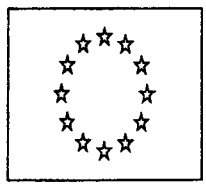

COMMISSION OF THE EUROPEAN COMMUNITIES

Brussels, 23.02.1998
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Communication from the Commission concerning the implementation of Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of the workers and the general public against the dangers arising from ionising radiation

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For the purposes of implementing Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of the workers and the general public against the dangers arising from ionising radiation[1], the Commission, having consulted the group of scientific experts referred to in Article 31 of the Euratom Treaty, wishes to communicate the following information:

I. General Remarks

The purpose of this communication is to assist the Member States in transposing into national law Council Directive 96/29/Euratom of 13 May 1996 laying down basic safety standards for the protection of the health of the workers and the general public against the dangers arising from ionising radiation, hereinafter called the Directive. The Directive repeals, with effect from 13 May 2000, the previously established Basic Safety Standards Directives[2].

It should be regarded as a reference document since Member States are bound only by the provisions of the Directive.

Exposure to ionising radiation can lead to detrimental health effects in human beings. The Directive sets out requirements designed for the protection of workers and the general public against the dangers of ionising radiation without unduly limiting the beneficial uses of the practices giving rise to radiation exposure. The Commission recognises that all those concerned with radiation protection have to make value judgements about the relative importance of different kinds of risks and about the balancing of risks and benefits.

The European Community is required by Article 30 of the Treaty establishing the European Atomic Energy Community to lay down basic standards for the protection of workers and the general public against the dangers of ionising radiation. These standards have been laid down in the form of Council Directives.

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1 OJ No L 159, 29.6.1996, p.1.

2 Notably Directive 80/836/Euratom (OJ No L 246, 17.9.1980, p.1.) as amended by Directive 84/467/Euratom (OJ No L 265, 5.10.1984, p.4.)

Those Directives have always made use of the recommendations of the International Commission on Radiological Protection (ICRP) and the International Commission on Radiation Units and Measurements (ICRU). Those organisations are internationally recognised for their assessments of the state of the art in their respective fields.

The ICRP publication on which the 1996 Directive is based is ICRP Publication N° 60 that contains the latest general recommendations issued by the ICRP to take account of the continuing development in scientific knowledge and administrative experience. This development has been of an evolutionary nature and it did not fundamentally change the system of protection recommended by ICRP Publication N° 26 on which the 1980/1984 Directive was based.

Until 1984 the Basic Safety Standards Directive has been the only instrument of derived legislation based on Article 31 of the Euratom Treaty. Since then, although it remained together with the Euratom Treaty itself, the central element of the European Community radiation protection system, it has been supplemented by a number of specific legal instruments[3].

The Directive does not affect general obligations relating to the protection of those at work as given for example in Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work[4]. In the case of mutually exclusive dispositions the Euratom Directive is given priority over EC Directives[5]

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[3]
- Council Decision 87/600/Euratom of 14 December 1987 on Community arrangements for the early exchange of information in the event of a radiological emergency OJ No L 371, 30.12.1987, p. 76
- Council Regulation (Euratom) No 3954/87 of 22 December 1987 laying down maximum permitted levels of radioactive contamination of foodstuffs and of feedingstuffs following a nuclear accident or any other case of radiological emergency OJ No L 371, 30.12.1987, p. 11. Regulation as amended by Regulation (Euratom) No 2218/89 (OJ No L 211, 22.7.1989, p. 19)
- Council Directive 89/618/Euratom of 27 November 1989 on informing the general public about health protection measures to be applied and steps to be taken in the event of a radiological emergency OJ No L 357, 7.12.1989, p. 31
- Council Directive 90/641/Euratom of 4 December 1990 on the operational protection of outside workers exposed to the risk of ionizing radiation during their activities in controlled areas OJ No L 349, 13.12.1990, p. 21
- Council Directive 92/3/Eurtom of 3 February 1992 on the supervision and control of shipments of radioactive waste between Member States and into and out of the Community OJ No L 35, 12.2.1992, p. 24
- Council Regulation (Euratom) No 1493/93 of 8 June 1993 on shipments of radioactive substances between Member States OJ No L 148, 19.6.1993, p. 1
- Council Directive 97/43/Euratom of 30 June 1997 on health protection of individuals against the dangers of ionizing radiation in relation to medical exposures, and repealing Directive 84/466/Euratom OJ No L 180, 9.7.1997, p. 22

[4] OJ No L 183, 29.6.1989, p.1.

[5] See Article 232 (2) EC Treaty.

One of the major new features of the Directive is the distinction between practices and interventions. Practices relate to those human activities that can increase radiation exposure; interventions are those human activities that prevent or decrease radiation exposure. Other new features are the increased recognition of the fact that some exposures due to work activities involving natural radiation sources are significant enough to warrant attention, the use of dose constraints in optimisation of protection, the concepts of clearance and of potential exposures. The development of scientific knowledge led to new concepts and quantities in dosimetry and radiation protection. It also led to lower dose limits, to redefined values for the application of the requirements on reporting and authorisation of practices and to new parameters for the estimation of doses from external radiation, notably from neutrons, and from intakes of radionuclides.

II. Comments on some Articles of the Directive[6]

a) TITLE I

Definitions

Article 1

The definitions relate to terms used in the Directive. Further definitions are given in Annex II. Where necessary, guidance on their interpretation is given below in the comments on the articles in question:

i) '*Accidental exposure*' is no longer limited to exposures whereby one of the dose limits laid down for exposed workers is exceeded.

ii) '*Emergency exposure*' should not be confused with '*Specially authorised exposures*', an emergency exposure is the exposure of a volunteer actively implementing urgent protective actions (Article 52). A specially authorised exposure is the carefully planned exposure of a category A worker who should be a volunteer for carrying out specific operations in exceptional circumstances (Article 12)

iii) '*Equivalent dose*' and '*Effective dose*'. The Directive uses the protection quantities recommended by ICRP Publication N° 60. They replace the previous quantities "Dose equivalent" and "Effective dose (equivalent)". It is noted that the ICRP recommends that "it is appropriate to treat as additive the weighted quantities used by the ICRP but assessed at different times, despite the use of different values of weighting factors. The ICRP does not recommend that any attempt be made to correct earlier values. It is also appropriate to add values of dose equivalent to equivalent dose and values of effective dose equivalent to effective dose without any adjustment".

iv) The newly introduced concept of '*Health detriment*' includes the probability of fatal cancer, of severe hereditary effects, of non-fatal cancer and the relative length of life lost.

v) *'Qualified expert'*. Advice on basic and additional training for qualified experts is given in Annex I of this communication.

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[6] Articles referred to in this Communication are those of Council Directive 96/29/Euratom of 13 May 1996.

vi) '*Undertaking*'. The obligations set out in Title VI for the protection of exposed workers and related to requirements for working areas are linked to the undertaking who has the legal responsibility for the practice. In a given working area more than one practice can be carried out by various undertakings or employers. In this context it should be noted that the Directive does not affect employers' obligations required by Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work[7].

b) TITLE II

Scope

Article 2

The Directive does not apply to radon in dwellings, for which a Commission Recommendation exists[8] nor to exposures to natural radiation sources essentially not controllable.

c) TITLE III

Reporting and authorisation of practices

Article 3

Reporting means the submission of a document to notify or inform the competent authorities of the intention to undertake a practice. Article 3(2) and Annex I specify the circumstances under which competent authorities may decide that reporting is not required. Member States are allowed to deviate from the values in Table A of Annex I, in exceptional circumstances and subject to specified conditions.

Article 4

Prior authorisation is the permission granted by the competent authority in individual written notification or in a legislative act that is individual in character, to carry out a practice. It implies the prior examination by the competent authorities of individual submitted cases.

Member States need not require such prior authorisation in the case of certain practices, exempted from the requirement to report as stated in Article 3(2) and in Article 4(3)(a), and in the case of practices, permitted according to conditions laid down in national legislation, where examination of individual cases is not considered necessary as a result of limited risk of exposure of human beings as stated in Article 4(3)(b). In compliance with Article 3(1) such latter practices are reported to the competent authorities.

Authorisation is needed under any circumstances for the practices referred to in Article 4(1)(b) and in Article 4(1)(d)

Article 6(5) identifies practices which are not permitted under any circumstances.

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[7] OJ N°L 183, 29.6.1989 p1

[8] Commission Recommendation (90/143/Euratom) of 21 February 1990 on the protection of the public against indoor exposure to radon (OJ No L 80, 27.3.1990, p.26.).

Article 5

This Article deals with the disposal, recycling or reuse of radioactive substances or materials.

