authorities in setting specific intervention levels for nuclear installations. (Ref. 2) Similar guidance has since been prepared separately by the International Commission on Radiological Protection (ICRP), the World Health Organization (WHO) and the Agency. (Refs. 3,4,5) The Agency's guidance, which was published in 1985, outlines the principles which apply in the setting of intervention dose levels at which measures for the protection of the public should be taken. In general, the published guidance represents an international expert consensus on the principles for establishing intervention levels for protection of the public in the event of a major nuclear accident and should be of particular use to those having responsibility for emergency response planning at the national, regional and nuclear facility level. The guidance given in the Agency's Safety Series No. 72, summarized in Table I of this document, is expressed in terms of dose ranges corresponding to each protective measure. The ranges are sufficiently wide to encompass the different intervention levels which may be adopted in practice, but the possibility of levels outside these ranges cannot be excluded. The protective measures normally available for avoiding or reducing the radiation dose which might be incurred by potentially exposed persons following an accident are shown in Table II.

DERIVED INTERVENTION LEVELS

8. Decision-making in an emergency will be more rapid and effective if the values which correspond to the intervention dose levels are expressed in terms of the levels of radionuclides present in appropriate environmental materials. These levels are termed "derived intervention levels" (DILs) and are the practical expression of the intervention dose level (e.g. uSv h^{-1}, Bq l^{-1}, Bq m^{-3}, Bq S m^{-3}, etc.). Contamination of an environmental material at the derived level is predicted to result in exposure at the intervention dose level. The need for, and extent of, protective measures can be determined by direct comparison of the environmental measurement results with the relevant

derived levels. The relationship between a DIL and the intervention dose level will depend on many parameters. Among the more important are the habits (e.g. diet) of the potentially exposed individuals, the physical and chemical forms of the released material and its metabolism when taken into the body, agricultural practice, and food preparation and processing. The potentially wide variation in many of these parameters makes it impossible to determine universally applicable DILs. However, there may sometimes be sufficient similarity for generic levels to be developed within particular countries and regions. Table III summarizes the more important quantities for which derived intervention levels need to be established.

9. In 1985 the Agency began developing a Safety Series publication giving guidance on the principles for setting derived intervention levels, the environmental pathways and ranges of radionuclides of potential radiological significance, and procedures for evaluation. Because many of the input parameters may be specific to a particular country or region, it was not intended to include specific numerical data. However, the spread of contamination resulting from the Chernobyl accident demonstrated an urgent need for more comprehensive guidance, not only on principles and evaluation procedures, but also on specific radionuclide levels in various environmental materials and foodstuffs at which controls on their use or consumption may need to be implemented. The draft was therefore revised so as to provide a more practical document, and the revised version was published in December 1986 as Safety Series No. 81, "Derived Intervention Levels for Application in Controlling Radiation Doses to the Public in the Event of a Nuclear Accident or Radiological Emergency: Principles, Procedures and Data". (Ref. 6.) Appropriate caveats are included in the text and tables to guide the user with regard to the application and limitations of the numerical values provided.

NEED FOR ADDITIONAL GUIDANCE

10. The guidance published by the various international organizations, including that contained in Safety Series No. 72, is directed primarily towards intervention in the early and intermediate phases of an accident, when

the main concern is avoiding non-stochastic effects and limiting the extent of stochastic risk to individuals. However, even in a major nuclear accident in which large quantities of radioactive material are released into the atmosphere, such effects will be restricted to within relatively short distances, probably not more than a few tens of kilometres, from the release point. Conversely, owing to the dilution and subsequent dispersion of the radioactive material over wide areas, the major part of the collective dose to populations (i.e. the quantity obtained by multiplying the average dose by the number of persons exposed) resulting from an accident will, in general, be accumulated at much greater distances, where the individual dose levels will be substantially below those of concern for non-stochastic effects or for significant individual stochastic risks. At these greater distances, the competent national authorities in the affected countries may still consider it prudent to attempt a further reduction of the individual stochastic risk and of the collective dose detriment for their populations, by means of protective measures such as controls on food supplies and drinking water. As a result of the accident at Chernobyl, with the exception of the immediately affected area within the Soviet Union it was nowhere necessary to take protective measures for the specific purpose of avoiding non-stochastic effects, although in several countries some form of intervention action was taken as a precautionary measure.

