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# Basic Safety Standards for Radiation Protection

## 1967 Edition

INTERNATIONAL ATOMIC ENERGY AGENCY

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# BASIC SAFETY STANDARDS FOR RADIATION PROTECTION

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# FOREWORD

This first revision of the Basic Safety Standards was approved by the Agency's Board of Governors in September 1965. It was prepared with the assistance of a panel of experts chaired by Professor L. Bugnard, Director of the French Institut National d'Hygiène, and attended by representatives of several international organizations. The panel took into consideration comments received from Member States as well as the important work done by the International Commission on Radiological Protection. A few changes were subsequently introduced on the basis of recommendations made by that Commission in 1966, as requested by the Board.

The Board has requested the Director General to apply the revised Standards to the Agency's operations, as well as to operations assisted by it, as required. It has also recommended to all Member States that their national regulations for radiation protection should conform, as far as is practicable, to the revised Standards.

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ACKNOWLEDGEMENTS

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## INTRODUCTION

1. Under Article III. A. 6 of its Statute "the Agency is authorized to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection of health and minimization of danger to life and property (including such standards for labour conditions), and to provide for the application of these standards to its own operations as well as to the operations making use of materials, services, equipment, facilities and information made available by the Agency or at its request or under its control or supervision: and to provide for the application of these standards, at the request of the parties, to operations under any bilateral or multilateral arrangement, or, at the request of a State, to any of that State's activities in the field of atomic energy."

2. The Agency's Health and Safety Measures, approved by the Board of Governors on 31 March 1960[1], provide that Agency safety standards shall include:

(a) The Agency's basic safety standards – standards prescribing maximum permissible levels of exposure to radiation and fundamental operational principles; and

(b) The Agency's detailed operational standards.

They further provide that the Agency's Basic Safety Standards should be, as far as possible, based on the recommendations of the International Commission on Radiological Protection (ICRP) and in accord with standards published by other international organizations.

3. In October 1958 the ICRP issued recommendations with respect to the maximum permissible accumulated dose for occupational radiation exposures and for exposure of the population. In 1959 it released recommendations regarding the maximum permissible concentrations of radioactive materials in air and water.

4. In 1964 the ICRP published recommendations amending those made in 1959 and revised in 1962. In 1966 the ICRP issued publication No. 9 which contained a number of significant changes. These amendments, together with the comments made by Member States, justified a revision of the Agency's Basic Safety Standards.

5. The Agency believes that the limits established in the following revised Basic Safety Standards for Radiation Protection, based as

[1] INFCIRC/18.

far as possible on the recommendations of the ICRP, provide an appropriate regulatory basis for the protection of the health and safety of employees and the public without imposing undue burdens upon users of radioactive material. The recommended limits of exposure, derived from extensive scientific and technical investigations and from years of experience with the practical problems of radiation protection, represent a consensus of opinion as to the measures generally considered desirable to provide appropriate degrees of safety in the situations to which these Standards apply.

6. The Agency recognizes that the ICRP's recommendations cannot be converted into regulations without loss of flexibility in their application to individual situations. It is, however, the policy of the Agency to minimize this loss of flexibility, both in the formulation of its regulations and in their administration, to the greatest extent compatible with the nature of the problem and with good regulatory practice.

7. Other publications in the Agency's Safety Series should be consulted for practical detailed guidance in implementing these standards. When applied to the Agency's operations or to operations assisted by the Agency, this document should be read in the light of the Agency's Health and Safety Measures[1].

## 1. MEANING OF TERMS USED

For the purposes of these standards the following terms have the meanings hereby assigned to them.

### 1.1. PHYSICAL AND RADIOLOGICAL TERMS

*Ionizing radiation:*[2]

Electromagnetic radiation (X-ray or $\gamma$-ray photons) or corpuscular radiation capable of producing ionization in its passage through matter.

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[1] INFCIRC/18.

[2] For a more detailed definition, consult Publication Report 10 a 1962 of the International Commission of Radiological Units and Measurements, published in Handbook 84, United States National Bureau of Standards.

*Source:*

Apparatus capable of producing, or substance producing, ionizing radiation.

*Nuclide:*

A species of atom having specified numbers of neutrons and protons in its nucleus.

*Radioactivity:*

Spontaneous disintegration of a nuclide.

*Radiotoxicity:*

The toxicity attributable to the radiation emitted by a radioactive substance within the body.

*External radiation:*

Radiation reaching the body from external sources.

*Internal radiation:*

Radiation arising from radioactive substances within the body.

