SAFETY SERIES No. 115

SAFETY STANDARDS

safety series

International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources

JOINTLY SPONSORED BY FAO, IAEA, ILO, OECD/NEA, PAHO, WHO

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1996

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CORRIGENDA
to
International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources
Safety Series No. 115

p. 48
In para. II.14(b) replace "focal spot position" with "focal spot size".

p. 88
In footnote a to Table I-I add the following two parent nuclides and progeny (first and sixth):

Sr-80	Rb-80
Ag-108m	Ag-108

p. 91
In para. II-2 replace "para. 205" with "para. 2.5".

p. 92
In footnote 40 replace "para. 418" with "para. I-18".

p. 277
In footnote d to Table II-IX replace "time" with "half-time".

p. 285
In Table IV-II replace "$Gy{\cdot}a^{-1}$" with "$Sv{\cdot}a^{-1}$".

p. 289
In para. V-11 replace "V-11–V-16" with "V.11–V.16".

p. 299
In the definition of **Committed effective dose** after "integration time τ" insert "and w_T is the tissue weighting factor for tissue T".

p. 304
In the definition of **Health professional** replace "paediatry" with "podiatry".

p. 307
In the definition of **Multiple scan average dose** replace the limits of integration with "+nI/2" and "–nI/2".

p. 319
In the Index spaces not preceded by commas should be inclusive intervals; e.g., "2.10 2.14" should be "2.10–2.14".

p. 319
In the entry for **authorized person** delete "2.7,".

p. 321
Replace the entry for **embryo** with "**embryo/foetus** I.17, I.27, II.16, II.18, Table IV-I".

p. 322
Replace "foetus (see embryo)" with "foetus (see embryo/foetus)".

p. 324
Replace "programme (see protection and safety programme)" with "programme (see protection and safety)".

INTERNATIONAL BASIC SAFETY STANDARDS FOR PROTECTION AGAINST IONIZING RADIATION AND FOR THE SAFETY OF RADIATION SOURCES

SAFETY SERIES No. 115

INTERNATIONAL BASIC SAFETY STANDARDS FOR PROTECTION AGAINST IONIZING RADIATION AND FOR THE SAFETY OF RADIATION SOURCES

Jointly sponsored by:
Food and Agriculture Organization of the United Nations
International Atomic Energy Agency
International Labour Organisation
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World Health Organization

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FOREWORD

These International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources mark the culmination of efforts that have continued over the past several decades towards the harmonization of radiation protection and safety standards internationally. The Standards are jointly sponsored by the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the International Labour Organisation (ILO), the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), the Pan American Health Organization (PAHO) and the World Health Organization (WHO) (the Sponsoring Organizations).

The unprecedented international effort to draft and review the Standards involved hundreds of experts from the Member States of the Sponsoring Organizations and from specialized organizations. The meeting of the Technical Committee that endorsed the Standards in December 1993 was attended by 127 experts from 52 countries and 11 organizations. A further Technical Committee verified the technical editing and the translations between English and Arabic, Chinese, French, Russian and Spanish.

The IAEA's Board of Governors approved the Standards at its 847th Meeting on 12 September 1994. For PAHO, the XXIV Pan American Sanitary Conference endorsed the Standards on 28 September 1994 following a recommendation from the 113th Meeting of the PAHO Executive Committee on 28 June 1994. The Director General of the FAO confirmed the FAO's technical endorsement of the Standards on 14 November 1994. WHO completed its adoption process for the Standards on 27 January 1995 when the Director-General's report on the subject was noted by the Executive Board at its 95th session. The ILO's Governing Body approved publication of the Standards at its meeting on 17 November 1994. The OECD/NEA Steering Committee approved the Standards at its meeting on 2 May 1995. This completed the authorization process for joint publication by all the Sponsoring Organizations.

The IAEA is herewith issuing the Standards in their final edition, which supersedes the Interim Edition (Safety Series No. 115-I) issued in December 1994. The Standards are issued in the IAEA Safety Series as a final publication in Arabic, Chinese, English, French, Russian and Spanish.

EDITORIAL NOTE

The Principal Requirements of these Standards, which are presented in the main body of the text, generally use the form 'shall' in making statements about requirements, duties and obligations. The Detailed Requirements, which are presented in the Appendices, also use 'shall' in statements consequential to the Principal Requirements, with the implication that these requirements apply unless other more desirable options for protection and safety have been established. As exceptions to this general rule, the requirements on or related to the justification of practices and of interventions, statements referring to the declaration of pregnancy by female workers and a number of statements on medical exposures use the form 'should' to mean a desired option, and a general condition, for protection and safety.

Many Principal Requirements of the Standards are not addressed to any specific party, the implication being that they should be fulfilled by the appropriate party(ies). Conversely, the Detailed Requirements in the Appendices generally specify the appropriate party(ies) responsible for fulfilling the requirement.

The values of committed effective dose per unit intake and the gut transfer factors given in Schedule II are based on the latest information provided by the ICRP and are consistent with the relevant ICRP publications. These values underwent quality assurance checking, as a result of which revisions were made. Please note that the values presented here consequently differ from those published in the Interim Edition of the Standards (Safety Series No. 115-I).

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

PREFACE

BACKGROUND

Although all the Sponsoring Organizations are involved in the international harmonization of radiation protection and safety, the IAEA is specifically authorized under the terms of its Statute to establish standards of safety for the protection of health and the minimization of danger to life, in consultation with the United Nations and the specialized agencies concerned. Not surprisingly, therefore, in the family of international governmental organizations, the first endeavour to establish standards for radiation protection and safety was made at the IAEA. The Board of Governors of the IAEA first approved radiation protection and safety measures in March 1960[1], when it was stated that "The Agency's basic safety standards ... will be based, to the extent possible, on the recommendations of the International Commission on Radiological Protection (ICRP)". The Board first approved basic safety standards in June 1962; they were published by the IAEA as Safety Series No. 9[2]. A revised version was published in 1967[3]. A third revision was published by the IAEA as the 1982 Edition of Safety Series No. 9[4]; this Edition was jointly sponsored by the IAEA, the ILO, the OECD/NEA and the WHO.

In 1990, an important step towards international harmonization of radiation protection and safety took place: an Inter-Agency Committee on Radiation Safety (IACRS) was constituted as a forum for consultation on and collaboration in radiation safety matters between international organizations[5]. The IACRS initially comprised the Commission of the European Communities (CEC), the Council for Mutual Economic Assistance (CMEA) (now defunct), the FAO, the IAEA, the ILO, the OECD/NEA, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and the WHO. The PAHO joined subsequently. The ICRP, the International Commission on Radiation Units and Measurements (ICRU), the International Electrotechnical Commission (IEC), the International Radiation Protection Association (IRPA) and the International Organization for Standardization (ISO)

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[1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Agency's Health and Safety Measures, INFCIRC/18, IAEA, Vienna (1960); The Agency's Safety Standards and Measures, INFCIRC/18/Rev. 1, IAEA, Vienna (1976).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Basic Safety Standards for Radiation Protection, Safety series No. 9, IAEA, Vienna (1962).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Basic Safety Standards for Radiation Protection (1967 Edition), Safety Series No. 9, IAEA, Vienna (1967).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Basic Safety Standards for Radiation Protection (1982 Edition), Safety Series No. 9, IAEA, Vienna (1982).

[5] See IAEA Annual Report for 1990, IAEA/GC(XXXV)/953, p. 86.

have observer status on the IACRS. The objective of the IACRS is to promote consistency and co-ordination of policies with respect to the following areas of common interest: applying principles, criteria and standards of radiation protection and safety and translating them into regulatory terms; co-ordinating research and development; advancing education and training; promoting widespread information exchange; facilitating the transfer of technology and know-how; and providing services in radiation protection and safety.

Within this framework, the Sponsoring Organizations established a Joint Secretariat for the preparation of the International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, the 'Standards', contained in this publication. The Joint Secretariat was co-ordinated by the IAEA. The Standards supersede the previous basic international standards and reflect knowledge gained subsequently and developments in radiation protection and safety and related fields.

The Standards are based primarily on the recommendations of the ICRP. The ICRP is a non-governmental scientific organization founded in 1928 to establish basic principles and recommendations for radiation protection; the most recent recommendations of the ICRP were issued in 1991[6].

Moreover, in relation to safety, the Standards take account of the principles recommended by the International Nuclear Safety Advisory Group (INSAG) which, under the auspices of the IAEA, has been elaborating nuclear safety concepts since 1985, such as its Basic Safety Principles for Nuclear Power Plants[7]; many of these principles are relevant to radiation sources and installations other than nuclear installations. The quantities and units used in the Standards are primarily those recommended by the ICRU, a sister organization of the ICRP.

The Standards are published in the IAEA Safety Series. This series of publications encompasses Safety Fundamentals, Safety Standards, Safety Guides and Safety Practices relating to nuclear safety and radiation protection, including radioactive waste management[8]. The IAEA Safety Series includes other related international standards, such as the Nuclear Safety Standards (NUSS) for nuclear power plants, the Regulations for the Safe Transport of Radioactive Material, and the forthcoming Radioactive Waste Management Standards (RADWASS). The other organizations of

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[6] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 1990 Recommendations of the International Commission on Radiological Protection, Publication No. 60, Pergamon Press, Oxford and New York (1991).

[7] INTERNATIONAL NUCLEAR SAFETY ADVISORY GROUP, Basic Safety Principles for Nuclear Power Plants, Safety Series No. 75-INSAG-3, IAEA, Vienna (1988).

[8] The objectives and principles underlying the Standards are summarized in INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and the Safety of Radiation Sources: Safety Fundamentals, Safety Series No. 120, IAEA, Vienna (1996).

the Joint Secretariat have also produced codes and guides in their respective spheres of activity. Notably, the ILO has issued a code of practice for the radiation protection of workers as well as other relevant publications; the PAHO and the WHO have issued a number of documents relating to the safety of workers and patients in medical applications of radiation; the FAO and the WHO have established, through the Codex Alimentarius Commission, guideline levels for radioactive substances in foodstuffs moving in international trade; and the OECD/NEA has published documents on specific topics relating to radiation protection and safety.

OBJECTIVE

The purpose of the Standards is to establish basic requirements for protection against the risks associated with exposure to ionizing radiation (hereinafter termed radiation) and for the safety of radiation sources that may deliver such exposure.

The Standards have been developed from widely accepted radiation protection and safety principles, such as those published in the Annals of the ICRP and the IAEA Safety Series. They are intended to ensure the safety of all types of radiation sources and, in doing so, to complement standards already developed for large and complex radiation sources, such as nuclear reactors and radioactive waste management facilities. For these sources, more specific standards, such as those issued by the IAEA, are typically needed to achieve acceptable levels of safety. As these more specific standards are generally consistent with the Standards, in complying with them, such more complex installations will also generally comply with the Standards.

The Standards are limited to specifying basic requirements of radiation protection and safety, with some guidance on how to apply them. General guidance on applying some of the requirements is available in the publications of the Sponsoring Organizations and additional guidance will be developed as needed in the light of experience gained in the application of the Standards.

SCOPE

The Standards comprise basic requirements to be fulfilled in all activities involving radiation exposure. The requirements have the force that is derived from the statutory provisions of the Sponsoring Organizations. They do not entail any obligation for States to bring their legislation into conformity with them, nor are they intended to replace the provisions of national laws or regulations, or the standards in force. They are aimed rather to serve as a practical guide for public authorities and services, employers and workers, specialized radiation protection bodies, enterprises and safety and health committees.

The Standards lay down basic principles and indicate the different aspects that should be covered by an effective radiation protection programme. They are not intended to be applied as they stand in all countries and regions, but should be interpreted to take account of local situations, technical resources, the scale of installations and other factors which will determine the potential for application.

The Standards cover a broad range of practices and sources that give rise to or could give rise to exposure to radiation, and many of the requirements have therefore been drafted in general terms. It follows that any given requirement may have to be fulfilled differently for different types of practice and source, according to the nature of the operations and the potential for exposures. Not all the requirements will apply to every practice or to every source, and it is up to the appropriate Regulatory Authority to specify which of the requirements are applicable in each case.

The scope of the Standards is limited to the protection of human beings only; it is considered that standards of protection that are adequate for this purpose will also ensure that no other species is threatened as a population, even if individuals of the species may be harmed. Moreover, the Standards apply only to ionizing radiation, namely gamma and X rays and alpha, beta and other particles that can induce ionization. They do not apply to non-ionizing radiation such as microwave, ultraviolet, visible light and infrared radiation. They do not apply either to the control of non-radiological aspects of health and safety. The Standards recognize that radiation is only one of many sources of risk in life, and that the risks associated with radiation should not only be weighed against its benefits but also viewed in perspective with other risks.

STRUCTURE

The Standards comprise a Preamble, the Principal Requirements, Appendices and Schedules. The Preamble states the aims and the bases of the Standards, explains the underlying principles and philosophy, and describes appropriate governmental arrangements for applying the Standards. The Principal Requirements specify what is imperative in order to fulfil the aims of the Standards. Consequential Detailed Requirements, subsidiary to the Principal Requirements, are specified in the Appendices. Quantitative standards and guidance are provided in the Schedules. A Glossary, the list of experts who contributed to the drafting and review process, and the list of the representatives of countries and organizations on the Technical Committees which endorsed the Standards in December 1993 and which verified the translations and technical editing of the Standards in August/September 1994 are also included. The Sponsoring Organizations are also briefly described.

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PREAMBLE: PRINCIPLES AND FUNDAMENTAL OBJECTIVES

It has been recognized since early studies on X rays and radioactive minerals that exposure to high levels of radiation can cause clinical damage to the tissues of the human body. In addition, long term epidemiological studies of populations exposed to radiation, especially the survivors of the atomic bombing of Hiroshima and Nagasaki in Japan in 1945, have demonstrated that exposure to radiation also has a potential for the delayed induction of malignancies. It is therefore essential that activities involving radiation exposure, such as the production and use of radiation sources and radioactive materials, and the operation of nuclear installations, including the management of radioactive waste, be subject to certain standards of safety in order to protect those individuals exposed to radiation.

Radiation and radioactive substances are natural and permanent features of the environment, and thus the risks associated with radiation exposure can only be restricted, not eliminated entirely. Additionally, the use of human made radiation is widespread. Sources of radiation are essential to modern health care: disposable medical supplies sterilized by intense radiation have been central to combating disease; radiology is a vital diagnostic tool; and radiotherapy is commonly part of the treatment of malignancies. The use of nuclear energy and applications of its by-products, i.e. radiation and radioactive substances, continue to increase around the world. Nuclear techniques are in growing use in industry, agriculture, medicine and many fields of research, benefiting hundreds of millions of people and giving employment to millions of people in the related occupations. Irradiation is used around the world to preserve foodstuffs and reduce wastage, and sterilization techniques have been used to eradicate disease carrying insects and pests. Industrial radiography is in routine use, for example to examine welds and detect cracks and help prevent the failure of engineered structures.

The acceptance by society of risks associated with radiation is conditional on the benefits to be gained from the use made of radiation. Nonetheless, the risks must be restricted and protected against by the application of radiation safety standards. The Standards provide a desirable international consensus for this purpose.

The Standards draw upon information derived from extensive research and development work by scientific and engineering organizations, at national and international levels, on the health effects of radiation and on techniques for the safe design and operation of radiation sources; and draw upon experience in many countries in the use of radiation and nuclear techniques. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), a body set up by the United Nations in 1955, compiles, assesses and disseminates information on the health effects of radiation and on levels of radiation exposure due to different sources; this information was taken into account in developing the Standards. Purely *scientific considerations, however, are only part of the basis for decisions on protection and safety, and the Standards implicitly encourage decision makers to make value judgements about the relative importance of risks of different kinds and about the balancing of risks and benefits.*

RADIATION EFFECTS

Exposure to radiation at high doses can cause effects such as nausea, reddening of the skin or, in severe cases, more acute syndromes that are clinically expressed in exposed individuals within a short period of time after the exposure. Such effects are termed 'deterministic effects' because they are certain to occur if the dose exceeds a threshold level. Radiation exposure can also induce somatic effects such as malignancies which are expressed after a latency period and may be epidemiologically detectable in a population; this induction is assumed to take place over the entire range of doses without a threshold level. Also, hereditary effects due to radiation exposure have been statistically detected in other mammalian populations and are presumed to occur in human populations also. These epidemiologically detectable effects — malignancies and hereditary effects — are termed 'stochastic effects' because of their random nature.