The disposal, recycling or reuse of materials containing radioactive substances which have been involved in practices subject to reporting or prior authorisation is subject to prior authorisation. Such materials may nevertheless be released from the requirements of the Directive subject to compliance with clearance levels established by national competent authorities. Such clearance levels shall be established following the basic criteria in Annex I. They may be generic or be established in individual cases. The term 'clearance' refers to material previously subject to regulatory control as part of the operations that gave rise to this disposal, recycling or reuse. On the other hand exemption from reporting according to Article 3(2) refers to material which does not need to become subject to regulatory control.

Article 3(2)(f) ensures that human activities involving materials contaminated as a result of authorised releases need not be reported.

In view of the internal market, a harmonised approach to the development of clearance levels is highly desirable. The Commission will therefore give technical guidance for national competent authorities on the establishment of clearance levels. The Commission, with the support of the group of scientific experts referred to in Article 31 of the Euratom Treaty, is working on a revised version of the technical guide (1988) on clearance levels for the recycling of material coming from the decommissioning of nuclear installations[9]. Other technical guides will follow.

d) TITLE IV

Justification, optimisation and dose limitation for practices

Article 6

This Article sets out the basic principles of radiation protection and thus requires Member States to base their procedures on these principles, namely justification, optimisation and dose limitation.

Determination of the justification of any new classes or types of practice is the duty of the Member State. It should take place before the introduction of the class or type of practice and as early as possible to reduce the influence of the already incurred costs in balancing economic and social factors against health detriment. Compliance with this principle can be safely assumed in respect of a new class or type of practice by the existence or laying down of regulations specifically concerning the class or type of practice. Paragraph 5 gives a list of practices considered a priori as not justifiable under any circumstances. The newly introduced proviso of Article 6 (2) reflects that there might be the need to review the justification of existing classes or types of practices. If an existing practice should be considered unjustified a transitional period could still be tolerated on the basis of a carefully weighted balance between economic, social or other benefits and the health detriment.

[9] Radiation protection No 43: Radiological protection criteria for the recycling of materials from the dismantling of nuclear installations, Luxembourg 1988.

Optimisation requires that exposures from practices shall be kept as low as reasonably achievable below the prescribed limits, economic and social factors being taken into account. The techniques for judging the need for further reductions in exposure in the light of what is reasonable are very diverse. They include formal aids to decision-making such as cost benefit analyses, but they are more usually based on professional judgement . The principle should be applied from the design stage, throughout all other stages to eventual decommissioning or disposal of sources.

The third principle requires that the sum of the doses to an individual from all relevant practices shall not exceed specified dose limits. The considerations which led to the establishment of the dose limits are presented in ICRP Publication N° 60. The dose limits are intended to protect the most highly exposed individuals which, in the case of members of the public, are defined as the *"reference group of the population"* (Article 1).

Article 7

The concept of dose constraint has been introduced in ICRP Publication 60 within the context of optimisation of protection. Dose constraints should not be confused with dose limits. They are essentially a ceiling to the predicted values of individual doses from a source, practice or task which could be determined to be acceptable in the process of optimisation of protection for that source, practice or task.

Dose constraints may be established and used by undertakings as a help for optimising protection in the design or in the planning stage. They may also be established by authorities, particularly in the context of public exposure. They may be matters for discussions between undertakings and authorities.

A guide on the utilisation of the newly introduced concept is given in a report[10] by a joint group of experts from the OECD Nuclear Energy Agency and from the European Commission, published by the OECD in 1996.

Article 9

The Directive has decreased the effective dose limit for exposed workers from 50 mSv in a year to 100 mSv in a consecutive five-year-period, subject to a maximum effective dose of 50 mSv in any single year.

While respecting the limit of 100 mSv in a consecutive five-year period Member States are entitled to decide instead an annual amount. In this case the effective dose limit would be 20 mSv in a year. Member States which wish to adopt stricter dose limits shall comply with Article 54.

The equivalent dose limits for the lens of the eye, the skin, the hands, forearms, feet and ankles remain unchanged. Their purpose is to protect against deterministic effects, for which scientific information indicates no need for change. However, the limit for the skin now applies to the dose averaged over any 1 cm^2 of skin, regardless of the area exposed. Compliance with the effective dose limit alone is not always sufficient to prevent the occurrence of deterministic effects on some organs or tissues. It is therefore necessary to ensure compliance with both the effective dose limit and the quivalent dose limits.

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[10] Considerations on the Concept of Dose constraint, Paris 1996.

Article 10

Article 10 aims at protecting the suckling child or the child to be born, via the working conditions of the nursing or the pregnant woman.

Article 22 (1) (b) identifies the additional information that women should be given.

Article 12

Specially authorised exposures replace the planned special exposures from Directive 80/836/Euratom. Experience on the application of planned special exposure under the terms of the 1980 Directive has shown that they have been applied very seldom if at all. A specially authorised exposure would involve an exposure above one of the dose limits for exposed workers established by national legislation in compliance with Article 9.

The Directive requires maximum exposure levels resulting from specially authorised exposures to be defined for each particular case by the competent authorities. No ceiling is given for such levels as it might be interpreted as a generally tolerable value.

Article 12 (2) should be read in conjunction with Articles 35 and 36 on the special surveillance of exposed workers.

Article 13

The Directive has decreased the effective dose limit for members of the public from 5 mSv to 1 mSv in a year; in special circumstances, a higher effective dose may be authorised in a single year, provided that the average over five consecutive years does not exceed 1 mSv per year.

The equivalent dose limits for the lens of the eye and for the skin are unchanged. Their purpose is to protect against deterministic effects, for which scientific information indicates no need for change. However, the limit for the skin now applies to the dose averaged over any 1 cm^2 of skin, regardless of the area exposed. Equivalent dose limits for the hands, forearms, feet and ankles are no longer seen as necessary. Compliance with the effective dose limit alone is not always sufficient to prevent the occurrence of deterministic effects on some organs or tissues. It is therefore necessary to ensure compliance with both the effective dose limit and the quivalent dose limits.

The dose limits apply to the sum of the doses to members of the public due to exposure to all relevant sources received in one year, through all exposure pathways.

Article 14

This Article requires optimisation of protection to be made not only with respect to individuals but also to the population as a whole.

The second paragraph requires regular assessments of the total of contributions to the exposure of the population from practices. The objective is to enable competent authorities and undertakings to identify trends in the pattern of exposures in particular where actions to reduce doses might be warranted. See also Article 45.

e) TITLE V

Estimation of effective dose

Articles 15 and 16

This Title refers to the values and relationships given in Annex II and the dose coefficients given in Annex III to be used for the estimation of effective and equivalent doses. The information contained in these annexes and the additional tables annexed to this Communication are taken from the most recent relevant work of ICRU and ICRP and reflect the current status of scientific knowledge. While competent authorities may authorise the use of equivalent methods (Article 15), it is recommended that these be kept in line with internationally recognised scientific guidance.

With regard to the estimation of effective dose for internal exposure, Annex III gives dose coefficients for different chemical and physical forms that have been considered for the listed radionuclides and corresponding parameter values. If specific information is not available, the indicated default parameters may be used. On the other hand, whenever information is available which permits a better estimation of the parameter values and corresponding dose coefficients, competent authorities may authorise the use of such information to calculate effective dose to workers and to members of the public.

In the above context, the last paragraph of Part B of Annex III relates to the choice of parameter values for inhalation dose coefficients for members of the public. The international scientific guidance referred to is now identified in Table 1 in Annex II of this communication.

In the first paragraph of Part B of Annex III it is stated that dose coefficients for members of the public also relate to apprentices and students aged between sixteen and eighteen years. While this makes allowance for the age dependence of dose coefficients, in some circumstances it may be useful to look into whether the default parameters used for members of the public are suitable for the physical and chemical forms in which radionuclides occur in the workplace. Article 15 allows Member States to authorise the use of dose coefficients for workers whenever these are more appropriate.

f) TITLE VI

Fundamental principles governing operational protection of exposed workers, apprentices and students for practice

Article 17

Consistent with Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work[11], Article 17(a) requires a prior evaluation of the radiological risk to exposed workers. This should be seen as the first step in identifying the protection measures required including the classification of workplaces and workers.

[11] OJ No L 183, 29.6.1989, p.1.

Article 17(b), dealing with classification of workplaces into different areas, introduces the concept of potential exposure, as defined in Article 1. An example of potential exposures is that resulting from the failure of the operation of an interlock preventing access to the beam of an irradiation facility. Any exposure resulting from such an event would be considered as accidental. Exposures that may result from events having a relatively high probability of occurrence, and contributing only small increments to the doses inherent in the normal working conditions, can be considered as resulting from the normal working conditions. An example of such exposures are those resulting from the spillage of a radiopharmaceutical in a nuclear medicine laboratory.