*Natural radiation:*

The various natural radiation sources include:

(a) External sources of extra-terrestrial origin (cosmic-rays) and external sources of terrestrial origin, i.e. the radioactive isotopes naturally present in the crust of the earth and in air; and

(b) Internal sources, i.e. the radioisotopes $^{40}K$ and $^{14}C$ which make up a small percentage of these elements and are normal constituents of the body, and other isotopes such as $^{226}Ra$ and $^{232}Th$ and their decay products, which are taken up from the natural environment.

*Controlled area:*

An area scheduled as such for the purpose of controlling individual personnel exposure and under the supervision of a person who has the knowledge and responsibility to apply appropriate radiation protection regulations.

*Qualified expert:*

A person having the knowledge and training required to give advice on protective measures and operating procedures which will ensure effective radiation protection for persons exposed to ionizing radiation.

*Competent authority:*

A national or international authority designated or otherwise recognized as such by a government for any purpose in connection with these standards.

*Emergency exposure:*

A planned exceptional exposure in the case of compelling or overwhelming necessity.

*Accidental exposure:*

An unforeseen exposure resulting in a radiation dose or intake of radioactive material exceeding the maximum permissible values.

*Absorbed dose:*

The absorbed dose of any ionizing radiation is the energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest.

*rad:*

The unit of absorbed dose. 1 rad = 100 erg/g

*The dose equivalent:*

(i) For protection purposes, it is useful to define a quantity which is termed the "dose equivalent" (DE).

(ii) (DE) is numerically equal to the product of absorbed dose D, quality factor (QF), dose distribution factor (DF), and other necessary modifying factors.

The unit of dose equivalent is the rem.

The quality factor (QF), as used in radiation protection, is the factor dependent on energy transfer by which the absorbed dose is multiplied to obtain, for the purposes of radiation protection, a quantity that expresses on a scale common to all ionizing radiations the dose received by exposed persons. Provision for other factors is also made. Thus, a distribution factor (DF) may be used to account for modifications of the biological effect due to a non-uniform distribution of internally deposited isotopes.

The QF values that should be used for radiation protection purposes are listed in Tables IA, IB and IC of Annex A.

In this text the terms dose and dose equivalent are used interchangeably.

*Dose commitment:*

The total dose to an organ or tissue over a period of 50 years resulting from an intake of radioactive material.

*The annual genetically significant dose*[3]*:*

The annual genetically significant dose to a population is the average of the individual gonad doses, each weighted for the expected number of children conceived subsequent to the exposure. The genetic dose to a population is assessed as the annual genetically significant dose multiplied by the mean age of child bearing which for the purpose of this report is taken to be 30 years.

[3] For calculation of the genetically significant dose to the population see the 1959 Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, para. 83, and the 1962 report, p. 389.

*curie:*

The special unit of activity is the curie (Ci). One curie equals $3.7 \times 10^{10}$ disintegrations $s^{-1}$ (exactly).

***Neutron flux density:***

Neutron flux density expresses the number of neutrons falling on a sphere of unit cross-sectional area per second.

## 2. SCOPE

2.1. These standards apply to the production, processing, handling, use, storage, transport and disposal of natural and artificially produced radioactive material, and to the use and operation of other radiation sources. Fall-out from nuclear weapon tests is excluded from these standards.

2.2. These standards apply to:

(a) Workers[4]
(b) Individual members of the public; and
(c) The whole population, as defined by the competent authority.

2.3. The doses referred to in these standards do not include:

(a) Doses to patients resulting from medical examination or treatment; or
(b) Doses resulting from natural radiation.

## 3. LIMITATION OF DOSES FOR EXPOSURES FROM CONTROLLABLE SOURCES

### 3.1. MAXIMUM PERMISSIBLE DOSES FOR WORKERS[5]

Maximum permissible doses represent the maximum values to which workers may be exposed under certain appropriately de-

[4] See also 4.1.3.

[5] Emergency doses and accidental exposures for workers are dealt with in section 4.

fined conditions. To the extent permitted by reasonable economic and social considerations actual exposures should be as far below the maximum as is practicable.

The total dose to any organ or tissue shall comprise the doses contributed by external sources during working hours and by the intake of radioactive materials into the body during working hours.

3.1.1. The maximum permissible dose to the whole body, gonads or red bone marrow of an individual shall be 5 rem in any one year.

3.1.1.1. It may sometimes be necessary to provide flexibility for the maximum permissible dose for exposure involving the whole body, gonad or the red bone marrow. In such cases (these cases, however, are felt to be infrequent) the total accumulated dose to the whole body, gonads or red bone marrow of an individual shall not exceed the maximum permissible dose derived from the formula $D = 5(N-18)$ where D is expressed in rem and N is the individual's age in years. Age in years may, for administrative purposes, be reckoned from any selected date of the year. Maximum permissible doses for single organs other than the red bone marrow, whole body and gonads are specified in paragraph 3.1.6. Exceptions and modifications to the application of the formula are indicated in paragraphs 3.1.2 through 3.1.5.