Deterministic effects are the result of various processes, mainly cell death and delayed cell division, caused by exposure to high levels of radiation. If extensive enough, these can impair the function of the exposed tissue. The severity of a particular deterministic effect in an exposed individual increases with the dose above the threshold for the occurrence of the effect.

Stochastic effects may ensue if an irradiated cell is modified rather than killed. Modified cells may, after a prolonged process, develop into a cancer. The body's repair and defence mechanisms make this a very improbable outcome at small doses; nevertheless, there is no evidence of a threshold dose below which cancer cannot result. The probability of occurrence of cancer is higher for higher doses, but the severity of any cancer that may result from irradiation is independent of the dose. If the cell damaged by radiation exposure is a germ cell, whose function is to transmit genetic information to progeny, it is conceivable that hereditary effects of various types may develop in the descendants of the exposed individual. The likelihood of stochastic effects is presumed to be proportional to the dose received, without a dose threshold.

In addition to the aforementioned health effects, other health effects may occur in infants due to exposure of the embryo or foetus to radiation. These effects include a greater likelihood of leukaemia and, for exposure above various threshold dose values during certain periods of pregnancy, severe mental retardation and congenital malformations.

Since a small likelihood of occurrence of stochastic effects at even the lowest doses is assumed, the Standards cover the entire range of doses with the aim of constraining any radiation detriment that may arise. The many aspects of the concept of radiation detriment make it undesirable to select any single quantity to represent it. The Standards are therefore based on a concept of detriment as recommended by the ICRP, which for stochastic effects includes the following quantities: the probability of fatal cancer attributable to radiation exposure; the weighted probability of incurring a non-fatal cancer; the weighted probability of severe hereditary effects; and the length of lifetime lost if the harm occurs.

PRACTICES AND INTERVENTIONS

Human activities that add radiation exposure to that which people normally incur due to background radiation, or that increase the likelihood of their incurring exposure, are termed 'practices' in the Standards. The human activities that seek to reduce the existing radiation exposure, or the existing likelihood of incurring exposure which is not part of a controlled practice, are termed 'interventions'.

The Standards apply to both the commencement and the continuation of practices that involve or could involve radiation exposure, and also to existing de facto situations in which exposure or its likelihood can be reduced or prevented by means of some intervention. For a practice, provisions for radiation protection and safety can be made before its commencement, and the associated radiation exposures and their likelihood can be restricted from the outset. In the case of intervention, the circumstances giving rise to exposure or the likelihood of exposure already exist, and their reduction can only be achieved by means of remedial or protective actions.

The practices for which the Standards are intended include the following: activities involving the production of radiation sources; the use of radiation and radioactive substances in medicine, research, industry, agriculture and teaching; the generation of nuclear power, including the entire cycle of related activities from the mining and processing of radioactive ores to the operation of nuclear reactors and fuel cycle facilities and the management of radioactive wastes; and activities, such as the underground mining of coal and of phosphatic and other minerals, that may enhance exposure to naturally occurring radioactive substances. Situations that may require intervention include: chronic exposure to naturally occurring sources of radiation such as radon in dwellings, and to radioactive residues from past activities and events; and emergency exposure situations such as might result from accidents or from deficiencies in existing practices.

TYPES OF RADIATION EXPOSURE

It is virtually certain that some radiation exposures will result from the normal performance of practices and that their magnitudes will be predictable, albeit with some degree of uncertainty: such expected exposures are referred to in the Standards as 'normal exposures'. Also, exposure scenarios can be envisaged for which there is a potential for exposure, but no certainty that an exposure will in fact occur; such unexpected but feasible exposures are termed 'potential exposures'. Potential exposures can become actual exposures if the unexpected situation does occur; for example as a consequence of equipment failure, design or operating errors, or unforeseen changes in environmental conditions, e.g. at a disposal site for radioactive waste. If the occurrence of such events can be foreseen, the probability of their occurrence and the resulting radiation exposure can be estimated.

The means specified in the Standards for controlling normal exposures is the restriction of the doses delivered. The primary means for controlling potential exposures is by good design of installations, equipment and operating procedures; this is intended to restrict the probability of occurrence of events that could lead to unplanned exposures and to restrict the magnitudes of the exposures that could result if such events were to occur.

The relevant radiation exposures covered by the Standards encompass the exposures, both normal and potential, of workers pursuing their occupations, of patients in diagnosis or treatment, and of members of the public who may be affected by a practice or by an intervention. For intervention situations the exposure can be chronic or, in some cases of emergencies, temporary. Thus exposures are divided into: 'occupational exposures' which are incurred at work and principally as a result of work; 'medical exposures' which are principally exposures of patients in diagnosis or treatment; and 'public exposures' which comprise all other exposures.

The Standards are intended to cover all people who may be exposed to radiation, including those in future generations who could be affected by present practices or interventions.

BASIC PRINCIPLES

The principles of radiation protection and safety on which the Standards are based are those developed by the ICRP and by INSAG. The detailed formulation of these principles can be found in the publications of these bodies and they cannot easily be paraphrased without losing their essence. However, a brief — although simplified — summary of the principles is as follows: a practice that entails or that could entail exposure to radiation should only be adopted if it yields sufficient benefit to the exposed individuals or to society to outweigh the radiation detriment it causes *or could cause (i.e. the practice must be justified)*[1]*; individual doses due to the combination of exposures from all relevant practices should not exceed specified dose limits; radiation sources and installations should be provided with the best available protection and safety measures under the prevailing circumstances, so that the magnitudes and likelihood of exposures and the numbers of individuals exposed be as low as reasonably achievable, economic and social factors being taken into account, and the doses they deliver and the risk they entail be constrained (i.e. protection and safety should be optimized); radiation exposure due to sources of radiation that are not part of a practice should be reduced by intervention when this is justified, and the intervention measures should be optimized; the legal person authorized to engage in a practice involving a source of radiation should bear the primary responsibility for protection and safety; a safety culture should be inculcated that governs the attitudes and behaviour in relation to protection and safety of all individuals and organizations dealing with sources of radiation; in-depth defensive measures should be incorporated into the design and operating procedures for radiation sources to compensate for potential failures in protection or safety measures;and protection and safety should be ensured by sound management and good engineering, quality assurance, training and qualification of personnel, comprehensive safety assessments and attention to lessons learned from experience and research.*

QUANTITIES AND UNITS

Although most of the requirements of the Standards are qualitative, the Standards also establish quantitative limits, and guidance levels. For these purposes, the main physical quantities used in the Standards are the rate of nuclear transformation of radionuclides (the activity) and the energy absorbed by a unit mass of a substance from the radiation to which it is exposed (the absorbed dose). The unit of activity is the reciprocal second, representing the number of nuclear transformations (or disintegrations) per second, which is termed the becquerel (Bq). The unit of absorbed dose is the joule per kilogram, termed the gray (Gy).

The absorbed dose is the basic physical dosimetric quantity of the Standards. However, it is not entirely satisfactory for radiation protection purposes because effectiveness in damaging human tissue differs for different types of ionizing radiation. Consequently, the absorbed dose averaged over a tissue or organ is multiplied by a radiation weighting factor to take account of the effectiveness of the given type of radiation in inducing health effects; the resulting quantity is termed the equivalent

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[1] *Usually, compliance with the principle of justification is adequately demonstrated in respect of a type of activity by the existence or the laying down of regulations specifically concerning the type of activity.*

dose. The quantity equivalent dose is used when individual organs or tissues are irradiated, but the likelihood of injurious stochastic effects due to a given equivalent dose differs for different organs and tissues. Consequently, the equivalent dose to each organ and tissue is multiplied by a tissue weighting factor to take account of the organ's radiosensitivity. The sum total of such weighted equivalent doses for all exposed tissues in an individual is termed the effective dose. The unit of equivalent dose and of effective dose is the same as that of absorbed dose, namely joule per kilogram, but the name sievert (Sv) is used in order to avoid confusion with the unit of absorbed dose (Gy).

When radionuclides are taken into the body, the resulting dose is received throughout the period of time during which they remain in the body. The committed dose is the total dose delivered during this period of time, and is calculated as a specified time integral of the rate of receipt of the dose. Any relevant dose restriction is applied to the committed dose from the intake.

The total impact of the radiation exposure due to a given practice or source depends on the number of individuals exposed and on the doses they receive. The collective dose, defined as the summation of the products of the mean dose in the various groups of exposed people and the number of individuals in each group, may therefore be used to characterize the radiation impact of a practice or source. The unit of collective dose is the man-sievert (man·Sv).

GOVERNMENTAL REGULATION

The Standards are intended to place requirements on those legal persons authorized to conduct practices that cause radiation exposure or to intervene in order to reduce existing exposures; these legal persons have the primary responsibility for applying the Standards. Governments, however, have responsibility for their enforcement, generally through a system that includes a Regulatory Authority, and for planning and taking actions in different circumstances. In addition, Governments generally provide for certain essential services for radiation protection and safety and for interventions that exceed or that complement the capabilities of the legal persons authorized to conduct practices.

The Standards are based therefore on the presumption that a national infrastructure is in place enabling the Government to discharge its responsibilities for radiation protection and safety.

NATIONAL INFRASTRUCTURES

Essential parts of a national infrastructure are: legislation and regulations; a Regulatory Authority empowered to authorize and inspect regulated activities and to enforce the legislation and regulations; sufficient resources; and adequate *numbers of trained personnel. The infrastructures must also provide ways and means of addressing societal concerns which extend beyond the legal responsibilities of the legal persons authorized to conduct practices involving sources of radiation. For example, national authorities ensure that appropriate arrangements are made for detecting any buildup of radioactive substances in the general environment, for disposing of radioactive wastes and for preparing for interventions, particularly during emergencies that could result in exposure of the general public. They also need to provide for the control of sources of radiation for which no other organization has responsibility, such as natural sources and radioactive residues from past practices.*

National infrastructures must provide for adequate arrangements to be made by those responsible for the education and training of specialists in radiation protection and safety, as well as for the exchange of information among specialists. A related responsibility is to set up appropriate means of informing the public, its representatives and the information media about the health and safety aspects of activities involving exposure to radiation and about regulatory processes. This provides information to facilitate the political process of setting national priorities and allocating resources for protection and safety and also helps to make the regulatory process more readily understandable.

National infrastructures must also provide facilities and services that are essential for radiation protection and safety, but are beyond the capabilities required of the legal persons who are authorized to conduct practices. Such facilities and services include those needed for intervention, personal dosimetry and environmental monitoring, and for calibration and intercomparison of radiation measuring equipment. Services could include the provision of central registries for occupational exposure records and the provision of information on equipment reliability. The provision of such services at the national level does not detract from the ultimate responsibility for radiation protection and safety borne by the legal persons authorized to conduct the practices.

THE REGULATORY AUTHORITY

Full and proper implementation of the Standards requires that a Regulatory Authority be established by the Government to regulate the introduction and conduct of any practice involving sources of radiation. Such a Regulatory Authority must be provided with sufficient powers and resources for effective regulation and should be independent of any Government departments and agencies that are responsible for the promotion and development of the practices being regulated. The Regulatory Authority must also be independent of registrants, licensees and the designers and constructors of the radiation sources used in practices. The effective separation of responsibilities between the functions of the Regulatory Authority and those of any *other party is to be made clear so that the regulators retain their independence of judgement and decision as safety authorities.*

The Standards are worded on the assumption that a single Regulatory Authority is responsible for all aspects of radiation protection and safety in a country. In some countries, however, regulatory responsibility for different practices or different aspects of radiation protection and safety may be divided between different authorities. Consequently, the term Regulatory Authority is generally used in the Standards to mean the relevant Regulatory Authority for the particular source or aspect of radiation safety in question. Regardless of the division of regulatory responsibilities, the government must ensure that all aspects are covered; for example, it must ensure that a specific body is assigned responsibility for the regulatory surveillance of protection and safety measures for patients and of quality assurance measures for equipment and techniques for medical uses of radiation.

The type of regulatory system adopted in a country will depend on the size, complexity and safety implications of the regulated practices and sources, as well as on the regulatory traditions in the country. The mechanism for carrying out regulatory duties may vary, with some authorities being completely self-sufficient and others delegating some inspection, assessment or other duties to various governmental, public or private agencies. A Regulatory Authority may also be self-sufficient in specialist expertise or it may consult expert advisers and advisory committees.

The general functions of the Regulatory Authority include the following: the assessment of applications for permission to conduct practices that entail or could entail exposure to radiation; the authorization of such practices and of the sources associated with them, subject to certain specified conditions; the conduct of periodic inspections to verify compliance with the conditions; and the enforcement of any necessary actions to ensure compliance with the regulations and standards. For these purposes, mechanisms are needed for notification, registration and licensing of the sources within practices, with provision for the exclusion or exemption of sources or practices from regulatory requirements under certain conditions. Provision is also needed for the surveillance, monitoring, review, verification and inspection of sources and for ensuring that adequate plans exist for dealing with radiation accidents and carrying out emergency interventions. The effectiveness of radiation protection and safety measures for each authorized practice and the total potential impact of authorized practices need to be assessed.

The powers of the inspectors of the Regulatory Authority must be well defined and consistency of enforcement must be maintained, with provision for appeal by those responsible for sources. Directives to both inspectors and regulated legal persons must be clear. The Regulatory Authority may need to provide guidance on how certain regulatory requirements are to be fulfilled for various practices, for example in regulatory guideline documents. An attitude of openness and co-operation must be fostered between regulated legal persons and inspectors, which includes facilitating access by inspectors to premises and to information.

An additional responsibility of the Regulatory Authority is to require all parties involved to develop a safety culture that includes: individual and collective commitment to safety on the part of workers, management and regulators; accountability of all individuals for protection and safety, including individuals at senior management level; and measures to encourage a questioning and learning attitude and to discourage complacency with respect to safety.

Due account needs to be taken by both the Regulatory Authority and the regulated legal persons of general experience and of new developments in radiation protection and the safety of sources.

PRINCIPAL REQUIREMENTS

1. GENERAL REQUIREMENTS

DEFINITIONS

1.1. Terms shall be interpreted as defined in the Glossary.

PURPOSE

1.2. These Standards specify the basic requirements for protection of people against exposure to ionizing radiation and for the safety of radiation sources, hereinafter termed protection and safety.

SCOPE

1.3. The Standards apply to practices, including any sources within the practices, and interventions which are:

(a) carried out in a State that chooses to adopt the Standards or requests any of the Sponsoring Organizations to provide for the application of the Standards;
(b) undertaken by States with the assistance of the FAO, the IAEA, the ILO, the PAHO, or the WHO, in the light of relevant national rules and regulations;
(c) carried out by the IAEA or involve the use of materials, services, equipment, facilities and non-published information made available by the IAEA or at its request or under its control or supervision; or
(d) carried out under any bilateral or multilateral arrangement whereby the parties request the IAEA to provide for the application of the Standards.

EXCLUSIONS

1.4. Any exposure whose magnitude or likelihood is essentially unamenable to control through the requirements of the Standards is deemed to be excluded from the Standards[2].

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[2] Examples are exposure from ^{40}K in the body, from cosmic radiation at the surface of the earth and from unmodified concentrations of radionuclides in most raw materials.

RESPONSIBLE PARTIES

1.5. The Regulatory Authority and, in the case of intervention, the Intervening Organizations shall be responsible for the enforcement of the Standards.

1.6. The principal parties having the main responsibilities for the application of the Standards shall be:

(a) registrants or licensees; and
(b) employers.

1.7. Other parties shall have subsidiary responsibilities for the application of the Standards. These parties may include, as appropriate:

(a) suppliers;
(b) workers;
(c) radiation protection officers;
(d) medical practitioners;
(e) health professionals;
(f) qualified experts;
(g) Ethical Review Committees; and
(h) any other party to whom a principal party has delegated specific responsibilities.

1.8. The parties shall have the general and specific responsibilities set out in the Standards.

1.9. The general responsibilities of principal parties, within the requirements specified by the Regulatory Authority, are:

(a) to establish protection and safety objectives in conformity with the relevant requirements of the Standards; and
(b) to develop, implement and document a protection and safety programme commensurate with the nature and extent of the risks associated with the practices and interventions under their responsibility and sufficient to ensure compliance with the requirements of the Standards, and, within this programme:
    (i) to determine the measures and resources needed to achieve the protection and safety objectives and to ensure that the resources are provided and the measures properly implemented;
    (ii) to keep such measures and resources continually under review, and regularly to verify that the protection and safety objectives are being achieved;
    (iii) to identify any failures and shortcomings in the protection and safety measures and resources, and to take steps to correct them and prevent their recurrence;

(iv) to establish arrangements, through representatives if appropriate, for facilitating consultation and co-operation between all relevant parties with respect to protection and safety; and
(v) to keep appropriate records regarding the discharge of their responsibilities.