Article 18-20

These articles give the requirements to implement Article 17. Article 18 (2) requires a distinction to be made between controlled and supervised areas. This distinction is primarily a management matter. It aims at facilitating the practical organisation of radiation protection commensurate with the radiological risk. It also draws the attention of the workers to the particular conditions of the workplace and makes them aware of their responsibilities as regards radiation protection.

Controlled areas should be established where workers are required to follow rules specially related to radiological protection rather than simply on the basis of a defined fraction of the dose limit. Special rules are required based on considerations of radiological risk, including expected dose to workers, possible spread of contamination and potential exposures.

The Directive does not require a controlled area to be surrounded by a supervised area, neither does it require that supervised areas only exist at the border of controlled areas.

Article 21

The classification of exposed workers in Category A and Category B workers is maintained. It is intended to simplify working arrangements and to ensure that workers are aware both of their own status and of the likely conditions in their place of work. It also contributes to ensure that radiation protection arrangements for workers are appropriate to the risks linked with their work and working conditions.

Article 28

The Directive requires a record of the results of the individual monitoring to be retained only for category A workers. Member States, however, are free to require such records to be kept for other persons who are individually monitored.

The individual dose record shall contain the estimated or measured doses separated into:

- those received routinely (Article 25),
- those received as specially authorised exposures (Article 12),
- those due to accidents (Article 26),

- those received as emergency exposures (Article 27) and, ,

- those received from natural radiation sources in a work activity declared to be of concern (Article 41), when decided by Member States.

The individual dose record shall also contain reports relating to the circumstances of an accident or emergency exposure and actions taken (Article 28(2)(b)).

A separate medical record shall be opened for each Category A worker as specified by Article 34.

Article 29

Article 29(2) requires Member States to determine the arrangements for conveying the results of individual monitoring following their national regulations concerning confidentiality and privacy.

Articles 31-37

One of the aims of medical surveillance of category A workers is to ensure that they are and continue to be medically fit for their duties. The approved medical practitioner conducting the surveillance must therefore have relevant information about these duties and the conditions in which they are carried out.

The nature of the periodic reviews shall depend on the type of work that is undertaken and the state of health of the worker.

For example special consideration may be needed in situations:

- where workers are required to use respiratory protective equipment,

- where workers with skin diseases or skin damage are required to handle radioactive substances which are not in the form of sealed sources,

- where workers are known to have psychological disorders.

g) TITLE VII

Significant increase in exposure due to natural radiation sources

Articles 40-42

In some cases, the exposures of workers and members of the public to natural radiation sources due to work activities are sufficiently high to warrant the introduction of radiation protection measures to monitor, control and reduce them . Examples are radon exposures in identified working places and exposures due to work with large amounts of materials with activity concentrations significantly above the normal levels of natural radionuclides in the earth's crust. Materials with elevated activity concentrations might include phosphate rock, rare earth materials, scales and residues from oil and gas industries. The potential to apply protection measures regarding these exposures may vary considerably depending for example on working conditions and within and between Member States, therefore the Directive leaves significant discretion to the Member States as regards actions to be taken.

The Directive sets up a four step system to deal with exposures due to natural radiation sources:

i) the use of surveys or other appropriate means to identify work activities which may lead to a significant increase in the exposure of workers or members of the public;

ii) the setting-up of appropriate means for monitoring exposures, and the evaluation of the related doses in identified workplaces;

iii) the implementation, as necessary of corrective measures to reduce exposure , and

iv) the total or partial application, as necessary, of radiation protection measures for practices (Title III, IV, V, VI and VIII).

Advice on the implementation of Title VII of the Directive concerning significant increase in exposure due to natural radiation sources, prepared with the support of the group of scientific experts referred to in Article 31 of the Euratom Treaty[12] has been issued by the Commission.

The advice covers protection of air crew.

i) TITLE IX

Intervention

Articles 48-53

A clear distinction between practices and interventions is one of the main modifications introduced by the Directive. Therefore, Title IX includes a section on the various phases for intervention in cases of a radiological emergency:

- preventive consideration of possible radiological emergency;
- preventive preparation of the intervention;
- implementation of the intervention, should an emergency occur.

Article 48(2) sets out the radiation protection principles for interventions. It makes clear that dose limits do not apply to interventions; however, they should normally be appropriate for workers involved in interventions. Intervention levels established by the competent authorities constitute indications as to the situations in which intervention would be appropriate.

Mainly following the Chernobyl accident a number of measures in relation to possible radiological emergencies have been adopted by the Community:

[12] Radiation Protection No 88: Recommendations for the implementation of Title VII of the European Basic Safety Standards Directive (BSS) Concerning significant Increase in Exposure due to Natural Radiation Sources, Luxembourg 1997.

- Regulations laying down maximum permitted levels of radioactive contamination of foodstuffs and feedingstuffs following a nuclear accident or any other case of radiological emergency, including a Council Regulation on the special conditions for exporting foodstuffs and feedingstuffs following a nuclear accident or any other case of radiological emergency[13];

- Council Decision on Community arrangements for the early exchange of information in the event of a radiological emergency[14];

- Council Directive on informing the general public about the health protection measures to be applied and steps to be taken in the event of a radiological emergency[15].

Following Council Conclusions of 27 November 1989 experts from the Member States meet regularly on issues of cooperation between Member States in the event of a radiological emergency.

The Commission, with the support of the Group of Experts Referred to in Article 31 of the Euratom Treaty, issued guidance on the radiological protection principles for relocation and return of people in the event of accidental releases of radioactive material[16] and on the radiological protection principles for emergency countermeasures to protect the public in the event of accidental releases of radioactive material[17].

Title IX also emphasises the importance, of international cooperation to ensure protection of the population concerned in the event of radiological emergencies and sets requirements on the Member States. These measures complement the obligations stemming from two international conventions adopted in 1986 which deal respectively with the early notification of a nuclear accident and mutual assistance in the event of a nuclear accident. The two conventions have been signed by all Member States[18].

Article 49 deals with potential exposures. The concept is to be used essentially in the preventive phase.

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13 Council Regulation (Euratom) No 3954/87 (OJ No L 371, 30.12.1987, p.1), as amended by Council Regulation (Euratom) No 2218/89 (OJ No L 211, 22.7.1989,p.1), Commission Regulation (Euratom) No 944/89 (OJ No L 101, 13.4.1989, p.17), Council Regulation (EEC) No 2219/89 (OJ No L 211, 22.7.1989, p.4), Commission Regulation (Euratom) 770/90 (OJ No L 83, 30.3.1990, p.78).

14 OJ No L 371, 30.12.1987, p;76.

15 OJ No L 357, 7.12.1989, p.31. See also Commission Communication on the implementation of Council Directive 89/619/Euratom of 27 November 1989 on informing the general public about health protection measures to be applied and steps to be taken in the event of a radiological emergency (OJ No C 103 of 19.4.1991, p.12).

16 Radiation Protection No 64: Radiological Protection Principles for Relocation and Return of People in the Event of Accidental Releases of Radioactive Material, Luxembourg 1993.

17 Radiation Protection No 87: Radiological Protection Principles for Emergency Countermeasures to Protect the Public in the Event of Accidental Releases of Radioactive Material, Luxembourg 1997.

18 With the exception of Luxembourg which did not sign, nor ratify the Convention on Mutual Assistance.

Article 53 deals with lasting exposure situations resulting from the after-effects of a radiological emergency or a past practice.

j) TITLE X

Final provisions

Article 54

Under Article 33 (3) of the Euratom Treaty, the Member States are required to communicate to the Commission any draft legislative, regulatory and administrative provision intended to ensure compliance with the basic safety standards[19].

As a result of Article 54 of the Directive, in the case a Member State is to adopt stricter dose limits, it has also to inform the other Member States. The Commission would normally be notified under Article 33 of the Treaty.

Annexes to the Directive

Annex I to the Directive

The exemption levels , which apply to practices, are worked out using scenarios, pathways and formulae presented in a report published by the Commission[20].

Annex II to the Directive

The values and relationships given in Annex II for external radiations are those required for the protection quantities defined by the International Commission on Radiological Protection in Publication 60 and the International Commission on Radiation Units and Measurement in Report 51.

During the preparation of the Directive some small changes were introduced by the ICRP in the composition of some tissues and organs used to work out the effective dose, in particular as regards the colon and the remainder tissues and organs*. Competent authorities may authorise the use of the updated ICRP guidance, as an equivalent method under the terms of Article 15.

The dose limits given in the Directive are expressed in terms of effective dose and equivalent dose. The need for measurable quantities that can be related to these protection quantities has led to the development of the operational quantities. The operational quantities for area monitoring are ambient dose equivalent and directional dose equivalent. The operational quantity for use in individual monitoring is the personal dose equivalent at a specified depth.