11. The action taken by national authorities was extremely varied, ranging from the simple reinforcement of existing environmental monitoring programmes without the adoption of any particular restrictive measures to compulsory restrictions on the trading and use of domestic foodstuffs and on imports. As a result of the confusion which arose from the widely varying reactions, including major differences in the levels at which protective action was initiated, several international organizations (WHO, FAO, CEC, NEA and the Agency) were requested by their governing bodies, inter alia, to review the adequacy of existing guidance on the application of intervention dose levels, to supplement this guidance with numerical values of derived intervention levels (particularly for various foodstuffs and environmental materials) and to seek better international harmonization of the radiation protection

criteria and rationale on which the definitions of intervention levels and th numerical values of derived intervention levels are based. The response of the international organizations, including the Agency, in the matter of intervention levels and derived interventions levels is summarized below.

RESPONSE OF INTERNATIONAL ORGANIZATIONS

IAEA

12. At the IAEA Post-Accident Review Meeting held in August 1986, leading Soviet scientists and engineers presented their account of the sequence of accident events at the Chernobyl plant, the consequences of those events, and the protective measures taken. In response to recommendations made by the Agency's International Nuclear Safety Advisory Group (Ref. 5), which participated in this meeting, provision was made in the Agency's expanded nuclear safety and radiation protection programme for the development by the Agency (in collaboration with such organizations as WHO and FAO) of additional guidance on intervention dose levels and corresponding derived intervention levels appropriate to reducing the stochastic risk and collective dose equivalent, especially at distances beyond the immediate area of accident impact. To this end, an advisory group met in February 1987 to review existing Agency guidance on intervention dose levels as published in Safety Series No. 72 - and recommend where:

(i) revision might be required in relation to the primary intervention levels and their application;

(ii) additional guidance should be provided on limiting the stochastic risk and collective dose equivalent, particularly at long distances from the accident release point; and

(iii) additional guidance should be developed on derived intervention levels.

13. In its review and recommendations, the group took into account the relevant work being carried out by other international organizations with a view to ensuring co-operation and co-ordination.

14. The advisory group concluded that the basic principles for the protection of the public as set out in Safety Series No. 72 remained valid. It recognized, however, that the guidance provided in Safety Series No. 72 had been developed more in the context of intervention within the general vicinity of an accident, rather than for application to an accident having an impact over long distances and on large populations and extending over long periods of time. The advisory group therefore clarified and amplified several parts of the existing guidance and identified other parts in which there was a need to develop and provide further guidance. The main areas of concern addressed by the advisory group were:

the criteria which apply in the implementation of protective measures for reducing the stochastic risk to the individual and for limiting the stochastic health detriment (i.e. the collective dose);

the exclusion of exposures resulting from sources other than the accident itself when determining the need for protective measures;

the need to take into account the special requirements of population groups that may be at particular risk, such as pregnant women and those having exceptionally high dietary intakes of particular foodstuffs which may be contaminated;

the measures that may be necessary for controlling persons who are not exposed in the normal course of their employment, but who may receive exposure due to the accidental contamination of their working environment; and

the criteria, based upon optimization principles, for developing a longer-term, internationally harmonized approach to the trading problems which may arise in the event of any future nuclear accident involving the dispersion of radioactive material in the environment.

15. The advisory group also developed guidance on the application of optimization principles in determining whether protective measures to reduce the collective dose equivalent to the population are warranted. It confirmed, through a series of optimization exercises, that the optimum value of dose[1/] for introducing the protective measures is likely to lie between 1 and 10 mSv from food consumed in any one year and is relatively independent of the accident sequence, the specific radionuclides involved and the size of the population likely to be affected by the protective measure. This supports th guidance given in Safety Series No. 72, which recommends a value of 5 mSv as the level of dose below which the introduction of protective measures would not be warranted.

16. The advisory group considered that, although the publication of Safety Series No. 81 had done much to satisfy the urgent need for guidance at the international level on the principles, application and determination of derived intervention levels, the guidance which it contained had been developed largely in support of Safety Series No. 72. The derived intervention levels given in Safety Series No. 81 had, therefore, been determined mainly in support of protective action decisions at the local or national level. For application to the control of international trade in foodstuffs, additional - broader - considerations would need to be taken into account. Also, derived intervention levels would need to be developed for other exposure pathways, such as contaminated clothing, buildings, roads and land surfaces.

17. A strong recommendation was made by the advisory group that, in translating an intervention dose level into derived limits for regulatory purposes, decision-makers should avoid incorporating pessimistic assumptions which might well lead to substantial departures from basic radiation

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1/ Strictly speaking, the optimum value of the "committed effective dose equivalent".

protection standards and to major inconsistencies in protection practice. In this connection, when derived intervention levels for international food trade are being set, it should be borne in mind that usually only a fraction of the total food basket is imported and that of this imported fraction only a limited amount is likely to come from the contaminated area. Generally, therefore, an intervention dose level will need to be applied only to a few per cent of the total food intake.