INSPECTIONS

1.10. The principal parties shall permit duly authorized representatives of the Regulatory Authority, and of the relevant Sponsoring Organizations when applicable, to inspect their protection and safety records and to carry out appropriate inspections of their authorized activities.

NON-COMPLIANCE

1.11. In the event of a breach of any applicable requirement of the Standards, principal parties shall, as appropriate:

(a) investigate the breach and its causes, circumstances and consequences;
(b) take appropriate action to remedy the circumstances that led to the breach and to prevent a recurrence of similar breaches;
(c) communicate to the Regulatory Authority, and to the relevant Sponsoring Organizations when applicable, on the causes of the breach and on the corrective or preventive actions taken or to be taken; and
(d) take whatever other actions are necessary as required by the Standards.

1.12. The communication of a breach of the Standards shall be prompt and it shall be immediate whenever an emergency exposure situation has developed or is developing.

1.13. Failure to take corrective or preventive actions within a reasonable time in accordance with national regulations shall be grounds for modifying, suspending or withdrawing any authorization that had been granted by the Regulatory Authority or, when applicable, by the relevant Sponsoring Organization.

1.14. Wilful breach of, attempted breach of or conspiracy to breach any requirement of the Standards shall be subject to the provisions for such infractions by the appropriate national legislation of the State, or by the Regulatory Authority or, when applicable, by the relevant Sponsoring Organization.

ENTRY INTO FORCE

1.15. The Standards shall come into force one year after the date of their adoption or acknowledgement, as appropriate, by the relevant Sponsoring Organization.

1.16. Should a State choose to adopt the Standards, the Standards shall come into force at the time indicated in the formal adoption by that State.

1.17. If a modification to an existing practice or source is required by the Regulatory Authority or, where applicable, by the relevant Sponsoring Organization, in order to comply with some requirement of the Standards, such a requirement shall take effect within an approved period if such a period is required for the modification.

RESOLUTION OF CONFLICTS

1.18. The requirements of the Standards are in addition to and not in place of other applicable requirements, such as those of relevant binding conventions and national regulations.

1.19. In cases of conflict between the requirements of the Standards and other applicable requirements, the Regulatory Authority shall determine which requirement is to be enforced.

1.20. Nothing in the Standards shall be construed as restricting any actions that may otherwise be necessary for protection and safety.

INTERPRETATION

1.21. Except as specifically authorized by the statutory Governing Body of a relevant Sponsoring Organization, no interpretation of the Standards by any officer or employee of the Sponsoring Organization other than a written interpretation by the Director General of the Sponsoring Organization will be binding on the Sponsoring Organization.

COMMUNICATIONS

1.22. The appropriate responsible party, as established by the Standards, shall report on compliance with the requirements of the Standards.

1.23. Reports on compliance and other communications on official interpretation of the Standards shall be addressed to the Regulatory Authority or the relevant Sponsoring Organizations, as appropriate.

2. REQUIREMENTS FOR PRACTICES

APPLICATION

Practices

2.1. The practices to which the Standards shall apply include:

(a) the production of sources and the use of radiation or radioactive substances for medical, industrial, veterinary or agricultural purposes, or for education, training or research, including any activities related to that use which involve or could involve exposure to radiation or radioactive substances;
(b) the generation of nuclear power, including any activities in the nuclear fuel cycle which involve or could involve exposure to radiation or radioactive substances;
(c) practices involving exposure to natural sources specified by the Regulatory Authority as requiring control; and
(d) any other practice specified by the Regulatory Authority.

Sources

2.2. The sources within any practice to which the requirements for practices of the Standards shall apply include:

(a) radioactive substances and devices that contain radioactive substances or produce radiation, including consumer products, sealed sources, unsealed sources, and radiation generators, including mobile radiography equipment;
(b) installations and facilities which contain radioactive substances or devices which produce radiation, including irradiation installations, mines and mills processing radioactive ores, installations processing radioactive substances, nuclear installations, and radioactive waste management facilities; and
(c) any other source specified by the Regulatory Authority.

2.3. The requirements of the Standards shall apply to each individual source of radiation within an installation or facility and to the complete installation or facility regarded as a source, as appropriate, according to the requirements of the Regulatory Authority.

Exposures

2.4. The exposures to which the requirements of the Standards apply are any occupational exposure, medical exposure or public exposure due to any relevant practice or source within the practice, including both normal exposures and potential exposures.

2.5. Exposure to natural sources shall normally be considered as a chronic exposure situation and, if necessary, shall be subject to the requirements for intervention, except that[3]:

(a) public exposure delivered by effluent discharges or the disposal of radioactive waste arising from a practice involving natural sources shall be subject to the requirements for practices given here, unless the exposure is excluded or the practice or the source is exempted; and
(b) occupational exposure of workers to natural sources shall be subject to the requirements for practices given in this section if these sources lead to:
    (i) exposure to radon required by or directly related to their work, irrespective of whether the exposure is higher or lower than the action level for remedial action relating to chronic exposure situations involving radon in workplaces[4], unless the exposure is excluded or the practice or the source is exempted; or
    (ii) exposure to radon incidental to their work, but the exposure is higher than the action level for remedial action relating to chronic exposure situations involving radon in workplaces[4]; unless the exposure is excluded or the practice or the source is exempted; or
    (iii) exposure specified by the Regulatory Authority to be subject to such requirements.

2.6. The detailed requirements for occupational exposures, medical exposures, public exposures and potential exposures are specified in Appendices I, II, III and IV respectively. These shall be considered consequential requirements subsidiary to those established in this Section, unless other more desirable options for protection and safety are established by the Regulatory Authority or, where applicable, by the relevant Sponsoring Organization.

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[3] At the time of the endorsement of the Standards, the available quantitative recommendations of the ICRP for protection against exposure to natural sources were confined to radon. It was therefore decided that the General Obligations for practices concerning protection against natural sources will be that exposure to natural sources, which is normally a chronic exposure situation, should be subject to intervention and that the requirements for practices should be generally limited to exposure to radon, the exposure to other natural sources being expected to be dealt with by exclusion or exemption of the source or otherwise at the discretion of the Regulatory Authority.

[4] See Schedule VI, Guidelines for Action Levels in Chronic Exposure Situations, para. VI-3.

BASIC OBLIGATIONS

General obligations

2.7. No practice shall be adopted, introduced, conducted, discontinued or ceased and no source within a practice shall, as applicable, be mined, milled, processed, designed, manufactured, constructed, assembled, acquired, imported, exported, distributed, sold, loaned, hired, received, sited, located, commissioned, possessed, used, operated, maintained, repaired, transferred, decommissioned, disassembled, transported, stored or disposed of, except in accordance with the appropriate requirements of the Standards, unless the exposure from such practice or source is excluded from the Standards or the practice or source is exempted from the requirements of the Standards, including the requirements of notification and authorization.

2.8. The application of the requirements of the Standards to any practice or any source within a practice or to any of the actions specified in para. 2.7 shall be commensurate with the characteristics of the practice or source and with the magnitude and likelihood of the exposures and shall also conform to any requirements specified by the Regulatory Authority or, whenever applicable, by the relevant Sponsoring Organizations. Not all the requirements are relevant for every practice or source, nor for all the actions specified in para. 2.7.

2.9. The transport of radioactive sources shall be subject to the requirements of the IAEA Regulations for the Safe Transport of Radioactive Material[5] and any applicable international convention.

ADMINISTRATIVE REQUIREMENTS

Notification

2.10. Any legal person intending to carry out any of the actions specified under the General Obligations for practices of the Standards (see paras 2.7 and 2.8) shall submit a notification to the Regulatory Authority of such an intention[6]. Notification for consumer products is required only with respect to manufacturing, assembling, importing and distributing.

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[5] See the most recent edition of the IAEA Regulations for the Safe Transport of Radioactive Material (published as IAEA Safety Series No. 6 (1990); 1996 edition to be issued).

[6] Notification alone is sufficient provided that the normal exposures associated with the practice or action are unlikely to exceed a small fraction, specified by the Regulatory Authority, of the relevant limits, and that the likelihood and expected amount of potential exposure and any other detrimental consequence are negligible.

Authorization: registration or licensing

2.11. The legal person responsible for any sealed source, unsealed source or radiation generator shall, unless the source is exempted, apply to the Regulatory Authority for an authorization which shall take the form of either a registration[7] or a licence.

2.12. The legal person responsible for any irradiation installation, mine or mill processing radioactive ores, installation processing radioactive substances, nuclear installation or radioactive waste management facility, or for any use of a source which the Regulatory Authority has not designated as suitable for registration, shall apply to the Regulatory Authority for an authorization which shall take the form of a licence.

2.13. Any legal person applying for an authorization shall:

(a) submit to the Regulatory Authority and, if applicable, the relevant Sponsoring Organization relevant information necessary to support the application;
(b) refrain from carrying out any of the actions described in the General Obligations for practices of the Standards (see paras 2.7 and 2.8) until the registration or licence, as appropriate, has been granted;
(c) make an assessment of the nature, magnitude and likelihood of the exposures attributed to the source and take all necessary steps for the protection and safety of both workers and the public; and
(d) if the potential for an exposure is greater than any level specified by the Regulatory Authority, have a safety assessment made and submitted to the Regulatory Authority as part of the application.

2.14. The legal person responsible for a source to be used for medical exposure shall include in the application for authorization:

(a) the qualifications in radiation protection of the medical practitioners who are to be so designated by name in the registration or licence; or
(b) a statement that only medical practitioners with the qualifications in radiation protection specified in the relevant regulations or to be specified in the registration or licence will be permitted to prescribe medical exposure by means of the authorized source.

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[7] Typical practices that are amenable to registration are those for which: (a) safety can largely be ensured by the design of the facilities and equipment; (b) the operating procedures are simple to follow; (c) the safety training requirements are minimal; and (d) there is a history of few problems with safety in operations. Registration is best suited to those practices for which operations do not vary significantly.

Authorized legal persons: registrants and licensees

2.15. Registrants and licensees shall bear the responsibility for setting up and implementing the technical and organizational measures that are needed for ensuring protection and safety for the sources for which they are authorized. They may appoint other people to carry out actions and tasks related to these responsibilities, but they shall retain the responsibility for the actions and tasks themselves. Registrants and licensees shall specifically identify the individuals responsible for ensuring compliance with the Standards.

2.16. Registrants and licensees shall notify the Regulatory Authority of their intentions to introduce modifications to any practice or source for which they are authorized, whenever the modifications could have significant implications for protection or safety, and shall not carry out any such modification unless specifically authorized by the Regulatory Authority.

Exemption

2.17. Practices and sources within a practice may be exempted from the requirements of the Standards provided that such sources comply with:

(a) the requirements on exemption specified in Schedule I, or
(b) any exemption levels defined by the Regulatory Authority on the basis of the exemption criteria specified in Schedule I.

2.18. Exemption shall not be granted for practices deemed not to be justified.

Clearance

2.19. Sources, including substances, materials and objects, within notified or authorized practices may be released from further requirements of the Standards subject to complying with clearance levels approved by the Regulatory Authority. Such clearance levels shall take account of the exemption criteria specified in Schedule I and shall not be higher than the exemption levels specified in Schedule I or defined by the Regulatory Authority on the basis of the criteria specified in Schedule I, unless otherwise approved by the Regulatory Authority[8].

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[8] Clearance of bulk amounts of materials with activity concentrations lower than the guidance exemption levels specified in Table I-I of Schedule I may require further consideration by the Regulatory Authority.

RADIATION PROTECTION REQUIREMENTS

Justification of practices

2.20. No practice or source within a practice should be authorized unless the practice produces sufficient benefit to the exposed individuals or to society to offset the radiation harm that it might cause; that is: unless the practice is justified, taking into account social, economic and other relevant factors.

2.21. Detailed requirements for the justification of practices involving medical exposures are given in Appendix II.

2.22. Except for justified practices involving medical exposures, the following practices are deemed to be not justified whenever they would result in an increase, by deliberate addition of radioactive substances or by activation, in the activity of the associated commodities or products:

(a) practices involving food, beverages, cosmetics or any other commodity or product intended for ingestion, inhalation or percutaneous intake by, or application to, a human being; and
(b) practices involving the frivolous use of radiation or radioactive substances in commodities or products such as toys and personal jewellery or adornments.

Dose limitation

2.23. The normal exposure of individuals shall be restricted so that neither the total effective dose nor the total equivalent dose to relevant organs or tissues, caused by the possible combination of exposures from authorized practices, exceeds any relevant dose limit specified in Schedule II, except in special circumstances provided for in Appendix I. Dose limits shall not apply to medical exposures from authorized practices.

Optimization of protection and safety

2.24. In relation to exposures from any particular source within a practice, except for therapeutic medical exposures, protection and safety shall be optimized in order that the magnitude of individual doses, the number of people exposed and the likelihood of incurring exposures all be kept as low as reasonably achievable, economic and social factors being taken into account, within the restriction that the doses to individuals delivered by the source be subject to dose constraints.

2.25. The process of optimization of protection and safety measures may range from intuitive qualitative analyses to quantitative analyses using decision aiding techniques, but shall be sufficient to take all relevant factors into account in a coherent way so as to contribute to achieving the following objectives:

(a) to determine optimized protection and safety measures for the prevailing circumstances, with account taken of the available protection and safety options as well as the nature, magnitude and likelihood of exposures; and
(b) to establish criteria, on the basis of the results of the optimization, for the restriction of the magnitudes of exposures and of their probabilities by means of measures for preventing accidents and mitigating their consequences.

Dose constraints

2.26. Except for medical exposure, the optimization of the protection and safety measures associated with any particular source within a practice shall be subject to dose constraints which:

(a) do not exceed either the appropriate values established or agreed to by the Regulatory Authority for such a source or values which can cause the dose limits to be exceeded; and
(b) ensure, for any source (including radioactive waste management facilities) that can release radioactive substances to the environment, that the cumulative effects of each annual release from the source be restricted so that the effective dose in any year to any member of the public, including people distant from the source and people of future generations, is unlikely to exceed any relevant dose limit, taking into account cumulative releases and the exposures expected to be delivered by all other relevant sources and practices under control.

Guidance levels for medical exposure

2.27. Guidance levels for medical exposure shall be established for use by medical practitioners. The guidance levels are intended:

(a) to be a reasonable indication of doses for average sized patients;
(b) to be established by relevant professional bodies in consultation with the Regulatory Authority following the detailed requirements of Appendix II and the guidance levels given in Schedule III;
(c) to provide guidance on what is achievable with current good practice rather than on what should be considered optimum performance;
(d) to be applied with flexibility to allow higher exposures if these are indicated by sound clinical judgement; and
(e) to be revised as technology and techniques improve.

MANAGEMENT REQUIREMENTS

Safety culture

2.28. A safety culture shall be fostered and maintained to encourage a questioning and learning attitude to protection and safety and to discourage complacency, which shall ensure that:

(a) policies and procedures be established that identify protection and safety as being of the highest priority;
(b) problems affecting protection and safety be promptly identified and corrected in a manner commensurate with their importance;
(c) the responsibilities of each individual, including those at senior management levels, for protection and safety be clearly identified and each individual be suitably trained and qualified;
(d) clear lines of authority for decisions on protection and safety be defined; and
(e) organizational arrangements and lines of communications be effected that result in an appropriate flow of information on protection and safety at and between the various levels in the organization of the registrant or licensee.

Quality assurance

2.29. Quality assurance programmes shall be established that provide, as appropriate:

(a) adequate assurance that the specified requirements relating to protection and safety are satisfied; and
(b) quality control mechanisms and procedures for reviewing and assessing the overall effectiveness of protection and safety measures.

Human factors

2.30. Provision shall be made for reducing as far as practicable the contribution of human error to accidents and other events that could give rise to exposures, by ensuring that:

(a) all personnel on whom protection and safety depend be appropriately trained and qualified so that they understand their responsibilities and perform their duties with appropriate judgement and according to defined procedures;
(b) sound ergonomic principles be followed as appropriate in designing equipment and operating procedures, so as to facilitate the safe operation or use of equipment, to minimize the possibility that operating errors will lead to accidents, and to reduce the possibility of misinterpreting indications of normal and abnormal conditions; and

(c) appropriate equipment, safety systems, and procedural requirements be provided and other necessary provisions be made:
   (i) to reduce, as far as practicable, the possibility that human error will lead to inadvertent or unintentional exposure of any person;
   (ii) to provide means for detecting human errors and for correcting or compensating for them; and
   (iii) to facilitate intervention in the event of failure of safety systems or of other protective measures.