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[19] See Commission Recommendation of 26 July 1991 on the application of the third and fourth paragraphs of Article 33 of the Euratom Treaty (OJ No L 238 of 27.8.1991, p.31).

[20] Radiation Protection No 65: Principles and Methods for Establishing concentrations and Quantities (Exemption Values) Below which Reporting is not Required in the European Directive, Luxembourg 1993.

* ICRP Publication No 67 Age dependent doses to members of the public for intake of radionuclides: Part 2. Annuals of the ICRP Volume 23. Part 3-4.

The requirements on doses in the Directive apply to the sum of the relevant doses from external and internal radiation exposure. In the case of internal exposure, the calculation is based on the use of dose coefficients which are the committed effective doses per unit intake of the relevant radionuclide. Tables in Annex III give the appropriate dose coefficients for workers and members of the public. These are based on parameters that generally apply. The Directive permits competent authorities to use other methods that are equivalent. For example where information is available on the actual chemical, physical or biological behaviour of a particular form of radionuclide the competent authorities may authorise the use of specially derived dose coefficients.

Annual Limits of Intake (ALI) are no longer used in the Directive. If required, they can be derived from the dose coefficients and the relevant dose limits.

Dose coefficients of Annex III are taken from ICRP Publication 68 (for workers) and ICRP Publication 72 (for members of the public).

Inhalation dose coefficients for workers are given both for 1 micrometer Activity Median Aerodynamic Diameter (AMAD) and for 5 micrometers AMAD. The advice from ICRP is that the default value for the AMAD is 5 micrometers and this should be used in the absence of specific information. Inhalation dose coefficients for members of the public are based on 1 micrometer AMAD. For inhalation by workers, materials categorised as lung absorption classes D, W and Y (days, weeks and years respectively, indications of the residence time) in ICRP Publication 30 were assigned to lung absorption types F, M and S (fast, moderate and slow) in the model of ICRP Publication 66.

Three tables, relevant for the estimation of doses from intakes or from exposure to inert gases are given in Annex II to this Communication.

Table 1 indicates the relevant ICRP publications for the source of information on lung absorption types and biokinetics models for systematic activity used to calculate the coefficients in Table B of Annex III of the Directive. For a number of elements, lung absorption type G has also been retained, which refers to their occurrence in specific chemical forms as soluble or reactive gases and vapours. The corresponding dose coefficients for soluble or reative gases and vapours for the different age classes are given in Table 2. The values for adults are appropriate for both workers and members of the public and thus the table complements the list of chemical forms for which dose coefficients for workers are given in Table (C.2) of Annex III of the Directive.

Table 3 gives effective doses for exposure of adults to inert gases. For most nuclides, internal exposure resulting from gases absorbed in body tissues or contained in the lungs is negligible compared to external exposure of skin and other organs when a person is submerged in a radioactive gas. Hence the dose coefficients, which apply to workers and members of the public, are expressed per unit integrated air concentration. Doses from the exposure to radon (i.e. radon-222) and thoron (i.e. radon-220) arise principally from the inhalation of their short-lived progeny, the data for which are given in paragraph C of Annex III of the Directive. Data for the parent radionuclides (radon and thoron) have therefore not been included in Table 3.

Attachments: Annex I and Annex II

ANNEX I

BASIC AND ADDITIONAL TRAINING FOR QUALIFIED EXPERTS

1. INTRODUCTION

The purpose of this annex is to provide advice on the training and experience of the "qualified expert" as defined in Article 1 of the Directive and referred to in Articles 12, 19, 20, 23, 38 and 47.

Surveys carried out by the Commission indicate a wide diversity in the current approaches of Member States to the training and qualifications necessary for recognition as a qualified expert.

It is therefore concluded that it is not possible to give an agreed set of harmonised requirements for such experts. An alternative approach, adopted in this annex, is to propose a basic syllabus the content of which all qualified experts should have received. Previous qualifications and training may already have covered part or all of this syllabus.

The depth of coverage of this syllabus should depend on the level and complexity of advice required from the qualified expert, which is generally linked to their level of involvement. It is therefore proposed that certain items should be covered in more detail for specific applications. Additional topics have also been identified which are recommended for five specific areas, i.e. nuclear installations, general industry, research and training, medical application, accelerators.

Training by itself is not sufficient. It needs to be supplemented by appropriate practical experience, the duration of which will depend on the complexity of the field of work. It is not possible to recommend any specific duration for either the training or the practical experience needed, as the surveys indicate a wide diversity of current practice in Member States.

2. BASIC SYLLABUS FOR THE QUALIFIED EXPERT IN RADIATION PROTECTION

The depth to which topics of the syllabus should be covered should depend on the level of advice/input required from the qualified expert.

BASIC ATOMIC AND NUCLEAR PHYSICS

BASIC BIOLOGY

INTERACTION OF RADIATION WITH MATTER

BIOLOGICAL EFFECTS OF RADIATION

DETECTION AND MEASUREMENT METHODS
(including uncertainties and limits of detection)

QUANTITIES AND UNITS (including dosimetry underlying regulatory quantities)

BASIS OF RADIATION PROTECTION STANDARDS
(e.g. epidemiology, linear hypothesis for stochastic effects, deterministic effects)

ICRP PRINCIPLES:

- Justification

- Optimisation

- Dose limitation

PRACTICES AND INTERVENTIONS (including natural radiation especially radon)

LEGAL AND REGULATORY BASIS:

- International recommendations/conventions

- European Union legislation

- National legislation and regulations (including competent authorities)

OPERATIONAL RADIATION PROTECTION:

- Types of sources (sealed, unsealed sources, X-ray units and accelerators)
- Hazard and risk assessment (including environmental impact)
- Minimisation of risk
- Control of releases
- Monitoring
  - area monitoring
  - personal dosimetry (external, real time and internal)
  - biological monitoring
- Critical group concept/dose calculation for critical group
- Ergonomics (e.g. user friendly design and layout of instrumentation)
- Operating rules and contingency planning
- Emergency procedures
- Remedial action/decontamination
- Analysis of past incidents including experience feedback

ORGANISATION OF RADIATION PROTECTION:

- Role of qualified experts
- Safety culture (importance of human behaviour)
- Communication skills (skills and ability to instil safety culture into others)
- Record keeping (sources, doses, unusual occurrences...)
- Permits to work and other authorisations
- Designation of areas and classification of workers
- Quality control/auditing
- Dealing with contractors

WASTE MANAGEMENT

- Principles of management

- Principles of disposal

TRANSPORT

PRACTICAL WORK/EXERCISES
(e.g. monitoring, laboratory techniques, handling of emergencies...)

3. ADDITIONAL MATERIAL

The coverage of certain items, selected as appropriate from the following list, should be expanded to a greater depth according to the specific needs:

SAFETY CULTURE

OPTIMISATION TECHNIQUES

HEALTH PHYSICS INSTRUMENTATION

- instrument calibration and testing

- limitations of instruments and techniques

EXTERNAL DOSIMETRY

INTERNAL DOSIMETRY
(including dosimetry for specific radionuclides, complex molecules...)

MONITORING OF THE WORK PLACE

SPECIAL DECONTAMINATION PROBLEMS

CONTAINMENT/FILTRATION

SPECIFIC PHYSIOLOGY OF INHALATION AND INGESTION

PROTECTIVE MEASURES AGAINST INCORPORATION

AREA DESIGNATION AND CONTROL

DESIGN AND SHIELDING CALCULATIONS

ENVIRONMENTAL MONITORING
(critical group and environmental impact of discharges)

POTENTIAL ACCIDENTS

EMERGENCY PROCEDURES AND INTERVENTION

WASTE MANAGEMENT

DECOMMISSIONING

TRANSPORT

4. ADDITIONAL TOPICS RECOMMENDED FOR SPECIFIC AREAS

4.1. NUCLEAR INSTALLATIONS (including research installations)

Basic additional training:

- fission and fusion process and products

- reactor engineering

- neutrons (properties; detection)

- criticality

- handling spent fuel

Additional training specific to fuel fabrication:

- toxicity of and associated measurement problems for high Z elements

Additional training specific to fuel processing and waste management:

- chemistry of the process

- remote handling

- fuel storage and waste management special problems

4.2. GENERAL INDUSTRY

a. use of sealed sources

- specific problems of:

  - controlling access, particularly in remote locations
  - transport (e.g. site radiography, mobile sources)
  - inadvertent exposure of non-radiation workers
  - safety culture (e.g. proper handling)

- potential hazards of specific sealed sources
- practical examples of accidents/misuses that have occurred

b. use of unsealed sources

- hazards of isotopes production and use (including inadvertent use)
- special waste management aspects (including airborne and liquid discharges)
- specific hazards associated with natural radiation