18. The guidance and recommendations of the advisory group are to be used as the basis for an Agency technical document (IAEA-TECDOC) due to be issued later in 1987 in support of Safety Series No. 72. A more comprehensive review of this guidance, taking into account any revision of ICRP Publication No. 40 (Ref. 3), is scheduled for early 1988, with a view to publishing a revised edition of Safety Series No. 72 later that year.

19. In all of its activities relating to intervention levels, the Agency is working in close collaboration with a number of other organizations. In particular, it has participated in expert group meetings of WHO, FAO, NEA and CEC in this area, and the work of these organizations is summarized in the following paragraphs.

WHO

20. The prime interest of WHO is with health, and this is reflected in its activities relating to derived intervention levels. WHO held an inter-agency meeting in November 1986 to inform other organizations of its plans in this field, to ensure that those plans were responsive to the real needs and fitted in with the activities of other organizations, and to obtain inter-agency support. WHO has embarked upon the development (particularly in relation to foodstuffs) of radionuclide contamination guideline values below which the introduction of control measures would not be advised. A meeting of experts was held in April 1987, with IAEA participation, to produce a draft document on this subject.

21. Recognizing that it would not be possible to obtain universal consensus on what constituted an "acceptable" health detriment, the expert group drew upon the ICRP optimization principle and developed it for application to post-accident situations. The draft document sets out guidance on how derived intervention levels are arrived at using this methodology and gives simplified "generic derived intervention levels" for two groups of radionuclides (low and high toxicity) and two classes of foodstuffs (low and high cost). The guideline values developed represent levels at which no control measures should be taken. They are aimed at assisting public health decision-makers who are not specialists in radiation protection to exercise responsible judgement. The expert group considered that these guideline values would be of particular use to countries which do not have a nuclear power programme and have therefore not developed expertise in this area. The draft will be reviewed and presented for finalization to a WHO Task Group scheduled to meet in September 1987. The 40th World Health Assembly has called for this work to be completed and presented at the 81st session of the WHO Executive Board, in January 1988.

FAO

22. In this general area, FAO is concerned with promoting and advising on food quality and consumer protection. In December 1986, in response to requests from several FAO Member States for advice on actions which would need to be taken with regard to the radionuclide contamination of foods, particularly those moving in international trade, FAO convened a group entitled "Expert Consultation on Recommended Limits for Radionuclide Contamination of Foods". The group derived "interim international radionuclide action levels for foods" (IRLAFs) - (e.g. for iodine-131, 400 Bq per kg; for caesium-137, 500 Bq per kg in the first year and 100 Bq per kg in subsequent years - and recommended that FAO seek their international acceptance and adoption. It considered that these levels would provide wide margins of safety and could be applied internationally in order to minimize unnecessary interruptions of international trade in food; they would - inter

alia - help to protect the welfare of agricultural and fisheries communities which might otherwise be affected by such interruptions. The development of the FAO IRLAFs is not intended to preclude the use of derived intervention levels in emergency situations or the development of such levels by WHO and other relevant international organizations.

23. The report of the group (Ref. 7) has been distributed to all FAO Member States. Also, it was discussed at the 19th session of the Codex Alimentarius Committee on Food Additives, in March 1987. The Committee recommended consideration of the report by the Codex Alimentarius Commission and, if necessary, the establishment of a special, ad hoc, working group of governmental experts to consider technical details of the report. However, as WHO had still to complete its work on preparing guideline values for derived intervention levels, the report was presented in June 1987 by FAO to the Commission for information only. It is intended that, following the January 1988 session of the WHO Executive Board, an inter-Secretariat group will further consider the question of a joint FAO/WHO approach for making recommendations to the Commission.

NEA

24. NEA has established an Expert Group on Intervention Levels in which the Agency is a participant and which has reviewed the emergency responses and corresponding primary and derived intervention levels adopted in its member countries - particularly in terms of objective radiation protection criteria and in the context of transboundary impacts and prolonged consequences of an accident. The Expert Group has sought to identify the key parameters influencing the decision-making process involved in managing accident situations and has considered the potential for the better harmonization of basic radiation protection criteria, including - if possible - their numerical values. It is exploring the potential for an optimization process designed to permit the development of generic intervention levels. The Expert Group has provided input to the work of WHO on the development of its guideline

values for derived intervention levels, and a draft of the Expert Group's report is expected to be presented to the WHO Task Group in September 1987. A final draft of the report will be considered at a WHO (Regional Office for Europe) meeting on the harmonization of intervention levels, in November 1987. The report is due to be published in January 1988.