Qualified experts

2.31. Qualified experts shall be identified and made available for providing advice on the observance of the Standards.

2.32. Registrants and licensees shall inform the Regulatory Authority of their arrangements to make available the expertise necessary to provide advice on the observance of the Standards. The information provided shall include the scope of the functions of any qualified experts identified.

TECHNICAL REQUIREMENTS

2.33. Relevant principal parties shall ensure that the protection and safety measures for practices and sources for which they have responsibilities, other than nuclear installations and radioactive waste management facilities, are governed by the interrelated technical requirements of paras 2.34–2.36. These technical requirements shall be applied when appropriate and to an extent commensurate with the magnitude and likelihood of the exposures expected from the practice or source. Nuclear installations and radioactive waste management facilities, including disposal facilities, are typically subject to more specific technical and other requirements such as those issued under the IAEA's Nuclear Safety Standards (NUSS)[9] Programme and Radioactive Waste Safety Standards (RADWASS)[10] Programme, as well as other relevant requirements of the Sponsoring Organizations. As these more specific requirements are generally consistent with the Standards, it follows that, in complying with them, such more complex installations should also generally comply with the Standards.

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[9] Publications within the IAEA's NUSS Programme, Safety Series No. 50.

[10] Publications within the IAEA's RADWASS Programme, Safety Series No. 111.

Security of sources

2.34. Sources shall be kept secure so as to prevent theft or damage and to prevent any unauthorized legal person from carrying out any of the actions specified in the General Obligations for practices of the Standards (see paras 2.7–2.9), by ensuring that:

(a) control of a source not be relinquished without compliance with all relevant requirements specified in the registration or licence and without immediate communication to the Regulatory Authority, and when applicable to the relevant Sponsoring Organization, of information regarding any decontrolled, lost, stolen or missing source;
(b) a source not be transferred unless the receiver possesses a valid authorization; and
(c) a periodic inventory of movable sources be conducted at appropriate intervals to confirm that they are in their assigned locations and are secure.

Defence in depth

2.35. A multilayer (defence in depth) system of provisions for protection and safety commensurate with the magnitude and likelihood of the potential exposures involved shall be applied to sources such that a failure at one layer is compensated for or corrected by subsequent layers, for the purposes of:

(a) preventing accidents that may cause exposure;
(b) mitigating the consequences of any such accident that does occur; and
(c) restoring sources to safe conditions after any such accident.

Good engineering practice

2.36. As applicable, the siting, location, design, construction, assembly, commissioning, operation, maintenance and decommissioning of sources within practices shall be based on sound engineering which shall, as appropriate:

(a) take account of approved codes and standards and other appropriately documented instruments;
(b) be supported by reliable managerial and organizational features, with the aim of ensuring protection and safety throughout the life of the sources;
(c) include sufficient safety margins for the design and construction of the sources, and for operations involving the sources, such as to ensure reliable performance during normal operation, taking into account quality, redundancy and inspectability, with emphasis on preventing accidents, mitigating their consequences and restricting any future exposures; and

(d) take account of relevant developments in technical criteria, as well as the results of any relevant research on protection or safety and lessons from experience.

VERIFICATION OF SAFETY

Safety assessments

2.37. Safety assessments related to protection and safety measures for sources within practices shall be made at different stages, including siting, design, manufacture, construction, assembly, commissioning, operation, maintenance and decommissioning, as appropriate, in order:

(a) to identify the ways in which normal exposures and potential exposures could be incurred, account being taken of the effect of events external to the sources as well as events directly involving the sources and their associated equipment;
(b) to determine the expected magnitudes of normal exposures and, to the extent reasonable and practicable, to estimate the probabilities and the magnitudes of potential exposures; and
(c) to assess the quality and extent of the protection and safety provisions.

Monitoring and verification of compliance

2.38. Monitoring and measurements shall be conducted of the parameters necessary for verification of compliance with the requirements of the Standards.

2.39. For the purposes of monitoring and verification of compliance, suitable equipment shall be provided and verification procedures introduced. The equipment shall be properly maintained and tested and shall be calibrated at appropriate intervals with reference to standards traceable to national or international standards.

Records

2.40. Records shall be maintained of the results of monitoring and verification of compliance, including records of the tests and calibrations carried out in accordance with the Standards.

3. REQUIREMENTS FOR INTERVENTION

APPLICATION

3.1. The intervention situations to which the Standards apply are:

(a) emergency exposure situations requiring protective action to reduce or avert temporary exposures, including:
   (i) accidents and emergencies in which an emergency plan or emergency procedures have been activated; and
   (ii) any other temporary exposure situation identified by the Regulatory Authority or the Intervening Organization as warranting intervention; and

(b) chronic exposure situations requiring remedial action to reduce or avert chronic exposure, including:
   (i) natural exposure, such as exposure to radon in buildings and workplaces;
   (ii) exposure to radioactive residues from past events, such as to the radioactive contamination caused by accidents, after the situation requiring protective action has been terminated, as well as from the conduct of practices and the use of sources not under the system of notification, and authorization; and
   (iii) any other chronic exposure situation specified by the Regulatory Authority or the Intervening Organization as warranting intervention.

3.2. The detailed requirements relating to emergency exposure situations and chronic exposure situations are set out in Appendices V and VI respectively. These shall be considered as consequential requirements subsidiary to those specified in this Section, unless other more desirable options for protection and safety are established by the Regulatory Authority or, where applicable, by a relevant Sponsoring Organization.

BASIC OBLIGATIONS

3.3. In order to reduce or avert exposures in intervention situations, protective actions or remedial actions shall be undertaken whenever they are justified.

3.4. The form, scale, and duration of any such protective action or remedial action shall be optimized so as to produce the maximum net benefit, understood in a broad sense, under the prevailing social and economic circumstances.

3.5. In the case of emergency exposure situations, protective actions are not normally likely to be necessary unless intervention levels or action levels[11] are or may be exceeded.

3.6. In the case of chronic exposure situations, remedial actions are not normally likely to be necessary unless the relevant action levels[11] are exceeded.

ADMINISTRATIVE REQUIREMENTS

Responsibilities

3.7. For occupational exposures incurred by workers undertaking intervention, the responsibilities set forth in Appendix V shall be discharged by the registrant or licensee, the employer and the Intervening Organizations, as required by the Regulatory Authority.

3.8. For public exposure in intervention situations, responsibilities identified and assigned by the government for the various organizational arrangements and functions necessary for ensuring effective intervention shall be discharged:

(a) by the appropriate national, regional or local Intervening Organizations; and,
(b) if a practice or source that is registered or licensed is involved, by the registrant or licensee.

3.9. Each registrant or licensee responsible for sources for which prompt intervention may be required shall ensure that an emergency plan exists that defines on-site responsibilities and takes account of off-site responsibilities appropriate for the source and provides for implementation of each relevant form of protective action, as set out in Appendix V.

3.10. The relevant Intervening Organizations shall prepare a general plan or plans for co-ordinating and implementing the actions required for supporting protective actions under the emergency plans of registrants and licensees, as well as for other situations that may require prompt intervention. This includes situations involving such sources of exposure as sources illegally brought into the country, falling satellites equipped with sources or radioactive materials released in accidents beyond national borders.

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[11] Intervention levels and action levels serve to protect members of the public and are specified separately for different protective actions and remedial actions. Optimized levels for justified interventions are normally selected for inclusion in emergency plans and remedial action plans, and, in the case of accidents, are re-evaluated at the time of their implementation on the basis of current conditions.

3.11. For chronic exposure situations in which the relevant action levels for remedial actions are or may be exceeded, the relevant Intervening Organizations shall ensure that generic or site specific remedial action plans, as necessary, are developed. When remedial action is to be undertaken, the legal person responsible for carrying out the remedial action shall ensure that it is in accordance with the generic remedial action plan or that specific remedial action plans are developed, approved and implemented.

Notification requirements

3.12. Registrants and licensees shall notify the Regulatory Authority and the relevant Intervening Organizations promptly when a situation requiring protective action has arisen or is expected to arise, and shall keep them informed of:

(a) the situation as it develops and how it is expected to develop;
(b) the measures taken for the protection of workers and members of the public; and
(c) the exposures that have been incurred and that are expected to be incurred.

RADIATION PROTECTION REQUIREMENTS

3.13. Intervention is justified only if it is expected to achieve more good than harm, with due regard to health, social and economic factors. If the dose levels approach or are expected to approach the levels specified in Schedule IV, protective actions or remedial actions will be justified under almost any circumstances.

3.14. Optimized intervention levels and action levels shall be specified in plans for intervention situations, on the basis of the guidelines given in Schedules V and VI, modified to take account of local and national conditions, such as:

(a) the individual and collective exposures to be averted by the intervention; and
(b) the radiological and non-radiological health risks and the financial and social costs and benefits associated with the intervention.

3.15. During the response to an accident, justification of intervention and optimization of pre-established intervention levels shall be reconsidered, with account taken of:

(a) those factors which are unique to the actual situation, such as the nature of the release, weather conditions and other relevant non-radiological factors; and
(b) the likelihood that the protective actions will provide a net benefit, given that future conditions may be uncertain.

APPENDICES:
DETAILED REQUIREMENTS

Appendix I

OCCUPATIONAL EXPOSURE

RESPONSIBILITIES

I.1. Registrants and licensees and employers of workers who are engaged in activities involving normal exposures or potential exposure shall be responsible for:

(a) the protection of workers from occupational exposure; and
(b) compliance with any other relevant requirements of the Standards.

I.2. Employers who are also registrants or licensees shall have the responsibilities of both employers and registrants or licensees.

I.3. Employers, registrants and licensees shall apply the requirements of the Standards to any occupational exposure, from either human made or natural sources, which is not excluded from the Standards.

I.4. Employers, registrants and licensees shall ensure, for all workers engaged in activities that involve or could involve occupational exposure, that:

(a) occupational exposures be limited as specified in Schedule II;
(b) occupational protection and safety be optimized in accordance with the relevant principal requirements of the Standards;
(c) decisions regarding measures for occupational protection and safety be recorded and made available to the relevant parties, through their representatives where appropriate, as specified by the Regulatory Authority;
(d) policies, procedures and organizational arrangements for protection and safety be established for implementing the relevant requirements of the Standards, with priority given to design and technical measures for controlling occupational exposures;
(e) suitable and adequate facilities, equipment and services for protection and safety be provided, the nature and extent of which are commensurate with the expected magnitude and likelihood of the occupational exposure;
(f) necessary health surveillance and health services be provided;
(g) appropriate protective devices and monitoring equipment be provided and arrangements made for its proper use;
(h) suitable and adequate human resources and appropriate training in protection and safety be provided, as well as periodic retraining and updating as required in order to ensure the necessary level of competence;
(i) adequate records be maintained as required by the Standards;
(j) arrangements be made to facilitate consultation and co-operation with workers with respect to protection and safety, through their representatives where

appropriate, about all measures necessary to achieve the effective implementation of the Standards; and

(k) necessary conditions to promote a safety culture be provided.

I.5. Employers, registrants or licensees shall ensure that workers exposed to radiation from sources other than natural sources that are not directly related to their work or not required by their work receive the same level of protection as if they were members of the public.

I.6. Registrants or licensees shall, as a precondition for engagement of workers who are not their employees, obtain from the employers, including self-employed individuals, the previous occupational exposure history of such workers and other information as may be necessary to provide protection and safety in compliance with the Standards.

I.7. If workers are to be engaged in work that involves or could involve a source that is not under the control of their employer, the registrant or licensee responsible for the source shall provide:

(a) appropriate information to the employer for the purpose of demonstrating that the workers are provided with protection in accordance with the Standards; and
(b) such additional available information about compliance with the Standards as the employer may request prior to, during and after the engagement of such workers by the registrant or licensee.

I.8. Employers, registrants and licensees shall take such administrative actions as are necessary to ensure that workers are informed that protection and safety are integral parts of a general occupational health and safety programme in which they have certain obligations and responsibilities for their own protection and the protection of others against radiation and for the safety of sources.

I.9. Employers, registrants and licensees shall facilitate compliance by workers with the requirements of the Standards.

I.10. Workers shall:

(a) follow any applicable rules and procedures for protection and safety specified by the employer, registrant or licensee;
(b) use properly the monitoring devices and the protective equipment and clothing provided;
(c) co-operate with the employer, registrant or licensee with respect to protection and safety and the operation of radiological health surveillance and dose assessment programmes;
(d) provide to the employer, registrant or licensee such information on their past and current work as is relevant to ensure effective and comprehensive protection and safety for themselves and others;

(e) abstain from any wilful action that could put themselves or others in situations that contravene the requirements of the Standards; and

(f) accept such information, instruction and training concerning protection and safety as will enable them to conduct their work in accordance with the requirements of the Standards.

I.11. If for any reason a worker is able to identify circumstances that could adversely affect compliance with the Standards, the worker shall as soon as feasible report such circumstances to the employer, registrant or licensee.

I.12. Employers, registrants or licensees shall record any report received from a worker that identifies circumstances which could affect compliance with the Standards, and shall take appropriate action.

I.13. Registrants and licensees shall, as a precondition for engagement of workers in activities that involve or could involve exposure from a source not under the registrant's or licensee's control, provide the employer with any information about worker protection under the Standards which the employer requests in order for the employer to demonstrate compliance with other applicable laws and regulations governing workplace hazards.

I.14. Nothing in the Standards shall be construed as relieving employers from complying with applicable national and local laws and regulations governing workplace hazards, including radiation hazards from natural sources which are unconnected with the work.

CONDITIONS OF SERVICE

Special compensatory arrangements

I.15. The conditions of service of workers shall be independent of the existence or the possibility of occupational exposure. Special compensatory arrangements or preferential treatment with respect to salary or special insurance coverage, working hours, length of vacation, additional holidays or retirement benefits shall neither be granted nor be used as substitutes for the provision of proper protection and safety measures to ensure compliance with the requirements of the Standards.

Pregnant workers

I.16. A female worker should, on becoming aware that she is pregnant, notify the employer in order that her working conditions may be modified if necessary.

I.17. The notification of pregnancy shall not be considered a reason to exclude a female worker from work; however, the employer of a female worker who has notified pregnancy shall adapt the working conditions in respect of occupational exposure so as to ensure that the embryo or foetus is afforded the same broad level of protection as required for members of the public.

Alternative employment

I.18. Employers shall make every reasonable effort to provide workers with suitable alternative employment in circumstances where it has been determined, either by the Regulatory Authority or in the framework of the health surveillance programme required by the Standards, that the worker, for health reasons, may no longer continue in employment involving occupational exposure.

Conditions for young persons

I.19. No person under the age of 16 years shall be subjected to occupational exposure.

I.20. No person under the age of 18 years shall be allowed to work in a controlled area unless supervised and then only for the purpose of training.

CLASSIFICATION OF AREAS

Controlled areas

I.21. Registrants and licensees shall designate as a controlled area any area in which specific protective measures or safety provisions are or could be required for:

(a) controlling normal exposures or preventing the spread of contamination during normal working conditions; and
(b) preventing or limiting the extent of potential exposures.

I.22. In determining the boundaries of any controlled area, registrants and licensees shall take account of the magnitudes of the expected normal exposures, the likelihood and magnitude of potential exposures, and the nature and extent of the required protection and safety procedures.

I.23. Registrants and licensees shall:

(a) delineate controlled areas by physical means or, where this is not reasonably practicable, by some other suitable means;
(b) where a source is brought into operation or energized only intermittently or is moved from place to place, delineate an appropriate controlled area by means that are appropriate under the prevailing circumstances and specify exposure times;

(c) display a warning symbol, such as that recommended by the International Organization for Standardization (ISO)[12], and appropriate instructions at access points and other appropriate locations within controlled areas;
(d) establish occupational protection and safety measures, including local rules and procedures that are appropriate for controlled areas;
(e) restrict access to controlled areas by means of administrative procedures, such as the use of work permits, and by physical barriers, which could include locks or interlocks; the degree of restriction being commensurate with the magnitude and likelihood of the expected exposures;
(f) provide, as appropriate, at entrances to controlled areas:
  (i) protective clothing and equipment;
  (ii) monitoring equipment; and
  (iii) suitable storage for personal clothing;
(g) provide, as appropriate, at exits from controlled areas:
  (i) equipment for monitoring for contamination of skin and clothing;
  (ii) equipment for monitoring for contamination of any object or substance being removed from the area;
  (iii) washing or showering facilities; and
  (iv) suitable storage for contaminated protective clothing and equipment; and
(h) periodically review conditions to determine the possible need to revise the protection measures or safety provisions, or the boundaries of controlled areas.