3.1.2. Provided the total dose in any one year does not exceed the maximum permissible dose given in paragraph 3.1.1, and subject to the provisions of (a), (b) and (c) below, a worker may receive in a quarter of a year a dose to the whole body, gonads and the red bone marrow not exceeding 3 rem. A dose of 3 rem may be received as a single dose within a quarter of a year, but this shall be avoided as far as practicable.

(a) The dose accumulation at rates up to 3 rem per quarter shall not apply in circumstances involving abdominal exposure of women of reproductive capacity. Women of reproductive capacity shall be employed only under conditions where the exposure of the abdomen is limited to 1.3 rem in a quarter, corresponding to 5 rem per year delivered at an even rate.

(b) The dose to the foetus of a pregnant woman accumulated during the period after pregnancy has been diagnosed shall not exceed 1 rem.

(c) In work with X-ray equipment of 150 kV and less or with other forms of soft radiation or where the abdomen is protected from or is not exposed to the radiation, the dose to the foetus will be considerably less than that received by the woman. In these conditions a woman in whom pregnancy has been diagnosed may continue to be engaged in radiation work involving exposure at a rate not exceeding 1.3 rem per quarter, estimated on the surface of the body (outside the protected area of the abdomen if penetrating radiation is involved).

3.1.3. If the dose previously accumulated in radiation work by a worker over any given period is not known, it shall be assumed that the worker has received the currently recommended maximum permissible dose in each year of that period.

3.1.4. Workers who have been exposed in accordance with the former ICRP recommendations which laid down a maximum permissible weekly dose of 0.3 rem and who have accumulated a dose higher than that determined by the formula shall not be exposed at a rate higher than 5 rem in any one year, until the accumulated dose at a subsequent time is lower than that determined by the formula.

3.1.5. If a worker begins to be engaged in radiation work at an age of less than 18 years, the dose to the whole body, gonads, and red bone marrow shall not exceed 5 rem in any one year while his age is less than 18 years, and the dose accumulated at the age of 30 shall not exceed 60 rem. In addition the other relevant requirements of paragraph 3.1 shall apply.

3.1.6. The dose to organs other than the gonads, the whole body and the bone marrow received shall not exceed the values listed below:

| Organ | Quarterly limit (rem) | Limit per year (rem) |
|---|---|---|
| Any single organ[a], excluding the gonads, the red bone marrow, bone, thyroid and skin | 8 | 15 |
| Bone, thyroid, skin of the whole body (excluding the skin of the hands, forearms, feet and ankles) | 15 | 30 |
| Hands, forearms, feet and ankles | 40 | 75 |

[a] Including the lens of the eye. However, in the case of irradiation of the lens of the eye with particulate radiation of high LET a special modifying factor is used as indicated in Annex A, Table I A, Table I B and Table I C.

*3.1.7. Planned special exposure*

Situations may occur infrequently during normal operations when it may be necessary to allow a few workers to receive exposure in excess of the recommended quarterly limits. In such circumstances, exposure or intakes of radioactive material may be allowed provided the dose commitments do not exceed twice the annual dose limit in any single event and in a lifetime 5 times this limit.

It is emphasized that doses or intakes of this magnitude are only justified when alternative techniques which do not involve such exposures of workers are either unavailable or impracticable.

Planned special exposure should not be allowed under the following conditions:

(a) If the addition of the intended dose to the worker's accumulated dose exceeds the amount determined by the procedure in paragraph 3.1.1.1.

(b) If the worker has received in the previous 12 months a single exposure or intake of radioactive material with a dose commitment in excess of the quarterly quota.
(c) If the worker has previously received an emergency exposure or intake or an accidental exposure in excess of 5 times the annual dose limit.
(d) In the case of women of reproductive capacity.

Doses resulting from planned special exposure shall be recorded with those from usual exposures but any excess over the recommended limits should not constitute a reason for excluding a worker from his usual occupation.

### 3.2. DOSE LIMITS FOR INDIVIDUAL MEMBERS OF THE PUBLIC

In any organ or tissue, the total dose shall comprise doses contributed by external sources and doses resulting from the intake of radioactive material.

**The annual dose limits for individual members of the public** are listed below:

| Organ | Limit per year (rem) |
|---|---|
| Whole body, gonads, red bone marrow | 0.5 |
| Any single organ, excluding the red bone marrow, gonads, bone, thyroid and skin | 1.5 |
| Bone, thyroid[a], skin of the whole body (excluding the skin of the hands, forearms, feet and ankles) | 3 |
| Hands, forearms, feet and ankles | 7.5 |

[a] The exposure of the thyroid of children below the age of 16 shall be limited to 1.5 rem in a year.