4.3. RESEARCH AND TRAINING

- potential hazards encountered by researchers and teachers
- design of experiments (understanding of)
- accelerators (special problems for research/training environment)
- special problems with X-rays (e.g. crystallography)
- hazards of isotopes production and use (including inadvertent use)

4.4. MEDICAL APPLICATIONS

- types and uses of different diagnostic and therapeutic procedures and equipments
- awareness of the patient protection, in particular relevant European Union legislation on radiation protection in relation to medical exposures, including requirements on potential exposures and equipment.
- specific problems of exposure control
  - staff
  - visitors/public
- hospital waste management
- design of special facilities (e.g.: rooms for special purposes)

4.5. ACCELERATORS

- special problems of radiation detection/measurement (response of instruments)
- control of access
- special design and shielding problems for accelerators

Table 1: Lung Absorption Types[21] used for the Calculation of Inhalation Dose Coefficients for Members of the Public Exposed to Particulate Aerosols or to Gases and Vapours

Element	Absorption Type(s)	ICRP Publication N° for details of Biokinetic Model and Absorption Type(s)
Hydrogen	F, M*, S, G	Publications 56, 67 and 71
Beryllium	M, S	Publication 30, Part 3
Carbon	F, M*, S, G	Publications 56, 67 and 71
Fluorine	F, M, S	Publication 30, Part 2
Sodium	F	Publication 30, Part 2
Magnesium	F, M	Publication 30, Part 3
Aluminium	F, M	Publication 30, Part 3
Silicon	F, M, S	Publication 30, Part 3
Phosphorus	F, M	Publication 30, Part 1
Sulphur	F, M*, S, G	Publications 67 and 71
Chlorine	F, M	Publication 30, Part 2
Potassium	F	Publication 30, Part 2
Calcium	F, M, S	Publication 71
Scandium	S	Publication 30, Part 3
Titanium	F, M, S	Publication 30, Part 3
Vanadium	F, M	Publication 30, Part 3
Chromium	F, M, S	Publication 30, Part 2
Manganese	F, M	Publication 30, Part 1
Iron	F, M*, S	Publications 69 and 71
Cobalt	F, M*, S	Publications 67 and 71
Nickel	F, M*, S, G	Publications 67 and 71
Copper	F, M, S	Publication 30, Part 2
Zinc	F, M*, S	Publications 67 and 71

[21] Particulates: Fast, Moderate, Slow (F, M, S), Gases and Vapours (G).

* Recommended default absorption Type for particulate aerosol when no specific information is available (see ICRP Publication N° 71).

Element	Absorption Type(s)	ICRP Publication N° for details of Biokinetic Model and Absorption Type(s)
Gallium	F, M	Publication 30, Part 3
Germanium	F, M	Publication 30, Part 3
Arsenic	M	Publication 30, Part 3
Selenium	F*, M, S	Publications 69 and 71
Bromine	F, M	Publication 30, Part 2
Rubidium	F	Publication 30, Part 2
Strontium	F, M*, S	Publications 67 and 71
Yttrium	M, S	Publication 30, Part 2
Zirconium	F, M*, S	Publications 56, 67 and 71
Niobium	F, M*, S	Publications 56, 67 and 71
Molybdenum	F, M*, S	Publications 67 and 71
Technetium	F, M*, S	Publications 67 and 71
Ruthenium	F, M*, S, G	Publications 56, 67 and 71
Rhodium	F, M, S	Publication 30, Part 2
Palladium	F, M, S	Publication 30, Part 3
Silver	F, M*, S	Publications 67 and 71
Cadmium	F, M, S	Publication 30, Part 2
Indium	F, M	Publication 30, Part 2
Tin	F, M	Publication 30, Part 3
Antimony	F, M*, S	Publications 69 and 71
Tellurium	F, M*, S, G	Publications 67 and 71
Iodine	F*, M, S, G	Publications 56, 67 and 71
Caesium	F*, M, S	Publications 56, 67 and 71
Barium	F, M*, S	Publications 67 and 71
Lanthanum	F, M	Publication 30, Part 3
Cerium	F, M*, S	Publications 56, 67 and 71
Praseodymium	M, S	Publication 30, Part 3
Neodymium	M, S	Publication 30, Part 3
Promethium	M, S	Publication 30, Part 3
Samarium	M	Publication 30, Part 3
Europium	M	Publication 30, Part 3

Element	Absorption Type(s)	ICRP Publication N° for details of Biokinetic Model and Absorption Type(s)
Gadolinium	F, M	Publication 30, Part 3
Terbium	M	Publication 30, Part 3
Dysprosium	M	Publication 30, Part 3
Holmium	M	Publication 30, Part 3
Erbium	M	Publication 30, Part 3
Thulium	M	Publication 30, Part 3
Ytterbium	M, S	Publication 30, Part 3
Lutetium	M, S	Publication 30, Part 3
Hafnium	F, M	Publication 30, Part 3
Tantalum	M, S	Publication 30, Part 3
Tungsten	F	Publication 30, Part 3
Rhenium	F, M	Publication 30, Part 2
Osmium	F, M, S	Publication 30, Part 2
Iridium	F, M, S	Publication 30, Part 2
Platinum	F	Publication 30, Part 3
Gold	F, M, S	Publication 30, Part 2
Mercury	F, M, G	Publication 30, Part 2
Thallium	F	Publication 30, Part 3
Lead	F, M*, S, G	Publications 67 and 71
Bismuth	F, M	Publication 30, Part 2
Polonium	F, M*, S, G	Publications 67 and 71
Astatine	F, M	Publication 30, Part 3
Francium	F	Publication 30, Part 3
Radium	F, M*, S	Publications 67 and 71
Actinium	F, M, S	Publication 30, Part 3
Thorium	F, M, S*	Publications 69 and 71
Protactinium	M, S	Publication 30, Part 3
Uranium	F, M*, S	Publications 69 and 71
Neptunium	F, M*, S	Publications 67 and 71
Plutonium	F, M*, S	Publications 67 and 71
Americium	F, M*, S	Publications 67 and 71

Element	Absorption Type(s)	ICRP Publication N° for details of Biokinetic Model and Absorption Type(s)
Curium	F, M*, S	Publication 71
Berkelium	M	Publication 30, Part 4
Californium	M	Publication 30, Part 4
Einsteinium	M	Publication 30, Part 4
Fermium	M	Publication 30, Part 4
Mendelevium	M	Publication 30, Part 4

Table 2: Committed Effective Dose per Unit Intake via Inhalation (Sv Bq^{-1}) for soluble or reactive Gases and Vapours