Supervised areas

I.24. Registrants and licensees shall designate as a supervised area any area not already designated as a controlled area but where occupational exposure conditions need to be kept under review even though specific protection measures and safety provisions are not normally needed.

I.25. Registrants and licensees shall, taking into account the nature and extent of radiation hazards in the supervised areas:

(a) delineate the supervised areas by appropriate means;
(b) display approved signs at appropriate access points to supervised areas; and
(c) periodically review the conditions to determine any need for protective measures and safety provisions or changes to the boundaries of supervised areas.

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[12] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, Basic Ionizing Radiation Symbol, ISO 361, ISO, Geneva (1975).

LOCAL RULES AND SUPERVISION

I.26. Employers, registrants and licensees shall, in consultation with workers, through their representatives if appropriate:

(a) establish in writing such local rules and procedures as are necessary to ensure adequate levels of protection and safety for workers and other persons;
(b) include in the local rules and procedures the values of any relevant investigation level or authorized level, and the procedure to be followed in the event that any such value is exceeded;
(c) make the local rules and procedures and the protective measures and safety provisions known to those workers to whom they apply and to other persons who may be affected by them;
(d) ensure that any work involving occupational exposure be adequately supervised and take all reasonable steps to ensure that the rules, procedures, protective measures and safety provisions be observed; and
(e) when required by the Regulatory Authority, designate a radiation protection officer.

I.27. Employers, in co-operation with registrants and licensees, shall:

(a) provide to all workers adequate information on the health risks due to their occupational exposure, whether normal exposure or potential exposure, adequate instruction and training on protection and safety, and adequate information on the significance for protection and safety of their actions;
(b) provide to female workers who are liable to enter controlled areas or supervised areas appropriate information on:
    (i) the risk to the embryo or foetus due to exposure of a pregnant woman;
    (ii) the importance for a female worker of notifying her employer as soon as she suspects that she is pregnant; and
    (iii) the risk to an infant ingesting radioactive substances by breast feeding;
(c) provide to those workers who could be affected by an emergency plan appropriate information, instruction and training; and
(d) keep records of the training provided to individual workers.

PERSONAL PROTECTIVE EQUIPMENT

I.28. Employers, registrants and licensees shall ensure that:

(a) workers be provided with suitable and adequate personal protective equipment which meets any relevant standards or specifications, including as appropriate:
    (i) protective clothing;

   (ii) protective respiratory equipment for which the protection characteristics are made known to the users; and
   (iii) protective aprons and gloves and organ shields;

(b) when appropriate, workers receive adequate instruction in the proper use of respiratory protective equipment, including testing for good fit;
(c) tasks requiring the use of some specific personal protective equipment be assigned only to workers who on the basis of medical advice are capable of safely sustaining the extra effort necessary;
(d) all personal protective equipment be maintained in proper condition and if appropriate be tested at regular intervals;
(e) appropriate personal protective equipment be maintained for use in the event of intervention; and
(f) if the use of personal protective equipment is considered for any given task, account be taken of any additional exposure that could result owing to the additional time or inconvenience, and of any additional non-radiological risks that might be associated with performing the task while using protective equipment.

I.29. Registrants and licensees shall minimize the need for relying on administrative controls and personal protective equipment for protection and safety during normal operations by providing appropriate protective measures and safety provisions, including well engineered controls and satisfactory working conditions.

CO-OPERATION BETWEEN EMPLOYERS, REGISTRANTS AND LICENSEES

I.30. If workers are engaged in work that involves or could involve a source that is not under the control of their employer, the registrant or licensee responsible for the source and the employer shall co-operate by the exchange of information and otherwise as necessary to facilitate proper protective measures and safety provisions.

I.31. The co-operation between the registrant or licensee and the employer shall include, where appropriate:

(a) the development and use of specific exposure restrictions and other means in order to ensure that the protective measures and safety provisions for such workers be at least as good as those provided for employees of the registrant or licensee;
(b) specific assessments of the doses received by such workers; and
(c) a clear allocation and documentation of the respective responsibilities of the employer and the registrant or licensee for occupational protection and safety.

INDIVIDUAL MONITORING AND EXPOSURE ASSESSMENT

I.32. The employer of any worker, as well as self-employed individuals, and the registrants and licensees shall be responsible for arranging for the assessment of the occupational exposure of workers, on the basis of individual monitoring where appropriate, and shall ensure that adequate arrangements be made with appropriate dosimetry services under an adequate quality assurance programme.

I.33. For any worker who is normally employed in a controlled area, or who occasionally works in a controlled area and may receive significant occupational exposure, individual monitoring shall be undertaken where appropriate, adequate and feasible. In cases where individual monitoring is inappropriate, inadequate or not feasible, the occupational exposure of the worker shall be assessed on the basis of the results of monitoring of the workplace and on information on the locations and durations of exposure of the worker.

I.34. For any worker who is regularly employed in a supervised area or who enters a controlled area only occasionally, individual monitoring shall not be required but the occupational exposure of the worker shall be assessed. This assessment shall be on the basis of the results of monitoring of the workplace or individual monitoring.

I.35. The nature, frequency and precision of individual monitoring shall be determined with consideration of the magnitude and possible fluctuations of exposure levels and the likelihood and magnitude of potential exposures.

I.36. Employers shall ensure that workers who may be exposed to radioactive contamination, including workers who use protective respiratory equipment, be identified and shall arrange for appropriate monitoring to the extent necessary to demonstrate the effectiveness of the protection provided and to assess the intake of radioactive substances or the committed doses, as appropriate.

MONITORING OF THE WORKPLACE

I.37. Registrants and licensees, in co-operation with employers if appropriate, shall establish, maintain and keep under review a programme for the monitoring of the workplace under the supervision, if so required by a Regulatory Authority, of a qualified expert and a radiation protection officer.

I.38. The nature and frequency of monitoring of workplaces shall:

(a) be sufficient to enable:
  (i) evaluation of the radiological conditions in all workplaces;

(ii) exposure assessment in controlled areas and supervised areas; and
(iii) review of the classification of controlled and supervised areas; and

(b) depend on the levels of ambient dose equivalent and activity concentration, including their expected fluctuations and the likelihood and magnitude of potential exposures.

I.39. The programmes for monitoring of the workplace shall specify:

(a) the quantities to be measured;
(b) where and when the measurements are to be made and at what frequency;
(c) the most appropriate measurement methods and procedures; and
(d) reference levels and the actions to be taken if they are exceeded.

I.40. Registrants and licensees, in co-operation with employers if appropriate, shall keep appropriate records of the findings of the workplace monitoring programme which shall be made available to workers, where appropriate through their representatives.

HEALTH SURVEILLANCE

I.41. Employers, registrants and licensees shall make arrangements for appropriate health surveillance in accordance with the rules established by the Regulatory Authority.

I.42. If one or more workers are to be engaged in work that involves or could involve exposure from a source that is not under the control of their employer, the registrant or licensee responsible for the source shall as a precondition for such engagement make any special arrangements for health surveillance with the employer which are needed to comply with the rules established by the Regulatory Authority.

I.43. Health surveillance programmes shall be:

(a) based on the general principles of occupational health; and
(b) designed to assess the initial and continuing fitness of workers for their intended tasks.

RECORDS

I.44. Employers, registrants and licensees shall maintain exposure records for each worker for whom assessment of occupational exposure is required in paras I.32–I.36 of this Appendix.

I.45. If workers are engaged in work that involves or could involve exposure from a source that is not under the control of their employer, the registrant or licensee responsible for the source shall provide both the worker and the worker's employer with the relevant exposure records.

I.46. The exposure records shall include:

(a) information on the general nature of the work involving occupational exposure;
(b) information on doses, exposures and intakes at or above the relevant recording levels and the data upon which the dose assessments have been based;
(c) when a worker is or has been occupationally exposed while in the employ of more than one employer, information on the dates of employment with each employer and the doses, exposures and intakes in each such employment; and
(d) records of any doses, exposures or intakes due to emergency interventions or accidents, which shall be distinguished from doses, exposures or intakes during normal work and which shall include references to reports of any relevant investigations.

I.47. Employers, registrants and licensees shall:

(a) provide for access by workers to information in their own exposure records;
(b) provide for access to the exposure records by the supervisor of the health surveillance programme, the Regulatory Authority and the relevant employer;
(c) facilitate the provision of copies of workers' exposure records to new employers when workers change employment;
(d) when a worker ceases to work, make arrangements for the retention of the worker's exposure records by the Regulatory Authority, or a State registry, or the registrant or licensee, as appropriate; and
(e) in complying with (a)–(d), give due care and attention to the maintenance of appropriate confidentiality of records.

I.48. If employers, registrants or licensees cease activities that involve occupational exposure of workers, they shall make arrangements for the retention of workers' exposure records by the Regulatory Authority or State registry, or by a relevant registrant or licensee, as appropriate.

I.49. Exposure records for each worker shall be preserved during the worker's working life and afterwards at least until the worker attains or would have attained the age of 75 years, and for not less than 30 years after the termination of the work involving occupational exposure.

SPECIAL CIRCUMSTANCES

I.50. In special circumstances, provided that a practice is justified as required by the Standards and is designed and conducted according to good practice, and that radiation protection in the practice has been optimized as required by the Standards but occupational exposures still remain above the dose limits, and that it can be predicted that reasonable efforts can in due course bring the occupational exposures under the limits, the Regulatory Authority may exceptionally approve a temporary change in a dose limitation requirement of the Standards. Such a change shall be approved only if formally requested by the registrant or licensee, if the Regulatory Authority determines that the practice is still justified and is satisfied that appropriate consultation with the workers concerned has taken place.

I.51. Should special circumstances exist which require a temporary change in some dose limitation requirement of the Standards, the registrant or licensee may apply to the Regulatory Authority for such a temporary change.

I.52. No temporary change in a dose limitation requirement shall be made without approval by the Regulatory Authority.

I.53. The registrant or licensee shall, in any application for a temporary change in a dose limitation requirement of the Standards:

(a) describe the special circumstances requiring the temporary change; and
(b) provide evidence to demonstrate that:
   (i) all reasonable efforts have been made to reduce exposures and protective measures and safety provisions have been optimized in accordance with the requirements of the Standards;
   (ii) the relevant employers and workers, through their representatives where appropriate, have been consulted and their agreement obtained on the need for a temporary change and on the conditions of the temporary change;
   (iii) all reasonable efforts are being made to improve the working conditions to the point where the dose limits specified in Schedule II, para. II-5 can be observed; and
   (iv) the monitoring and recording of the exposures of individual workers are sufficient to demonstrate compliance with the relevant requirements of Schedule II and are sufficient to facilitate the transfer of exposure records between relevant employers as required by the Standards.

I.54. Any temporary change in a dose limitation requirement of the Standards shall:

(a) be in accordance with the dose limitation for special circumstances given in Schedule II;
(b) be for a limited period of time;
(c) be subject to annual review;
(d) not be renewable; and
(e) relate to specified work areas.

Appendix II

MEDICAL EXPOSURE

RESPONSIBILITIES

II.1. Registrants and licensees shall ensure that:

(a) no patient be administered a diagnostic or therapeutic medical exposure unless the exposure is prescribed by a medical practitioner;
(b) medical practitioners be assigned the primary task and obligation of ensuring overall patient protection and safety in the prescription of, and during the delivery of, medical exposure;
(c) medical and paramedical personnel be available as needed, and either be health professionals or have appropriate training adequately to discharge assigned tasks in the conduct of the diagnostic or therapeutic procedure that the medical practitioner prescribes;
(d) for therapeutic uses of radiation (including teletherapy and brachytherapy), the calibration, dosimetry and quality assurance requirements of the Standards be conducted by or under the supervision of a qualified expert in radiotherapy physics;
(e) the exposure of individuals incurred knowingly while voluntarily helping (other than in their occupation) in the care, support or comfort of patients undergoing medical diagnosis or treatment be constrained as specified in Schedule II; and
(f) training criteria be specified or be subject to approval, as appropriate, by the Regulatory Authority in consultation with relevant professional bodies.

II.2. Registrants and licensees should ensure that for diagnostic uses of radiation the imaging and quality assurance requirements of the Standards be fulfilled with the advice of a qualified expert in either radiodiagnostic physics or nuclear medicine physics, as appropriate.

II.3. Medical practitioners shall promptly inform the registrant or licensee of any deficiencies or needs regarding compliance with the Standards with respect to protection and safety of patients and shall take such actions as may be appropriate to ensure the protection and safety of patients.

JUSTIFICATION OF MEDICAL EXPOSURES

II.4. Medical exposures should be justified by weighing the diagnostic or therapeutic benefits they produce against the radiation detriment they might cause, taking into account the benefits and risks of available alternative techniques that do not involve medical exposure.

II.5. In justifying each type of diagnostic examination by radiography, fluoroscopy or nuclear medicine, relevant guidelines will be taken into account, such as those established by the WHO[13-15].

II.6. Any radiological examination for occupational, legal or health insurance purposes undertaken without reference to clinical indications is deemed to be not justified unless it is expected to provide useful information on the health of the individual examined or unless the specific type of examination is justified by those requesting it in consultation with relevant professional bodies.

II.7. Mass screening of population groups involving medical exposure is deemed to be not justified unless the expected advantages for the individuals examined or for the population as a whole are sufficient to compensate for the economic and social costs, including the radiation detriment. Account should be taken in justification of the potential of the screening procedure for detecting disease, the likelihood of effective treatment of cases detected and, for certain diseases, the advantages to the community from the control of the disease.

II.8. The exposure of humans for medical research is deemed to be not justified unless it is:

(a) in accordance with the provisions of the Helsinki Declaration[16] and follows the guidelines for its application prepared by Council for International Organizations of Medical Sciences (CIOMS)[17] and WHO[18]; and

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[13] WORLD HEALTH ORGANIZATION, A Rational Approach to Radiodiagnostic Investigations, Technical Report Series No. 689, WHO, Geneva (1983).

[14] WORLD HEALTH ORGANIZATION, Rational Use of Diagnostic Imaging in Pediatrics, Technical Report Series No. 757, WHO, Geneva (1987).

[15] WORLD HEALTH ORGANIZATION, Effective Choices for Diagnostic Imaging in Clinical Practices, Technical Report Series No. 795, WHO, Geneva (1990).

[16] Adopted by the 18th World Medical Assembly, Helsinki, 1964, and as amended by the 29th World Medical Assembly, Tokyo, 1975, the 35th World Medical Assembly, Venice, 1983, and the 41st World Medical Assembly, Hong Kong, 1989; available from the World Medical Association, F-01210 Ferney-Voltaire, France.

[17] COUNCIL FOR INTERNATIONAL ORGANIZATIONS OF MEDICAL SCIENCES in collaboration with WORLD HEALTH ORGANIZATION, International Ethical Guidelines for Biomedical Research Involving Human Subjects, CIOMS, Geneva (1993).

[18] WORLD HEALTH ORGANIZATION, Use of Ionizing Radiation and Radionuclides on Human Beings for Medical Research, Training and Non-Medical Purposes, Technical Report Series No. 611, WHO, Geneva (1977).

(b) subject to the advice of an Ethical Review Committee (or any other institutional body assigned similar functions by national authorities) and to applicable national and local regulations.

II.9. Radiological examinations for theft detection purposes are deemed to be not justified; should they nonetheless be conducted, they shall not be considered medical exposure but shall be subject to the requirements for occupational and public exposure of the Standards.

OPTIMIZATION OF PROTECTION FOR MEDICAL EXPOSURES

II.10. The requirements in this subsection shall be considered to be in addition to any relevant requirements for optimization of protection specified in other parts of the Standards.

Design considerations

General

II.11. The requirements for the safety of sources specified in other parts of the Standards shall also apply to sources used in medical exposure, where relevant, and, in particular, equipment used in medical exposure shall be so designed that:

(a) failure of a single component of the system be promptly detectable so that any unplanned medical exposure of patients is minimized; and
(b) the incidence of human error in the delivery of unplanned medical exposure be minimized.