CEC

25. Following the Chernobyl accident, levels for protection against iodine 131 were recommended by the Commission early in May 1986. At the end of May, the CEC Council of Ministers agreed on maximum caesium-134 and caesium-137 contamination levels for agricultural produce imported from outside the European Community; it also agreed that the levels to be used for intra Community trade would not be lower. For the future, an Expert Group provided for under Article 31 of the EURATOM Treaty to advise the Commission on radiation protection has proposed, using a simplified food basket and grouping of isotopes, a system of easily applied levels which, in any future accident, could be used as a temporary measure pending detailed examination of the particular situation with a view to determining the need for controls more appropriate to the specific circumstances. On the basis of recommendation made by the Expert Group, the Commission has formulated a proposal for a Council of Ministers regulation laying down a two-stage system of maximum permitted radioactivity levels for foodstuffs, drinking water and animal feedstuffs which can be speedily introduced in the event of abnormal radioactivity levels or of a nuclear accident. Following the introduction of pre-determined interim levels, the Commission, having taken the advice of the Expert Group, would rapidly set replacement levels more appropriate to the specific circumstances, for presentation to Member countries' representatives. The Council of Ministers is expected to take a decision regarding this proposal by 31 October 1987. Until that date, the provisional values previously agreed upon by the Council (e.g. in the case of caesium-(134 + 137), 370 Bq per kg for milk and infant foods and 600 Bq per kg for other foodstuffs) will remain in force.

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TABLE I INTERVENTION LEVELS FOR PROTECTIVE MEASURES IN THE EARLY AND INTERMEDIATE PHASES OF AN ACCIDENT

Early phase

Protective measure	Dose[a] (mSv or mGy)	
	Whole body[b]	Lung[c], thyroid and any single organ preferentially irradiated
Sheltering	5 - 50[d]	50 - 500
Administration of stable iodine		50 - 500[e]
Evacuation	50 - 500	500 - 5000

Intermediate phase

Protective measure	Dose equivalent committed in first year (mSv)	
	Whole body	Individual organs preferentially irradiated
Control of foodstuffs and water	5 - 50[d]	50 - 500
Relocation	50 - 500	Not expected

[a] Dose projected in the short term (typically, the first week).

[b] Where several organs or tissues are irradiated at low levels of dose the effective dose equivalent should also be calculated and compared with the whole body dose.

[c] In the event of high dose alpha irradiation of the lung, the numerical values apply to the product of the relative biological effectiveness (RBE) and the absorbed dose in milligrays. For planning purposes, an RBE of 10 is suggested.

[d] Or effective dose equivalent.

[e] Thyroid only.

Note: Special consideration should also be given to the implications of irradiation of pregnant women and other specially sensitive groups.

TABLE II EXPOSURE PATHWAYS, ACCIDENT PHASES AND PROTECTIVE MEASURES FOR WHICH INTERVENTION LEVELS MAY BE ESTABLISHED

Potential exposure pathway	Accident phase	Protective measure
1. External radiation from facility	*Early*	Sheltering Evacuation Control of access
2. External radiation from plume	*Early*	Sheltering Evacuation Control of access
3. Inhalation of activity in plume	*Early*	Sheltering Administration of stable iodine Evacuation Control of access
4. Contamination of skin and clothes	*Early*	Sheltering Evacuation Decontamination of persons
5. External radiation from ground deposition of activity	*Intermediate*	Evacuation Relocation Decontamination of land and property
	Late	
6. Inhalation of resuspended activity	*Late*	Relocation Decontamination of land and property
7. Ingestion of contaminated food and water	*Late*	Food and water controls

Note: The use of stored animal feed to limit the uptake of radionuclides by domestic animals in the food-chain can be applicable in any of the phases.

TABLE III. USEFUL QUANTITIES FOR DERIVED INTERVENTION LEVELS (DILs)

Derived quantity	Relevant exposure pathways	Relevant protective measure
External gamma dose rate ($Sv \cdot s^{-1}$)	External gamma irradiation from plume and from deposited material	Evacuation, sheltering, relocation
Time integral of radionuclide concentration in air ($Bq \cdot s \cdot m^{-3}$)	Inhalation of plume	Sheltering, evacuation, stable iodine
	External beta irradiation from plume	Sheltering, evacuation
	External beta irradiation from deposition on skin	Sheltering, evacuation
Ground deposits of radionuclides ($Bq \cdot m^{-2}$)	External beta and gamma irradiation from deposited material	Evacuation, relocation
	Inhalation of resuspended material	Evacuation, relocation
Concentration of radionuclides in foodstuffs, pasture or drinking water ($Bq \cdot kg^{-1}$)	Ingestion of foodstuffs or drinking water	Restrictions on production or consumption