Nuclide	Physical half-life	Absorption	% deposit	Age ≤ 1 a		f_1 for g > 1 a	Age 1-2a	2-7a	7-12a	12-17a	>17a
				f_1	h(g)		h(g)	h(g)	h(g)	h(g)	h(g)[a]
Tritiated water	12.3 a	V[1]	100	1.000	$6.4\ 10^{-11}$	1.000	$4.8\ 10^{-11}$	$3.1\ 10^{-11}$	$2.3\ 10^{-11}$	$1.8\ 10^{-11}$	$1.8\ 10^{-11}$
Elemental hydrogen	12.3 a	V	0.01	1.000	$6.4\ 10^{-15}$	1.000	$4.8\ 10^{-15}$	$3.1\ 10^{-15}$	$2.3\ 10^{-15}$	$1.8\ 10^{-15}$	$1.8\ 10^{-15}$
Tritiated methane	12.3 a	V	1	1.000	$6.4\ 10^{-13}$	1.000	$4.8\ 10^{-13}$	$3.1\ 10^{-13}$	$2.3\ 10^{-13}$	$1.8\ 10^{-13}$	$1.8\ 10^{-13}$
Organically bound tritium	12.3 a	V	100	1.000	$1.1\ 10^{-10}$	1.000	$1.1\ 10^{-10}$	$7.0\ 10^{-11}$	$5.5\ 10^{-11}$	$4.1\ 10^{-11}$	$4.1\ 10^{-11}$
Carbon-11 vapour	0.340 h	V	100	1.000	$2.8\ 10^{-11}$	1.000	$1.8\ 10^{-11}$	$9.7\ 10^{-12}$	$6.1\ 10^{-12}$	$3.8\ 10^{-12}$	$3.2\ 10^{-12}$
Carbon-11 dioxide	0.340 h	V	100	1.000	$1.8\ 10^{-11}$	1.000	$1.2\ 10^{-11}$	$6.5\ 10^{-12}$	$4.1\ 10^{-12}$	$2.5\ 10^{-12}$	$2.2\ 10^{-12}$
Carbon-11 monoxide	0.340 h	V	40	1.000	$1.0\ 10^{-11}$	1.000	$6.7\ 10^{-12}$	$3.5\ 10^{-12}$	$2.2\ 10^{-12}$	$1.4\ 10^{-12}$	$1.2\ 10^{-12}$
Carbon-14 vapour	$5.73\ 10^{3}$ a	V	100	1.000	$1.3\ 10^{-9}$	1.000	$1.6\ 10^{-9}$	$9.7\ 10^{-10}$	$7.9\ 10^{-10}$	$5.7\ 10^{-10}$	$5.8\ 10^{-10}$
Carbon-14 dioxide	$5.73\ 10^{3}$ a	V	100	1.000	$1.9\ 10^{-11}$	1.000	$1.9\ 10^{-11}$	$1.1\ 10^{-11}$	$8.9\ 10^{-12}$	$6.3\ 10^{-12}$	$6.2\ 10^{-12}$
Carbon-14 monoxide	$5.73\ 10^{3}$ a	V	40	1.000	$9.1\ 10^{-12}$	1.000	$5.7\ 10^{-12}$	$2.8\ 10^{-12}$	$1.7\ 10^{-12}$	$9.9\ 10^{-13}$	$8.0\ 10^{-13}$
Carbon disulphide-35	87.4 d	F	100	1.000	$6.9\ 10^{-9}$	0.800	$4.8\ 10^{-9}$	$2.4\ 10^{-9}$	$1.4\ 10^{-9}$	$8.6\ 10^{-10}$	$7.0\ 10^{-10}$
Sulphur-35 dioxide	87.4 d	F	85	1.000	$9.4\ 10^{-10}$	0.800	$6.6\ 10^{-10}$	$3.4\ 10^{-10}$	$2.1\ 10^{-10}$	$1.3\ 10^{-10}$	$1.1\ 10^{-10}$
Nickel-56 carbonyl	6.10 d	b[2]	100	1.000	$6.8\ 10^{-9}$	1.000	$5.2\ 10^{-9}$	$3.2\ 10^{-9}$	$2.1\ 10^{-9}$	$1.4\ 10^{-9}$	$1.2\ 10^{-9}$
Nickel-57 carbonyl	1.50 d	b[2]	100	1.000	$3.1\ 10^{-9}$	1.000	$2.3\ 10^{-9}$	$1.4\ 10^{-9}$	$9.2\ 10^{-10}$	$6.5\ 10^{-10}$	$5.6\ 10^{-10}$

[1] V: Very Fast absorption

[2] Refer to section 5.6 of ICRP Publication N° 71.

a applicable to both workers and adult members of the public

Table 2: Committed Effective Dose per Unit Intake via Inhalation (Sv Bq^{-1}) for soluble or reactive Gases and Vapours

Nuclide	Physical half-life	Absorption	% deposit	Age ≤ 1 a		f_1 for g > 1 a	Age 1-2a	2-7a	7-12a	12-17a	>17a
				f_1	h(g)		h(g)	h(g)	h(g)	h(g)	h(g)[a]
Nickel-59 carbonyl	$7.50\ 10^{4}$ a	b[2]	100	1.000	$4.0\ 10^{-9}$	1.000	$3.3\ 10^{-9}$	$2.0\ 10^{-9}$	$1.3\ 10^{-9}$	$9.1\ 10^{-10}$	$8.3\ 10^{-10}$
Nickel-63 carbonyl	96.0 a	b[2]	100	1.000	$9.5\ 10^{-9}$	1.000	$8.0\ 10^{-9}$	$4.8\ 10^{-9}$	$3.0\ 10^{-9}$	$2.2\ 10^{-9}$	$2.0\ 10^{-9}$
Nickel-65 carbonyl	2.52 h	b[2]	100	1.000	$2.0\ 10^{-9}$	1.000	$1.4\ 10^{-9}$	$8.1\ 10^{-10}$	$5.6\ 10^{-10}$	$4.0\ 10^{-10}$	$3.6\ 10^{-10}$
Nickel-66 carbonyl	2.27 d	b[2]	100	1.000	$1.0\ 10^{-8}$	1.000	$7.1\ 10^{-9}$	$4.0\ 10^{-9}$	$2.7\ 10^{-9}$	$1.8\ 10^{-9}$	$1.6\ 10^{-9}$
Ruthenium-94 tetroxide	0.863 h	F	100	0.100	$5.5\ 10^{-10}$	0.050	$3.5\ 10^{-10}$	$1.8\ 10^{-10}$	$1.1\ 10^{-10}$	$7.0\ 10^{-11}$	$5.6\ 10^{-11}$
Ruthenium-97 tetroxide	2.90 d	F	100	0.100	$8.7\ 10^{-10}$	0.050	$6.2\ 10^{-10}$	$3.4\ 10^{-10}$	$2.2\ 10^{-10}$	$1.4\ 10^{-10}$	$1.2\ 10^{-10}$
Ruthenium-103 tetroxide	39.3 d	F	100	0.100	$9.0\ 10^{-9}$	0.050	$6.2\ 10^{-9}$	$3.3\ 10^{-9}$	$2.1\ 10^{-9}$	$1.3\ 10^{-9}$	$1.1\ 10^{-9}$
Ruthenium-105 tetroxide	4.44 h	F	100	0.100	$1.6\ 10^{-9}$	0.050	$1.0\ 10^{-9}$	$5.3\ 10^{-10}$	$3.2\ 10^{-10}$	$2.2\ 10^{-10}$	$1.8\ 10^{-10}$
Ruthenium-106 tetroxide	1.01 a	F	100	0.100	$1.6\ 10^{-7}$	0.050	$1.1\ 10^{-7}$	$6.1\ 10^{-8}$	$3.7\ 10^{-8}$	$2.2\ 10^{-8}$	$1.8\ 10^{-8}$
Tellurium-116 vapour	2.49 h	F	100	0.600	$5.9\ 10^{-10}$	0.300	$4.4\ 10^{-10}$	$2.5\ 10^{-10}$	$1.6\ 10^{-10}$	$1.1\ 10^{-10}$	$8.7\ 10^{-11}$
Tellurium-121 vapour	17.0 d	F	100	0.600	$3.0\ 10^{-9}$	0.300	$2.4\ 10^{-9}$	$1.4\ 10^{-9}$	$9.6\ 10^{-10}$	$6.7\ 10^{-10}$	$5.1\ 10^{-10}$
Tellurium-121m vapour	154 d	F	100	0.600	$3.5\ 10^{-8}$	0.300	$2.7\ 10^{-8}$	$1.6\ 10^{-8}$	$9.8\ 10^{-9}$	$6.6\ 10^{-9}$	$5.5\ 10^{-9}$
Tellurium-123 vapour	$1.00\ 10^{13}$ a	F	100	0.600	$2.8\ 10^{-8}$	0.300	$2.5\ 10^{-8}$	$1.9\ 10^{-8}$	$1.5\ 10^{-8}$	$1.3\ 10^{-8}$	$1.2\ 10^{-8}$
Tellurium-123m vapour	120 d	F	100	0.600	$2.5\ 10^{-8}$	0.300	$1.8\ 10^{-8}$	$1.0\ 10^{-8}$	$5.7\ 10^{-9}$	$3.5\ 10^{-9}$	$2.9\ 10^{-9}$
Tellurium-125m vapour	58.0 d	F	100	0.600	$1.5\ 10^{-8}$	0.300	$1.1\ 10^{-8}$	$5.9\ 10^{-9}$	$3.2\ 10^{-9}$	$1.9\ 10^{-9}$	$1.5\ 10^{-9}$
Tellurium-127 vapour	9.35 h	F	100	0.600	$6.1\ 10^{-10}$	0.300	$4.4\ 10^{-10}$	$2.3\ 10^{-10}$	$1.4\ 10^{-10}$	$9.2\ 10^{-11}$	$7.7\ 10^{-11}$
Tellurium-127m vapour	109 d	F	100	0.600	$5.3\ 10^{-8}$	0.300	$3.7\ 10^{-8}$	$1.9\ 10^{-8}$	$1.0\ 10^{-8}$	$6.1\ 10^{-9}$	$4.6\ 10^{-9}$

a applicable to both workers and adult members of the public

Table 2: Committed Effective Dose per Unit Intake via Inhalation (Sv Bq^{-1}) for soluble or reactive Gases and Vapours