II.12. Registrants and licensees shall:

(a) taking into account information provided by suppliers, identify possible equipment failures and human errors that could result in unplanned medical exposures;
(b) take all reasonable measures to prevent failures and errors, including the selection of suitably qualified personnel, the establishment of adequate procedures for the calibration, quality assurance and operation of diagnostic and therapeutic equipment, and the provision to personnel of appropriate training and periodic retraining in the procedures, including protection and safety aspects;
(c) take all reasonable measures to minimize the consequences of failures and errors that may occur; and
(d) develop appropriate contingency plans for responding to events that may occur, display plans prominently, and periodically conduct practice drills.

II.13. Registrants and licensees, in specific co-operation with suppliers, shall ensure that, with regard to equipment consisting of radiation generators and that containing sealed sources used for medical exposures:

(a) whether imported into or manufactured in the country where it is used, the equipment conform to applicable standards of the International Electrotechnical Commission (IEC) and the ISO or to equivalent national standards;
(b) performance specifications and operating and maintenance instructions, including protection and safety instructions, be provided in a major world language understandable to the users and in compliance with the relevant IEC or ISO standards with regard to 'accompanying documents', and that this information be translated into local languages when appropriate;
(c) where practicable, the operating terminology (or its abbreviations) and operating values be displayed on operating consoles in a major world language acceptable to the user;
(d) radiation beam control mechanisms be provided, including devices that indicate clearly and in a fail-safe manner whether the beam is 'on' or 'off';
(e) as nearly as practicable, the exposure be limited to the area being examined or treated by using collimating devices aligned with the radiation beam;
(f) the radiation field within the examination or treatment area without any radiation beam modifiers (such as wedges) be as uniform as practicable and the non-uniformity be stated by the supplier; and
(g) exposure rates outside the examination or treatment area due to radiation leakage or scattering be kept as low as reasonably achievable.

Requirements for radiation generators and equipment using sealed sources for diagnostic radiology

II.14. Registrants and licensees, in specific co-operation with suppliers, shall ensure that:

(a) radiation generators and their accessories be designed and manufactured so as to facilitate the keeping of medical exposures as low as reasonably achievable consistent with obtaining adequate diagnostic information;
(b) operational parameters for radiation generators, such as generating tube potential, filtration, focal spot position, source–image receptor distance, field size indication and either tube current and time or their product, be clearly and accurately indicated;
(c) radiographic equipment be provided with devices that automatically terminate the irradiation after a preset time, tube current–time product or dose; and
(d) fluoroscopic equipment be provided with a device that energizes the X ray tube only when continuously depressed (such as a 'dead man's switch') and equipped with indicators of the elapsed time and/or entrance surface dose monitors.

Requirements for radiation generators and irradiation installations for radiotherapy

II.15. Registrants and licensees, in specific co-operation with suppliers, shall ensure that:

(a) radiation generators and irradiation installations include provisions for selection, reliable indication and confirmation (when appropriate and to the extent feasible) of operational parameters such as type of radiation, indication of energy, beam modifiers (such as filters), treatment distance, field size, beam orientation and either treatment time or preset dose;
(b) irradiation installations using radioactive sources be fail-safe in the sense that the source will be automatically shielded in the event of an interruption of power and will remain shielded until the beam control mechanism is reactivated from the control panel;
(c) high energy radiotherapy equipment:
    (i) have at least two independent 'fail to safety' systems for terminating the irradiation; and
    (ii) be provided with safety interlocks or other means designed to prevent the clinical use of the machine in conditions other than those selected at the control panel;
(d) the design of safety interlocks be such that operation of the installation during maintenance procedures, if interlocks are bypassed, could be performed only under direct control of the maintenance personnel using appropriate devices, codes or keys;
(e) radioactive sources for either teletherapy or brachytherapy be so constructed that they conform to the definition of a sealed source; and
(f) when appropriate, monitoring equipment be installed or be available to give warning of an unusual situation in the use of radiation generators and radionuclide therapy equipment.

Operational considerations

Diagnostic exposure

II.16. Registrants and licensees shall ensure for diagnostic radiology that:

(a) the medical practitioners who prescribe or conduct radiological diagnostic examinations:
    (i) ensure that the appropriate equipment be used;
    (ii) ensure that the exposure of patients be the minimum necessary to achieve the required diagnostic objective, taking into account norms of acceptable image quality established by appropriate professional bodies and relevant guidance levels for medical exposure; and

   (iii) take into account relevant information from previous examinations in order to avoid unnecessary additional examinations;

(b) the medical practitioner, the technologist or other imaging staff select the following parameters, as relevant, such that their combination produce the minimum patient exposure consistent with acceptable image quality and the clinical purpose of the examination, paying particular attention to this selection for paediatric radiology and interventional radiology:

   (i) the area to be examined, the number and size of views per examination (e.g. number of films or computed tomography slices) or the time per examination (e.g. fluoroscopic time);
   (ii) the type of image receptor (e.g. high versus low speed screens);
   (iii) the use of antiscatter grids;
   (iv) proper collimation of the primary X ray beam to minimize the volume of patient tissue being irradiated and to improve image quality;
   (v) appropriate values of operational parameters (e.g. tube generating potential, current and time or their product);
   (vi) appropriate image storage techniques in dynamic imaging (e.g. number of images per second); and
   (vii) adequate image processing factors (e.g. developer temperature and image reconstruction algorithms);

(c) portable and mobile radiological equipment be used only for examinations where it is impractical or not medically acceptable to transfer patients to a stationary radiological installation and only after proper attention has been given to the radiation protection measures required in its use;

(d) radiological examinations causing exposure of the abdomen or pelvis of women who are pregnant or likely to be pregnant be avoided unless there are strong clinical reasons for such examinations;

(e) any diagnostic examination of the abdomen or pelvis of women of reproductive capacity be planned to deliver the minimum dose to any embryo or foetus that might be present; and

(f) whenever feasible, shielding of radiosensitive organs such as the gonads, lens of the eye, breast and thyroid be provided as appropriate.

II.17. Registrants and licensees shall ensure for nuclear medicine that:

(a) the medical practitioners who prescribe or conduct diagnostic applications of radionuclides:

   (i) ensure that the exposure of patients be the minimum required to achieve the intended diagnostic objective;
   (ii) take into account relevant information from previous examinations in order to avoid unnecessary additional examinations; and
   (iii) take into account the relevant guidance levels for medical exposure;

(b) the medical practitioner, the technologist or other imaging staff, as appropriate, endeavour to achieve the minimum patient exposure consistent with acceptable image quality by:
    (i) appropriate selection of the best available radiopharmaceutical and its activity, noting the special requirements for children and for patients with impairment of organ function;
    (ii) use of methods for blocking the uptake in organs not under study and for accelerated excretion when applicable;
    (iii) appropriate image acquisition and processing;
(c) administration of radionuclides for diagnostic or radiotherapeutic procedures to women pregnant or likely to be pregnant be avoided unless there are strong clinical indications;
(d) for mothers in lactation, discontinuation of nursing be recommended until the radiopharmaceutical is no longer secreted in an amount estimated to give an unacceptable effective dose to the nursling[19]; and
(e) administration of radionuclides to children for diagnostic procedures be carried out only if there is a strong clinical indication, and the amount of activity administered be reduced according to body weight, body surface area or other appropriate criteria.

Therapeutic exposure

II.18. Registrants and licensees shall ensure that:

(a) exposure of normal tissue during radiotherapy be kept as low as reasonably achievable consistent with delivering the required dose to the planning target volume, and organ shielding be used when feasible and appropriate;
(b) radiotherapeutic procedures causing exposure of the abdomen or pelvis of women who are pregnant or likely to be pregnant be avoided unless there are strong clinical indications;
(c) administration of radionuclides for therapeutic procedures to women who are pregnant or likely to be pregnant or who are nursing be avoided unless there are strong clinical indications;
(d) any therapeutic procedure for pregnant women be planned to deliver the minimum dose to any embryo or foetus; and
(e) the patient be informed of possible risks.

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[19] Examples of good practice are at least 3 weeks for ^{67}Ga, ^{111}In, ^{131}I and ^{201}Tl, at least 2 days for ^{123}I and at least 12 hours for ^{99m}Tc.

Calibration

II.19. Registrants and licensees shall ensure that:

(a) the calibration of sources used for medical exposure be traceable to a Standards dosimetry laboratory;
(b) radiotherapy equipment be calibrated in terms of radiation quality or energy and either absorbed dose or absorbed dose rate at a predefined distance under specified conditions, e.g. following the recommendations given in IAEA Technical Reports Series No. 277[20];
(c) sealed sources used for brachytherapy be calibrated in terms of activity, reference air kerma rate in air or absorbed dose rate in a specified medium, at a specified distance, for a specified reference date;
(d) unsealed sources for nuclear medicine procedures be calibrated in terms of activity of the radiopharmaceutical to be administered, the activity being determined and recorded at the time of administration; and
(e) the calibrations be carried out at the time of commissioning a unit, after any maintenance procedure that may have an effect on the dosimetry and at intervals approved by the Regulatory Authority.

Clinical dosimetry

II.20. Registrants and licensees shall ensure that the following items be determined and documented:

(a) in radiological examinations, representative values for typical sized adult patients of entrance surface doses, dose–area products, dose rates and exposure times, or organ doses;
(b) for each patient treated with external beam radiotherapy equipment, the maximum and minimum absorbed doses to the planning target volume together with the absorbed dose to a relevant point such as the centre of the planning target volume, plus the dose to other relevant points selected by the medical practitioner prescribing the treatment;
(c) in brachytherapeutic treatments performed with sealed sources, the absorbed doses at selected relevant points in each patient;
(d) in diagnosis or treatment with unsealed sources, representative absorbed doses to patients; and
(e) in all radiotherapeutic treatments, the absorbed doses to relevant organs.

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[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Absorbed Dose Determination for Photon and Electron Beams, Technical Reports Series No. 277, IAEA, Vienna (1987).

II.21. In radiotherapeutic treatments, registrants and licensees shall ensure, within the ranges achievable by good clinical practice and optimized functioning of equipment, that:

(a) the prescribed absorbed dose at the prescribed beam quality be delivered to the planning target volume; and
(b) doses to other tissues and organs be minimized.

Quality assurance for medical exposures

II.22. Registrants and licensees, in addition to applying the relevant requirements for quality assurance specified elsewhere in the Standards, shall establish a comprehensive quality assurance programme for medical exposures with the participation of appropriate qualified experts in the relevant fields, such as radiophysics or radiopharmacy, taking into account the principles established by the WHO[21–23] and the PAHO[24].

II.23. Quality assurance programmes for medical exposures shall include:

(a) measurements of the physical parameters of the radiation generators, imaging devices and irradiation installations at the time of commissioning and periodically thereafter;
(b) verification of the appropriate physical and clinical factors used in patient diagnosis or treatment;
(c) written records of relevant procedures and results;
(d) verification of the appropriate calibration and conditions of operation of dosimetry and monitoring equipment; and
(e) as far as possible, regular and independent quality audit reviews of the quality assurance programme for radiotherapy procedures.

GUIDANCE LEVELS

II.24. Registrants and licensees should ensure that guidance levels for medical exposure be determined as specified in the Standards, revised as technology improves and used as guidance by medical practitioners, in order that:

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[21] WORLD HEALTH ORGANIZATION, Quality Assurance in Diagnostic Radiology, WHO, Geneva (1982).

[22] WORLD HEALTH ORGANIZATION, Quality Assurance in Nuclear Medicine, WHO, Geneva (1982).

[23] WORLD HEALTH ORGANIZATION, Quality Assurance in Radiotherapy, WHO, Geneva (1988).

[24] PAN AMERICAN HEALTH ORGANIZATION, Publicación Científica No. 499, Control de Calidad en Radioterapia: Aspectos Clínicos y Físicos, PAHO, Washington, DC (1986).

(a) corrective actions be taken as necessary if doses or activities fall substantially below the guidance levels and the exposures do not provide useful diagnostic information and do not yield the expected medical benefit to patients;
(b) reviews be considered if doses or activities exceed the guidance levels as an input to ensuring optimized protection of patients and maintaining appropriate levels of good practice; and
(c) for diagnostic radiology, including computed tomography examinations, and for nuclear medicine examinations, the guidance levels be derived from the data from wide scale quality surveys which include entrance surface doses and cross-sectional dimensions of the beams delivered by individual facilities and activities of radiopharmaceuticals administered to patients for the most frequent examinations in diagnostic radiology and nuclear medicine respectively.

II.25. In the absence of wide scale surveys, performance of diagnostic radiography and fluoroscopy equipment and of nuclear medicine equipment should be assessed on the basis of comparison with the guidance levels specified in Schedule III, Tables III-I to III-V. These levels should not be regarded as a guide for ensuring optimum performance in all cases, as they are appropriate only for typical adult patients and, therefore, in applying the values in practice, account should be taken of body size and age.

DOSE CONSTRAINTS

II.26. The Ethical Review Committee or other institutional body assigned similar functions on the subject by national authorities shall specify dose constraints to be applied on a case by case basis in the optimization of protection for persons exposed for medical research purposes if such medical exposure does not produce direct benefit to the exposed individual.

II.27. Registrants and licensees shall constrain any dose to individuals incurred knowingly while voluntarily helping (other than in their occupation) in the care, support or comfort of patients undergoing medical diagnosis or treatment, and to visitors to patients who have received therapeutic amounts of radionuclides or who are being treated with brachytherapy sources, to a level not exceeding that specified in Schedule II, para. II-9.

MAXIMUM ACTIVITY FOR PATIENTS IN THERAPY ON DISCHARGE FROM HOSPITAL

II.28. In order to restrict the exposure of any members of the household of a patient who has undergone a therapeutic procedure with sealed or unsealed radionuclides and members of the public, such a patient shall not be discharged from hospital before the activity of radioactive substances in the body falls below the level specified in Schedule III, Table III-VI. Written instructions to the patient concerning contact with other persons and relevant precautions for radiation protection shall be provided as necessary.

INVESTIGATION OF ACCIDENTAL MEDICAL EXPOSURES

II.29. Registrants and licensees shall promptly investigate any of the following incidents:

(a) any therapeutic treatment delivered to either the wrong patient or the wrong tissue, or using the wrong pharmaceutical, or with a dose or dose fractionation differing substantially from the values prescribed by the medical practitioner or which may lead to undue acute secondary effects;
(b) any diagnostic exposure substantially greater than intended or resulting in doses repeatedly and substantially exceeding the established guidance levels; and
(c) any equipment failure, accident, error, mishap or other unusual occurrence with the potential for causing a patient exposure significantly different from that intended.

II.30. Registrants and licensees shall, with respect to any investigation required under para. II.29:

(a) calculate or estimate the doses received and their distribution within the patient;
(b) indicate the corrective measures required to prevent recurrence of such an incident;
(c) implement all the corrective measures that are under their own responsibility;
(d) submit to the Regulatory Authority, as soon as possible after the investigation or as otherwise specified by the Regulatory Authority, a written report which states the cause of the incident and includes the information specified in (a) to (c), as relevant, and any other information required by the Regulatory Authority; and
(e) inform the patient and his or her doctor about the incident.

RECORDS

II.31. Registrants and licensees shall keep for a period specified by the Regulatory Authority and make available, as required, the following records:

(a) in diagnostic radiology, necessary information to allow retrospective dose assessment, including the number of exposures and the duration of fluoroscopic examinations;
(b) in nuclear medicine, types of radiopharmaceuticals administered and their activities;
(c) in radiation therapy, a description of the planning target volume, the dose to the centre of the planning target volume and the maximum and minimum doses delivered to the planning target volume, the doses to other relevant organs, the dose fractionation, and the overall treatment time; and
(d) the exposure of volunteers in medical research.

II.32. Registrants and licensees shall keep and make available, as required, the results of the calibrations and periodic checks of the relevant physical and clinical parameters selected during treatments.

Appendix III

PUBLIC EXPOSURE

RESPONSIBILITIES

III.1. Registrants and licensees shall apply the requirements of the Standards as specified by the Regulatory Authority to any public exposure delivered by a practice or source for which they are responsible, unless the exposure is excluded from the Standards or the practice or source delivering the exposure is exempted from the requirements of the Standards. Should the non-excluded exposure or the non-exempted source be a natural exposure or a natural source, respectively, registrants and licensees shall, as specified by the Regulatory Authority, apply the requirements (see para. 2.5) unless the exposure to radon is below the action levels for chronic exposure established by the Regulatory Authority, taking into account the guideline levels specified in Schedule VI.

III.2. Registrants and licensees shall be responsible, with respect to the sources under their responsibility, for the establishment, implementation and maintenance of:

(a) protection and safety policies, procedures and organizational arrangements in relation to public exposure in fulfilment of the requirements of the Standards;
(b) measures for ensuring:
    (i) the optimization of the protection of members of the public whose exposure is attributable to such sources; and
    (ii) the limitation of the normal exposure of the relevant critical group, which is attributable to such sources, in order that the total exposure be not higher than the dose limits for members of the public; in selecting the critical group, account shall be taken of all those in present and future generations whether in the countries or places where the sources are located or in any other country or place;
(c) measures for ensuring the safety of such sources, in order that the likelihood of public exposures be controlled in accordance with the requirements of the Standards;
(d) suitable and adequate facilities, equipment and services for the protection of the public, the nature and extent of which are commensurate with the magnitude and likelihood of the exposure;
(e) appropriate protection and safety training to the personnel having functions relevant to the protection of the public, as well as periodic retraining and updating as required, in order to ensure the necessary level of competence;
(f) appropriate monitoring equipment and surveillance programmes to assess public exposure to the satisfaction of the Regulatory Authority;

(g) adequate records of the surveillance and monitoring as required by the Standards;
(h) emergency plans or procedures, commensurate with the nature and magnitude of the risk involved, and kept ready to actuate in accordance with the Principal Requirements and the Detailed Requirements in Appendix V.

III.3. Registrants and licensees shall be responsible for ensuring that the optimization process for measures to control the discharge of radioactive substances from a source to the environment is subject to dose constraints established or approved by the Regulatory Authority, taking into account, as appropriate:

(a) dose contributions from other sources and practices, including realistically assessed possible future sources and practices;
(b) potential changes in any condition that could affect public exposure, such as changes in the characteristics and operation of the source, changes in exposure pathways, changes in the habits or distribution of the population, modification of critical groups, or changes in environmental dispersion conditions;
(c) current good practice in the operation of similar sources or practices; and
(d) any uncertainties in the assessment of exposures, especially in potential contributions to the exposures if the source and the critical group are separated in distance or time.

III.4. Should a practice or source within a practice discharge radioactive substances to the environment that could cause public exposure in a country other than the country where the practice or source is located, and where a monetary value of unit collective dose is required by the Regulatory Authority to be used for the optimization of the control of discharges, registrants and licensees shall be responsible for ensuring that the monetary value applied to the collective dose incurred outside the country where the practice or source is located is not less than the value prescribed within it[25].

CONTROL OF VISITORS

III.5. Registrants and licensees, in co-operation with employers when appropriate, shall:

(a) ensure that visitors be accompanied in any controlled area by a person knowledgeable about the protection and safety measures for that area;

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[25] The minimum international value of the unit collective dose for transboundary exposure recommended by the IAEA should be used as guidance. See INTERNATIONAL ATOMIC ENERGY AGENCY, Assigning a Value to Transboundary Radiation Exposure, Safety Series No. 67, IAEA, Vienna (1985).

(b) provide adequate information and instruction to visitors before they enter a controlled area so as to ensure appropriate protection of the visitors and of other individuals who could be affected by their actions; and
(c) ensure that adequate control over entry of visitors to a supervised area be maintained and that appropriate signs be posted in such areas.

SOURCES OF EXTERNAL IRRADIATION

III.6. Registrants and licensees shall ensure that, if a source of external irradiation can cause exposure to the public:

(a) prior to commissioning, the floor plans and equipment arrangement for all new installations and all significant modifications to existing installations utilizing such sources of external irradiation be subject to review and approval by the Regulatory Authority;
(b) specific dose constraints for the operation of such a source be established to the satisfaction of the Regulatory Authority; and
(c) shielding and other protective measures that are optimized in accordance with the requirements of the Standards be provided as appropriate for restricting public exposure to the satisfaction of the Regulatory Authority.

RADIOACTIVE CONTAMINATION IN ENCLOSED SPACES

III.7. Registrants and licensees shall ensure that:

(a) for sources for which they are responsible, measures that are optimized in accordance with the requirements of the Standards be taken as appropriate for restricting public exposure to contamination in areas accessible to the public; and
(b) specific containment provisions be established for the construction and operation of a source that could cause spread of contamination in areas accessible to the public.

RADIOACTIVE WASTE

III.8. Registrants and licensees shall:

(a) ensure that the activity and volume of any radioactive waste that results from the sources for which they are responsible be kept to the minimum practicable, and that the waste be managed, i.e. collected, handled, treated, conditioned, transported, stored and disposed of, in accordance with the requirements of the Standards and any other applicable standard[26]; and

(b) segregate, and treat separately if appropriate, different types of radioactive waste where warranted by differences in factors such as radionuclide content, half-life, concentration, volume and physical and chemical properties, taking into account the available options for waste disposal.

DISCHARGE OF RADIOACTIVE SUBSTANCES TO THE ENVIRONMENT

III.9. Registrants and licensees shall ensure that radioactive substances from authorized practices and sources not be discharged to the environment unless:

(a) the discharge is within the discharge limits authorized by the Regulatory Authority;
(b) the discharges are controlled;
(c) the public exposures committed by the discharges are limited as specified in Schedule II; and
(d) the control of the discharges is optimized in accordance with the Principal Requirements of the Standards.

III.10. Registrants and licensees, before initiating the discharge to the environment of any solid, liquid or gaseous radioactive substance from sources under their responsibility, shall, as appropriate:

(a) determine the characteristics and activity of the material to be discharged, and the potential points and methods of discharge;
(b) determine by an appropriate pre-operational study all significant exposure pathways by which discharged radionuclides can deliver public exposure;
(c) assess the doses to the critical groups due to the planned discharges; and
(d) submit this information to the Regulatory Authority as an input to the establishment of authorized discharge limits and conditions for their implementation[27].

III.11. Registrants and licensees, during the operational stages of sources under their responsibility, shall:

(a) keep all radioactive discharges as far below the authorized discharge limits as is reasonably achievable;

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[26] See the publications within the IAEA's RADWASS Programme, Safety Series No. 111, on the safe management of radioactive waste.

[27] INTERNATIONAL ATOMIC ENERGY AGENCY, Principles for Limiting Releases of Radioactive Effluents into the Environment, Safety Series No. 77, IAEA, Vienna (1986).

(b) monitor the discharges of radionuclides with sufficient detail and accuracy to demonstrate compliance with the authorized discharge limits and to permit estimation of the exposure of critical groups;
(c) record the monitoring results and estimated exposures;
(d) report the monitoring results to the Regulatory Authority at approved intervals; and
(e) report promptly to the Regulatory Authority any discharges exceeding the authorized discharge limits in accordance with reporting criteria established by the Regulatory Authority.

III.12. Registrants and licensees shall, as appropriate and in agreement with the Regulatory Authority, review and adjust their discharge control measures for the sources under their responsibility in the light of operating experience, taking into account any changes in exposure pathways and the composition of critical groups that could affect the assessment of doses due to the discharges.

MONITORING OF PUBLIC EXPOSURE

III.13. Registrants and licensees shall, if appropriate:

(a) establish and carry out a monitoring programme sufficient to ensure that the requirements of the Standards regarding public exposure to sources of external irradiation be satisfied and to assess such exposure;
(b) establish and carry out a monitoring programme sufficient to ensure that the requirements of the Standards for discharges of radioactive substances to the environment and the requirements established by the Regulatory Authority in granting the discharge authorization be satisfied and that the conditions assumed in deriving the authorized discharge limits remain valid and sufficient to enable the exposures to critical groups to be estimated;
(c) keep appropriate records of the results of the monitoring programmes;
(d) report a summary of the monitoring results to the Regulatory Authority at approved intervals;
(e) report promptly to the Regulatory Authority any significant increase in environmental radiation fields or contamination that could be attributed to the radiation or radioactive discharges emitted by sources under their responsibility;
(f) establish and maintain a capability to carry out emergency monitoring, in case of unexpected increases in radiation fields or radioactive contamination due to accidental or other unusual events affecting sources under their responsibility; and
(g) verify the adequacy of the assumptions made for the prior assessment of radiological consequences of the discharges.

CONSUMER PRODUCTS

III.14. Consumer products capable of causing exposure to radiation shall not be supplied to members of the public unless:

(a) such exposure is excluded from the Standards;
(b) such products meet the exemption requirements specified in Schedule I or have been exempted by the Regulatory Authority; or
(c) such products are authorized for use by members of the public.

III.15. Suppliers of non-exempt consumer products shall ensure that such products comply with the requirements of the Standards, and in particular that those aspects of their design and construction that could affect the exposure of people during normal handling and use, as well as in the event of mishandling, misuse, accident or disposal, have been optimized, using dose constraints established or approved by the Regulatory Authority and taking into account:

(a) the various radionuclides that could be used and their radiation types, energies, activities and half-lives;
(b) the chemical and physical forms of the radionuclides that could be used and their influence on protection and safety in normal and abnormal circumstances;
(c) the containment and shielding of the radioactive material in the consumer product and the access to this material in normal and abnormal circumstances;
(d) the need for servicing or repair and the ways in which this could be done; and
(e) relevant experience with similar consumer products.

III.16. Suppliers of consumer products shall ensure that:

(a) where practicable, a legible label be firmly affixed to a visible surface of each consumer product stating that:
    (i) the product contains radioactive material; and
    (ii) the sale of the product to the public has been authorized by the relevant Regulatory Authority; and
(b) the information specified in (a) be also displayed legibly on each package in which a consumer product is supplied.

III.17. Suppliers of consumer products shall provide clear and appropriate information and instructions with each consumer product on:

(a) the correct installation, use and maintenance of the product;
(b) servicing and repair;
(c) the radionuclides involved and their activities at a specified date;
(d) radiation dose rates during normal operation and during servicing and repair operations; and
(e) recommended disposal procedures.

Appendix IV

POTENTIAL EXPOSURE: SAFETY OF SOURCES

RESPONSIBILITIES

IV.1. Registrants and licensees shall ensure the safety of the sources, including installations, for which they are responsible and shall:

(a) apply the Principal Requirements specified in the Standards; and
(b) apply as appropriate the Detailed Requirements set out in Appendix IV.

IV.2. Guidance on the practical aspects of the safety of nuclear installations and of radioactive waste management facilities is given in publications within the NUSS Programme and RADWASS Programme in the IAEA Safety Series as well as in documents of the Sponsoring Organizations. Appendix IV specifies requirements on the practical aspects of the safety of sources and practices other than nuclear installations and radioactive waste management facilities, which are intended to support the Principal Requirements of the Standards.

SAFETY ASSESSMENT

IV.3. Registrants and licensees shall conduct a safety assessment, either generic or specific for the source for which they are responsible, as required under the Principal Requirements. Generic safety assessments are usually sufficient for types of source with a high degree of uniformity in design. Specific safety assessments are usually required in other cases but the specific safety assessment need not reconsider those aspects covered by a generic safety assessment, if such an assessment has been conducted for the source.

IV.4. The safety assessment shall include, as appropriate, a systematic critical review of:

(a) the nature and magnitude of potential exposures and the likelihood of their occurrence;
(b) the limits and technical conditions for operation of the source;
(c) the ways in which structures, systems, components and procedures related to protection or safety might fail, singly or in combination, or otherwise lead to potential exposures, and the consequences of such failures;
(d) the ways in which changes in the environment could affect protection or safety;
(e) the ways in which operating procedures related to protection or safety might be erroneous, and the consequences of such errors; and
(f) the protection and safety implications of any proposed modifications.

IV.5. The registrant or licensee shall, as appropriate, take into account in the safety assessment:

(a) factors which could precipitate a substantial release of any radioactive substance and the measures available to prevent or control such a release, and the maximum activity of any radioactive substance which, in the event of a major failure of the containment, might be released to the atmosphere;
(b) factors which could precipitate a smaller but continuing release of any radioactive substance and the measures available to prevent or control such a release;
(c) factors which could give rise to the unintended operation of any radiation beam and the measures available to prevent, identify and control such occurrences;
(d) the extent to which redundant and diverse safety features, being independent of each other so that failure of one does not result in failure of any other, are appropriate in order to restrict the probability and magnitude of potential exposures.

IV.6. The safety assessment shall be documented and, if appropriate, independently reviewed within the relevant quality assurance programme. Additional reviews shall be performed as necessary for ensuring that the technical specifications or conditions of use continue to be met whenever:

(a) significant modifications to a source or its associated plant or its operating or maintenance procedures are envisaged;
(b) operating experience, or other information about accidents, failures, errors or other events that could lead to potential exposures indicates that the current assessment might be invalid; and
(c) any significant changes in activities, or any relevant changes in guidelines or standards, are envisaged or have been made.

IV.7. If as a result of a safety assessment, or for any other reason, opportunities for improving the protection or safety measures associated with a source within a practice seem to be available and desirable, any consequential modifications shall be made cautiously and only after a favourable assessment of all the implications for protection and safety; and if such improvements cannot all be implemented, or not all at once, they shall be prioritized so as to result in optimum improvements in protection or safety.

REQUIREMENTS FOR DESIGN

Responsibilities

IV.8. Registrants and licensees, in specific co-operation with suppliers, shall ensure that the following responsibilities be discharged, if applicable:

(a) to provide a well designed and constructed source that:
   (i) provides for protection and safety in compliance with the Standards;
   (ii) meets engineering, performance and functional specifications; and
   (iii) meets quality norms commensurate with the protection and safety significance of components and systems;

(b) to ensure that sources be tested to demonstrate compliance with the appropriate specifications; and

(c) to make available information in a major world language acceptable to the user concerning the proper installation and use of the source and its associated risks.

IV.9. In addition, and where applicable, registrants and licensees shall make suitable arrangements with suppliers of sources:

(a) to establish and maintain mechanisms for suppliers to obtain information from the registrants and licensees or other users on the use, maintenance, operating experience, dismantling and disposal of sources, and in any particular normal or abnormal operating conditions that may be important for the protection of individuals or the safety of the source;

(b) to establish and maintain a mechanism to feed back to registrants and licensees information that may have implications for protection or safety affecting other registrants or licensees, or that may have implications for future improvements in protection or safety in the design of their products.

Prevention of accidents and mitigation of their consequences

IV.10. Systems and components of sources that are related to protection or safety shall be designed, constructed, operated and maintained so as to prevent accidents, as far as possible, and in general to restrict to levels which are as low as reasonably achievable, social and economic considerations being taken into account, the magnitude and likelihood of exposure of workers and members of the public.

IV.11. The registrant or licensee of any source or practice shall make suitable arrangements:

(a) to prevent, as far as possible, any accident, occurrence or incident that could reasonably be foreseen in connection with the source or practice;

(b) to limit the consequences of any accident, occurrence or incident that does occur;

(c) to provide workers with the information, training, and equipment necessary to restrict their potential exposure;

(d) to ensure that there be adequate procedures for the control of the source and of any potential accident that could reasonably be foreseen;

(e) to ensure that safety significant systems, components and equipment can be inspected and tested regularly for any degradation that could lead to abnormal conditions or inadequate performance;
(f) to ensure that maintenance, inspection and testing appropriate to the preservation of the protection and safety provisions can be carried out without undue occupational exposure;
(g) to provide, wherever appropriate, automatic systems for safely shutting off or reducing radiation output from sources in the event that operating conditions exceed the operating ranges;
(h) to ensure that abnormal operating conditions that could significantly affect protection or safety be detected by systems that respond quickly enough to allow for timely corrective action to be taken; and
(i) to ensure that all relevant safety documentation be available in local languages.

IV.12. As required in Appendix V, if the safety assessment indicates that there is a reasonable remaining likelihood of an accident affecting either workers or members of the public, the registrant or licensee shall prepare an emergency plan. This plan is to be designed to secure as far as possible the protection and safety of anyone who may be affected by the accident. As part of this plan the registrant or licensee should ensure that:

(a) any worker under the registrant's or licensee's control who may be involved in or affected by arrangements in the plan has been suitably and sufficiently trained and if appropriate issued with suitable protective equipment and dosimeters; and
(b) if appropriate, rehearsals of the arrangements in the plans be carried out at suitable intervals.

Location and siting of sources

IV.13. Account shall be taken in choosing the location for any small source within installations and facilities such as hospitals and manufacturing plants of:

(a) factors that could affect the safety and security of the source;
(b) factors that could affect the occupational exposure and public exposure caused by the source, including features such as ventilation, shielding and distance from occupied areas; and
(c) the feasibility in engineering design of taking into account the foregoing factors.

IV.14. The selection of a site for a source that holds a large inventory of radioactive substances and has the potential for releases of large amounts of such radioactive substances shall take into account any features that might affect the radiation safety of the source and features that might be affected by the source, and the feasibility of off-site intervention, including carrying out emergency plans and protective actions.