Nuclide	Physical half-life	Absorption	% deposit	Age ≤ 1 a		f_1 for g > 1 a	Age 1-2a	2-7a	7-12a	12-17a	>17a
				f_1	h(g)		h(g)	h(g)	h(g)	h(g)	h(g)[a]
Tellurium-129 vapour	1.16 h	F	100	0.600	$2.5\ 10^{-10}$	0.300	$1.7\ 10^{-10}$	$9.4\ 10^{-11}$	$6.2\ 10^{-11}$	$4.3\ 10^{-11}$	$3.7\ 10^{-11}$
Tellurium-129m vapour	33.6 d	F	100	0.600	$4.8\ 10^{-8}$	0.300	$3.2\ 10^{-8}$	$1.6\ 10^{-8}$	$8.5\ 10^{-9}$	$5.1\ 10^{-9}$	$3.7\ 10^{-9}$
Tellurium-131 vapour	0.417 h	F	100	0.600	$5.1\ 10^{-10}$	0.300	$4.5\ 10^{-10}$	$2.6\ 10^{-10}$	$1.4\ 10^{-10}$	$9.5\ 10^{-11}$	$6.8\ 10^{-11}$
Tellurium-131m vapour	1.25 d	F	100	0.600	$2.1\ 10^{-8}$	0.300	$1.9\ 10^{-8}$	$1.1\ 10^{-8}$	$5.6\ 10^{-9}$	$3.7\ 10^{-9}$	$2.4\ 10^{-9}$
Tellurium-132 vapour	3.26 d	F	100	0.600	$5.4\ 10^{-8}$	0.300	$4.5\ 10^{-8}$	$2.4\ 10^{-8}$	$1.2\ 10^{-8}$	$7.6\ 10^{-9}$	$5.1\ 10^{-9}$
Tellurium-133 vapour	0.207 h	F	100	0.600	$5.5\ 10^{-10}$	0.300	$4.7\ 10^{-10}$	$2.5\ 10^{-10}$	$1.2\ 10^{-10}$	$8.1\ 10^{-11}$	$5.6\ 10^{-11}$
Tellurium-133m vapour	0.923 h	F	100	0.600	$2.3\ 10^{-9}$	0.300	$2.0\ 10^{-9}$	$1.1\ 10^{-9}$	$5.0\ 10^{-10}$	$3.3\ 10^{-10}$	$2.2\ 10^{-10}$
Tellurium-134 vapour	0.696 h	F	100	0.600	$6.8\ 10^{-10}$	0.300	$5.5\ 10^{-10}$	$3.0\ 10^{-10}$	$1.6\ 10^{-10}$	$1.1\ 10^{-10}$	$8.4\ 10^{-11}$
Elemental iodine-120	1.35 h	V	100	1.000	$3.0\ 10^{-9}$	1.000	$2.4\ 10^{-9}$	$1.3\ 10^{-9}$	$6.4\ 10^{-10}$	$4.3\ 10^{-10}$	$3.0\ 10^{-10}$
Elemental iodine-120m	0.883 h	V	100	1.000	$1.5\ 10^{-9}$	1.000	$1.2\ 10^{-9}$	$6.4\ 10^{-10}$	$3.4\ 10^{-10}$	$2.3\ 10^{-10}$	$1.8\ 10^{-10}$
Elemental iodine-121	2.12 h	V	100	1.000	$5.7\ 10^{-10}$	1.000	$5.1\ 10^{-10}$	$3.0\ 10^{-10}$	$1.7\ 10^{-10}$	$1.2\ 10^{-10}$	$8.6\ 10^{-11}$
Elemental iodine-123	13.2 h	V	100	1.000	$2.1\ 10^{-9}$	1.000	$1.8\ 10^{-9}$	$1.0\ 10^{-9}$	$4.7\ 10^{-10}$	$3.2\ 10^{-10}$	$2.1\ 10^{-10}$
Elemental iodine-124	4.18 d	V	100	1.000	$1.1\ 10^{-7}$	1.000	$1.0\ 10^{-7}$	$5.8\ 10^{-8}$	$2.8\ 10^{-8}$	$1.8\ 10^{-8}$	$1.2\ 10^{-8}$
Elemental iodine-125	60.1 d	V	100	1.000	$4.7\ 10^{-8}$	1.000	$5.2\ 10^{-8}$	$3.7\ 10^{-8}$	$2.8\ 10^{-8}$	$2.0\ 10^{-8}$	$1.4\ 10^{-8}$
Elemental iodine-126	13.0 d	V	100	1.000	$1.9\ 10^{-7}$	1.000	$1.9\ 10^{-7}$	$1.1\ 10^{-7}$	$6.2\ 10^{-8}$	$4.1\ 10^{-8}$	$2.6\ 10^{-8}$
Elemental iodine-128	0.416 h	V	100	1.000	$4.2\ 10^{-10}$	1.000	$2.8\ 10^{-10}$	$1.6\ 10^{-10}$	$1.0\ 10^{-10}$	$7.5\ 10^{-11}$	$6.5\ 10^{-11}$
Elemental iodine-129	$1.57\ 10^{7}$ a	V	100	1.000	$1.7\ 10^{-7}$	1.000	$2.0\ 10^{-7}$	$1.6\ 10^{-7}$	$1.7\ 10^{-7}$	$1.3\ 10^{-7}$	$9.6\ 10^{-8}$

a applicable to both workers and adult members of the public

Table 2: Committed Effective Dose per Unit Intake via Inhalation (Sv Bq^{-1}) for soluble or reactive Gases and Vapours

Nuclide	Physical half-life	Absorption	% deposit	Age ≤ 1 a		f_1 for g > 1 a	Age 1-2a	2-7a	7-12a	12-17a	>17a
				f_1	h(g)		h(g)	h(g)	h(g)	h(g)	h(g)[a]
Elemental iodine-130	12.4 h	V	100	1.000	$1.9\ 10^{-8}$	1.000	$1.7\ 10^{-8}$	$9.2\ 10^{-9}$	$4.3\ 10^{-9}$	$2.8\ 10^{-9}$	$1.9\ 10^{-9}$
Elemental iodine-131	8.04 d	V	100	1.000	$1.7\ 10^{-7}$	1.000	$1.6\ 10^{-7}$	$9.4\ 10^{-8}$	$4.8\ 10^{-8}$	$3.1\ 10^{-8}$	$2.0\ 10^{-8}$
Elemental iodine-132	2.30 h	V	100	1.000	$2.8\ 10^{-9}$	1.000	$2.3\ 10^{-9}$	$1.3\ 10^{-9}$	$6.4\ 10^{-10}$	$4.3\ 10^{-10}$	$3.1\ 10^{-10}$
Elemental iodine-132m	1.39 h	V	100	1.000	$2.4\ 10^{-9}$	1.000	$2.1\ 10^{-9}$	$1.1\ 10^{-9}$	$5.6\ 10^{-10}$	$3.8\ 10^{-10}$	$2.7\ 10^{-10}$
Elemental iodine-133	20.8 h	V	100	1.000	$4.5\ 10^{-8}$	1.000	$4.1\ 10^{-8}$	$2.1\ 10^{-8}$	$9.7\ 10^{-9}$	$6.3\ 10^{-9}$	$4.0\ 10^{-9}$
Elemental iodine-134	0.876 h	V	100	1.000	$8.7\ 10^{-10}$	1.000	$6.9\ 10^{-10}$	$3.9\ 10^{-10}$	$2.2\ 10^{-10}$	$1.6\ 10^{-10}$	$1.5\ 10^{-10}$
Elemental iodine-135	6.61 h	V	100	1.000	$9.7\ 10^{-9}$	1.000	$8.5\ 10^{-9}$	$4.5\ 10^{-9}$	$2.1\ 10^{-9}$	$1.4\ 10^{-9}$	$9.2\ 10^{-10}$
Methyl iodide-120	1.35 h	V	70	1.000	$2.3\ 10^{-9}$	1.000	$1.9\ 10^{-9}$	$1.0\ 10^{-9}$	$4.8\ 10^{-10}$	$3.1\ 10^{-10}$	$2.0\ 10^{-10}$
Methyl iodide-120m	0.883 h	V	70	1.000	$1.0\ 10^{-9}$	1.000	$8.7\ 10^{-10}$	$4.6\ 10^{-10}$	$2.2\ 10^{-10}$	$1.5\ 10^{-10}$	$1.0\ 10^{-10}$
Methyl iodide-121	2.12 h	V	70	1.000	$4.2\ 10^{-10}$	1.000	$3.8\ 10^{-10}$	$2.2\ 10^{-10}$	$1.2\ 10^{-10}$	$8.3\ 10^{-11}$	$5.6\ 10^{-11}$
Methyl iodide-123	13.2 h	V	70	1.000	$1.6\ 10^{-9}$	1.000	$1.4\ 10^{-9}$	$7.7\ 10^{-10}$	$3.6\ 10^{-10}$	$2.4\ 10^{-10}$	$1.5\ 10^{-10}$
Methyl iodide-124	4.18 d	V	70	1.000	$8.5\ 10^{-8}$	1.000	$8.0\ 10^{-8}$	$4.5\ 10^{-8}$	$2.2\ 10^{-8}$	$1.4\ 10^{-8}$	$9.2\ 10^{-9}$
Methyl iodide-125	60.1 d	V	70	1.000	$3.7\ 10^{-8}$	1.000	$4.0\ 10^{-8}$	$2.9\ 10^{-8}$	$2.2\ 10^{-8}$	$1.6\ 10^{-8}$	$1.1\ 10^{-8}$
Methyl iodide-126	13.0 d	V	70	1.000	$1.5\ 10^{-7}$	1.000	$1.5\ 10^{-7}$	$9.0\ 10^{-8}$	$4.8\ 10^{-8}$	$3.2\ 10^{-8}$	$2.0\ 10^{-8}$
Methyl iodide-128	0.416 h	V	70	1.000	$1.5\ 10^{-10}$	1.000	$1.2\ 10^{-10}$	$6.3\ 10^{-11}$	$3.0\ 10^{-11}$	$1.9\ 10^{-11}$	$1.3\ 10^{-11}$
Methyl iodide-129	$1.57\ 10^{7}$ a	V	70	1.000	$1.3\ 10^{-7}$	1.000	$1.5\ 10^{-7}$	$1.2\ 10^{-7}$	$1.3\ 10^{-7}$	$9.9\ 10^{-8}$	$7.4\ 10^{-8}$
Methyl iodide-130	12.4 h	V	70	1.000	$1.5\ 10^{-8}$	1.000	$1.3\ 10^{-8}$	$7.2\ 10^{-9}$	$3.3\ 10^{-9}$	$2.2\ 10^{-9}$	$1.4\ 10^{-9}$

a applicable to both workers and adult members of the public

Table 2: Committed Effective Dose per Unit Intake via Inhalation (Sv Bq^{-1}) for soluble or reactive Gases and Vapours

Nuclide	Physical half-life	Absorption	% deposit	Age ≤ 1 a		f$_1$ for g > 1 a	Age 1-2a	2-7a	7-12a	12-17a	>17a
				f$_1$	h(g)		h(g)	h(g)	h(g)	h(g)	h(g)[a]
Methyl iodide-131	8.04 d	V	70	1.000	$1.3\ 10^{-7}$	1.000	$1.3\ 10^{-7}$	$7.4\ 10^{-8}$	$3.7\ 10^{-8}$	$2.4\ 10^{-8}$	$1.5\ 10^{-8}$
Methyl iodide-132	2.30 h	V	70	1.000	$2.0\ 10^{-9}$	1.000	$1.8\ 10^{-9}$	$9.5\ 10^{-10}$	$4.4\ 10^{-10}$	$2.9\ 10^{-10}$	$1.9\ 10^{-10}$
Methyl iodide-132m	1.39 h	V	70	1.000	$1.8\ 10^{-9}$	1.000	$1.6\ 10^{-9}$	$8.3\ 10^{-10}$	$3.9\ 10^{-10}$	$2.5\ 10^{-10}$	$1.6\ 10^{-10}$
Methyl iodide-133	20.8 h	V	70	1.000	$3.5\ 10^{-8}$	1.000	$3.2\ 10^{-8}$	$1.7\ 10^{-8}$	$7.6\ 10^{-9}$	$4.9\ 10^{-9}$	$3.1\ 10^{-9}$
Methyl iodide-134	0.876 h	V	70	1.000	$5.1\ 10^{-10}$	1.000	$4.3\ 10^{-10}$	$2.3\ 10^{-10}$	$1.1\ 10^{-10}$	$7.4\ 10^{-11}$	$5.0\ 10^{-11}$
Methyl iodide-135	6.61 h	V	70	1.000	$7.5\ 10^{-9}$	1.000	$6.7\ 10^{-9}$	$3.5\ 10^{-9}$	$1.6\ 10^{-9}$	$1.1\ 10^{-9}$	$6.8\ 10^{-10}$
Mercury-193 vapour	3.50 h	b[3]	70	1.000	$4.2\ 10^{-9}$	1.000	$3.4\ 10^{-9}$	$2.2\ 10^{-9}$	$1.6\ 10^{-9}$	$1.2\ 10^{-9}$	$1.1\ 10^{-9}$
Mercury-193m vapour	11.1 h	b[3]	70	1.000	$1.2\ 10^{-8}$	1.000	$9.4\ 10^{-9}$	$6.1\ 10^{-9}$	$4.5\ 10^{-9}$	$3.4\ 10^{-9}$	$3.1\ 10^{-9}$
Mercury-194 vapour	$2.60\ 10^{3}$ a	b[3]	70	1.000	$9.4\ 10^{-9}$	1.000	$8.3\ 10^{-8}$	$6.2\ 10^{-8}$	$5.0\ 10^{-9}$	$4.3\ 10^{-8}$	$4.0\ 10^{-8}$
Mercury-195 vapour	9.90 h	b[3]	70	1.000	$5.3\ 10^{-9}$	1.000	$4.3\ 10^{-9}$	$2.8\ 10^{-9}$	$2.1\ 10^{-9}$	$1.6\ 10^{-9}$	$1.4\ 10^{-9}$
Mercury-195m vapour	1.73 d	b[3]	70	1.000	$3.0\ 10^{-8}$	1.000	$2.5\ 10^{-8}$	$1.6\ 10^{-8}$	$1.2\ 10^{-8}$	$8.8\ 10^{-9}$	$8.2\ 10^{-9}$
Mercury-197 vapour	2.67 d	b[3]	70	1.000	$1.6\ 10^{-8}$	1.000	$1.3\ 10^{-8}$	$8.4\ 10^{-9}$	$6.3\ 10^{-9}$	$4.7\ 10^{-9}$	$4.4\ 10^{-9}$
Mercury-197m vapour	23.8 h	b[3]	70	1.000	$2.1\ 10^{-8}$	1.000	$1.7\ 10^{-8}$	$1.1\ 10^{-8}$	$8.2\ 10^{-9}$	$6.2\ 10^{-9}$	$5.8\ 10^{-9}$
Mercury-199m vapour	0.710 h	b[3]	70	1.000	$6.5\ 10^{-10}$	1.000	$5.3\ 10^{-10}$	$3.4\ 10^{-10}$	$2.5\ 10^{-10}$	$1.9\ 10^{-10}$	$1.8\ 10^{-10}$
Mercury-203 vapour	46.6 d	b[3]	70	1.000	$3.0\ 10^{-8}$	1.000	$2.3\ 10^{-8}$	$1.5\ 10^{-8}$	$1.0\ 10^{-8}$	$7.7\ 10^{-9}$	$7.0\ 10^{-9}$

[3] Deposition 10% : 20% : 40% (bronchial: bronchiolar: alveolar-interstitial), 1,7 day retention half-time (ICRP publication 68)

a applicable to both workers and adult members of the public

Table 3 **Effective Dose for Exposure of adults (workers or members of the public) to inert gases**

Nuclide	$t_{1/2}$	Effective dose per unit integrated air concentration (Sv d^{-1}/Bq m^{-3})
Argon		
Ar-37	35.0 d	$4.1\ 10^{-15}$
Ar-39	269 a	$1.1\ 10^{-11}$
Ar-41	1.83 h	$5.3\ 10^{-9}$
Krypton		
Kr-74	11.5 m	$4.5\ 10^{-9}$
Kr-76	14.8 h	$1.6\ 10^{-9}$
Kr-77	74.7 m	$3.9\ 10^{-9}$
Kr-79	1.46 d	$9.7\ 10^{-10}$
Kr-81	$2.10\ 10^{5}$ a	$2.1\ 10^{-11}$
Kr-83m	1.83 h	$2.1\ 10^{-13}$
Kr-85	10.7 a	$2.2\ 10^{-11}$
Kr-85m	4.48 h	$5.9\ 10^{-10}$
Kr-87	1.27 h	$3.4\ 10^{-9}$
Kr-88	2.84 h	$8.4\ 10^{-9}$
Xenon		
Xe-120	40.0 m	$1.5\ 10^{-9}$
Xe-121	40.1 m	$7.5\ 10^{-9}$
Xe-122	20.1 h	$1.9\ 10^{-10}$
Xe-123	2.08 h	$2.4\ 10^{-9}$
Xe-125	17.0 h	$9.3\ 10^{-10}$
Xe-127	36.4 d	$9.7\ 10^{-10}$
Xe-129m	8.0 d	$8.1\ 10^{-11}$
Xe-131m	11.9 d	$3.2\ 10^{-11}$
Xe-133m	2.19 d	$1.1\ 10^{-10}$
Xe-133	5.24 d	$1.2\ 10^{-10}$
Xe-135m	15.3 m	$1.6\ 10^{-9}$
Xe-135	9.10 h	$9.6\ 10^{-10}$
Xe-138	14.2 m	$4.7\ 10^{-9}$

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