REQUIREMENTS FOR OPERATIONS

Responsibilities

IV.15. Registrants and licensees may delegate certain tasks involved with the operation of sources under their responsibility but shall retain the responsibility for ensuring that all operations are conducted in a manner consistent with the requirements of the Standards.

IV.16. Where applicable, registrants and licensees should:

(a) establish clear lines of responsibility and accountability for protection and safety of the sources throughout their operational lifetime, and establish protection and safety organizations as appropriate;
(b) for any source under their control that has the potential to give rise to exposures at levels greater than those specified by the Regulatory Authority as needing a specific safety assessment as required by Appendix IV, carry out and keep up to date that special assessment;
(c) assess the likely consequences of potential exposures, their magnitude and probability of occurrence, and the number of persons who may be affected by them;
(d) have in place operating procedures that are subject to periodic review and updating under an adequate quality assurance programme;
(e) establish procedures for reporting and learning from accidents, occurrences and incidents;
(f) establish arrangements for the periodic review of the overall effectiveness of the protection and safety measures;
(g) ensure that adequate maintenance, testing, inspection and servicing be carried out as needed so that sources remain capable of meeting their design requirements for protection and safety throughout their lifetime.

Accountability for sources

IV.17. Registrants and licensees shall maintain an accountability system that includes records of:

(a) the location and description of each source for which they are responsible; and
(b) the activity and form of each radioactive substance for which they are responsible.

Investigations and follow-up

IV.18. Registrants and licensees shall conduct formal investigations as specified by the Regulatory Authority if:

(a) a quantity or operating parameter related to protection or safety exceeds an investigation level or is outside the stipulated range of operating conditions; or
(b) any equipment failure, accident, error, mishap or other unusual event or circumstance occurs which has the potential for causing a quantity to exceed any relevant limit or operating restriction.

IV.19. The investigation shall be conducted as soon as possible after the event and a written report produced on its cause, with a verification or determination of any doses received or committed and recommendations for preventing the recurrence of similar events.

IV.20. A summary report of any formal investigation relating to events prescribed by the Regulatory Authority, including exposures greater than a dose limit, shall be communicated to the Regulatory Authority as soon as possible and to other parties as appropriate.

Accident management preparedness

IV.21. Registrants and licensees shall be prepared to take any necessary action for responding to and correcting any reasonably foreseeable operating mishap or accident that could involve a source.

IV.22. For sources with the potential for abnormal exposures, where there is a possibility for taking action to control or otherwise influence the course of an accident and to mitigate its consequences, registrants and licensees shall:

(a) prepare in advance guidance on accident management in their premises that takes into account the expected response of the protection and safety features of the source to accidents;
(b) make available equipment, instrumentation and diagnostic aids that may be needed to control the course and consequences of accidents involving sources; and
(c) train operating and emergency personnel and periodically retrain them in the procedures to be followed if an accident occurs.

Feedback of operating experience

IV.23. Registrants and licensees shall ensure that information on both normal and abnormal operations significant to protection or safety be disseminated or made available, as appropriate, to the Regulatory Authority and other relevant parties, as specified by the Regulatory Authority. This information would cover, for example, doses associated with given activities, maintenance data, descriptions of events and corrective actions.

QUALITY ASSURANCE

IV.24. Registrants and licensees shall be responsible for establishing the quality assurance programme required by the principal requirements of these Standards, and the nature and extent of the quality assurance programme shall be commensurate with the magnitude and the likelihood of the potential exposures from the sources for which they are responsible.

IV.25. The quality assurance programme shall provide for:

(a) planned and systematic actions aimed at providing adequate confidence that the specified design and operational requirements related to protection and safety are satisfied, including provisions for feedback of operational experience;
(b) a framework for the analysis of tasks, development of methods, establishment of norms and identification of necessary skills for the design and operation of the source; and
(c) validation of designs and supply and use of materials, of manufacturing, inspection and testing methods, and of operating and other procedures.

Appendix V

EMERGENCY EXPOSURE SITUATIONS

RESPONSIBILITIES

V.1. It is presumed that the State will have determined in advance the allocation of responsibilities for the management of interventions in emergency exposure situations between the Regulatory Authority, national and local Intervening Organizations and registrants or licensees.

EMERGENCY PLANS

V.2. Emergency plans shall be prepared which specify how the responsibilities for the management of interventions will be discharged on the site, off the site and across national boundaries, as appropriate, in separate but interconnecting plans.

V.3. The appropriate responsible authorities shall ensure that:

(a) emergency plans be prepared and approved for any practice or source which could give rise to a need for emergency intervention;
(b) Intervening Organizations be involved in the preparation of emergency plans, as appropriate;
(c) the content, features and extent of emergency plans take into account the results of any accident analysis and any lessons learned from operating experience and from accidents that have occurred with sources of a similar type;
(d) emergency plans be periodically reviewed and updated;
(e) provision be made for training personnel involved in implementing emergency plans and the plans be rehearsed at suitable intervals in conjunction with designated authorities; and
(f) prior information be provided to members of the public who could reasonably be expected to be affected by an accident.

V.4. Emergency plans shall include, as appropriate:

(a) allocation of responsibilities for notifying the relevant authorities and for initiating intervention;
(b) identification of the various operating and other conditions of the source which could lead to the need for intervention;
(c) intervention levels, based on a consideration of the guidelines in Schedule V, for the relevant protective actions and the scope of their application, with account taken of the possible degrees of severity of accidents or emergencies that could occur;

(d) procedures, including communication arrangements, for contacting any relevant Intervening Organization and for obtaining assistance from fire-fighting, medical, police and other relevant organizations;
(e) a description of the methodology and instrumentation for assessing the accident and its consequences on and off the site;
(f) a description of the public information arrangements in the event of an accident; and
(g) the criteria for terminating each protective action.

V.5. Registrants and licensees shall ensure that adequate provision be made for generating adequate information promptly and communicating it to the responsible authorities, for:

(a) the early prediction or assessment of the extent and significance of any accidental discharge of radioactive substances to the environment;
(b) rapid and continuous assessment of the accident as it proceeds; and
(c) determining the need for protective actions.

V.6. On-site emergency plans shall be implemented by registrants and licensees.

V.7. Off-site emergency plans and any transboundary plan shall be implemented by the Intervening Organizations.

INTERVENTION FOR EMERGENCY EXPOSURE SITUATIONS

General

V.8. Intervention in emergency exposure situations shall be carried out on the basis of intervention levels and action levels. Intervention levels are expressed in terms of the dose that is expected to be averted over time by a specific protective action associated with the intervention, and action levels in terms of the activity concentration of radionuclides in, for example, foodstuffs, water and crops.

V.9. Intervention levels and action levels shall be optimized for the relevant protective actions but they should not allow that certain levels of doses, for which intervention will almost always be justified, be exceeded. The values of intervention levels included in emergency plans shall be used as initial criteria for implementing protective actions, but may be modified to take into account the prevailing circumstances and their likely evolution.

Justification of intervention

V.10. Protective actions will almost certainly be justified if the projected dose, rather than the averted dose, or the dose rate to any individual is otherwise likely to lead to serious injury. In such circumstances, any decision not to take protective action on an urgent basis will have to be justified. The levels of dose which could lead to such injury are given in Schedule IV.

Optimization of protective actions: intervention levels and actions levels

Intervention and action levels for immediate protective actions

V.11. Decisions to take immediate protective action shall be made in the light of circumstances prevailing at the time of an accident and be based on the expectation of a release, if this is feasible, of radioactive substances to the environment, rather than delayed pending measurements to confirm the release. In addition to these protective actions, there are others, such as personal decontamination or elementary forms of respiratory protection, that may be invoked in special cases but for which intervention levels have not been established.

V.12. Intervention levels for immediate protective actions, including sheltering, evacuation and iodine prophylaxis, shall be specified in emergency plans, taking into account the guidelines given in Schedule V, and intervention shall be considered for any population in which the avertable dose is expected to exceed the intervention levels.

V.13. Action levels for the withdrawal and substitution of specific supplies of food and drinking water shall be specified in emergency plans as appropriate.

V.14. If there is no shortage of food and there are no other compelling social or economic factors, the action levels for the withdrawal and substitution of specific supplies of food and drinking water shall be based on the guidelines given in Schedule V and shall comply with the recommendations of the FAO–WHO Codex Alimentarius Commission for the international trade of food that has been contaminated with radionuclides[28]. The action levels shall be applied to food as consumed, and to dried or concentrated food after dilution or reconstitution.

V.15. In certain circumstances, if food is scarce or there are other serious social or economic considerations, higher optimized action levels for food and drinking water would be expected to be used. However, decisions to take action above the action levels specified in Schedule V shall be subject to the process of justification of intervention and optimization of the action levels.

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[28] JOINT FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS/WORLD HEALTH ORGANIZATION FOOD STANDARDS PROGRAMME, Codex Alimentarius Commission, Codex Alimentarius, Vol. 1 (1991) Section 6.1, Levels for Radionuclides.

V.16. Classes of food, such as spices, that are consumed in small quantities (e.g. less than 10 kg per person per year), which represent a very small fraction of the total diet and would increase individual exposure very little, may have action levels ten times higher than those for major foodstuffs.

Intervention and action levels for longer term protective actions

V.17. Agricultural, hydrological and other technical or industrial protective actions shall be considered following contamination of land or water after an accident, taking into account the guidance of the FAO and the IAEA on radiation accidents and agricultural countermeasures[29].

V.18. The international trading of food that has been contaminated with radionuclides shall be subject to the recommendations of the FAO–WHO Codex Alimentarius Commission[30] specified in Schedule V.

V.19. Intervention levels for temporary relocation and return of exposed persons shall be specified in emergency plans taking into account the guidelines given in Schedule V.

V.20. The Intervening Organization shall keep people who are temporarily relocated informed of their likely time of return to their homes and about the safeguarding of their property.

V.21. Consideration shall be given to permanent resettlement of exposed persons if:

(a) the duration of temporary relocation is expected to exceed an agreed period; or
(b) permanent resettlement is justified by virtue of the dose which could be averted.

Guidelines on generic intervention levels for permanent resettlement are given in Schedule V.

V.22. Appropriate consultations with people potentially affected shall be made before initiating programmes of permanent resettlement.

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[29] INTERNATIONAL ATOMIC ENERGY AGENCY/FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, Guidelines for Agricultural Countermeasures Following an Accidental Release of Radionuclides, Technical Reports Series No. 363, IAEA, Vienna (1994).

[30] JOINT FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS/WORLD HEALTH ORGANIZATION FOOD STANDARDS PROGRAMME, Codex Alimentarius Commission, Codex Alimentarius, Vol. 1 (1991) Section 6.1, Levels for Radionuclides.

ASSESSMENT AND MONITORING AFTER ACCIDENTS

V.23. All reasonable steps shall be taken to assess exposure incurred by members of the public as a consequence of an accident, and the results of the assessments shall be made publicly available.

V.24. The assessments shall be based on the best available information, and shall be promptly updated in the light of any information that would produce substantially more accurate results.

V.25. Comprehensive records shall be maintained of assessments and their updates, and of monitoring results for workers, the public and the environment.

CESSATION OF INTERVENTION AFTER AN ACCIDENT

V.26. A protective action will be discontinued when further assessment shows that continuation of the action is no longer justified.

PROTECTION OF WORKERS UNDERTAKING AN INTERVENTION

V.27. No worker undertaking an intervention[31] shall be exposed in excess of the maximum single year dose limit for occupational exposure specified in Schedule II, except:

(a) for the purpose of saving life or preventing serious injury;
(b) if undertaking actions intended to avert a large collective dose; or
(c) if undertaking actions to prevent the development of catastrophic conditions.

When undertaking intervention under these circumstances, all reasonable efforts shall be made to keep doses to workers below twice the maximum single year dose limit, except for life saving actions, in which every effort shall be made to keep doses below ten times the maximum single year dose limit in order to avoid deterministic effects on health. In addition, workers undertaking actions in which their doses may approach or exceed ten times the maximum single year dose limit shall do so only when the benefits to others clearly outweigh their own risk.

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[31] Workers undertaking an intervention may include, in addition to those employed by registrants and licensees, such assisting personnel as police, firemen, medical personnel and drivers and crews of evacuation vehicles.

V.28. Workers who undertake actions in which the dose may exceed the maximum single year dose limit shall be volunteers[32] and shall be clearly and comprehensively informed in advance of the associated health risk, and shall, to the extent feasible, be trained in the actions that may be required.

V.29. The legal person responsible for ensuring compliance with the foregoing requirements shall be specified in emergency plans.

V.30. Once the emergency phase of an intervention has ended, workers undertaking recovery operations, such as repairs to plant and buildings, waste disposal or decontamination of the site and surrounding area, shall be subject to the full system of detailed requirements for occupational exposure prescribed in Appendix I.

V.31. All reasonable steps shall be taken to provide appropriate protection during the emergency intervention and to assess and record the doses received by workers involved in emergency intervention. When the intervention has ended, the doses received and the consequent health risk shall be communicated to the workers involved.

V.32. Workers shall not normally be precluded from incurring further occupational exposure because of doses received in an emergency exposure situation. However, qualified medical advice shall be obtained before any such further exposure if a worker who has undergone an emergency exposure receives a dose exceeding ten times the maximum single year dose limit or at the worker's request.

[32] If military personnel are involved, these requirements may not apply in some circumstances. Exposure of such personnel shall, however, be limited to ad hoc levels to be specified by the Regulatory Authority.

Appendix VI

CHRONIC EXPOSURE SITUATIONS

RESPONSIBILITIES

VI.1. It is presumed that the State will have determined the allocation of responsibilities for the management of interventions in chronic exposure situations between the Regulatory Authority, national and local Intervening Organizations and registrants or licensees.

REMEDIAL ACTION PLANS

VI.2. Generic or site specific remedial action plans for chronic exposure situations shall be prepared by the Intervening Organization, as appropriate. The plans shall specify remedial actions and action levels that are justified and optimized, taking into account:

(a) the individual and collective exposures;
(b) the radiological and non-radiological risks; and
(c) the financial and social costs, the benefits and the financial liability for the remedial actions.

ACTION LEVELS FOR CHRONIC EXPOSURE SITUATIONS[33]

VI.3. Action levels for intervention through remedial action shall be specified in terms of appropriate quantities, such as the annual average ambient dose equivalent rate or a suitable average activity concentration of radionuclides that exist at the time remedial action is being considered.

VI.4. For the action levels for chronic exposure situations, account shall be taken of the benefits and costs assessed in the remedial action plan. For radon in dwellings and workplaces, optimized action levels are expected generally to fall within the guidelines specified in Schedule VI.

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[33] At the time of the endorsement of the Standards, recommendations were available from the ICRP for chronic exposure to radon only. The detailed and quantitative requirements for chronic exposure situations therefore focus on exposure to radon.

VI.5. The decision on whether remedial actions for chronic exposure situations in dwellings should be mandatory or advisory shall be taken by the Regulatory Authority or the Intervening Organization, taking into account the social and legal circumstances that apply[34].

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[34] The recommendations of the ICRP emphasize the role of national authorities in deciding the levels of funding for general reduction in radon levels or other aspects of housing improvements (see INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Protection against Radon-222 at Home and at Work, ICRP Publication No. 65, *Ann. ICRP* **23** 2, Pergamon Press, Oxford (1993), para. (68)).

SCHEDULES

Schedule I

EXEMPTIONS

EXEMPTION CRITERIA

I-1. Practices and sources within practices may be exempted from the requirements of the Standards, including those for notification, registration or licensing, if the Regulatory Authority is satisfied that the sources meet the exemption criteria or the exemption levels specified in this Schedule or other exemption levels specified by the Regulatory Authority on the basis of these exemption criteria. Exemption should not be granted to permit practices that would otherwise not be justified.

I-2. The general principles for exemption[35] are that:

(a) the radiation risks to individuals caused by the exempted practice or source be sufficiently low as to be of no regulatory concern;
(b) the collective radiological impact of the exempted practice or source be sufficiently low as not to warrant regulatory control under the prevailing circumstances; and
(c) the exempted practices and sources be inherently safe, with no appreciable likelihood of scenarios that could lead to a failure to meet the criteria in (a) and (b).

I-3. A practice or a source within a practice may be exempted without further consideration provided that the following criteria are met in all feasible situations:

(a) the effective dose expected to be incurred by any member of the public due to the exempted practice or source is of the order of 10 μSv or less in a year, and
(b) either the collective effective dose committed by one year of performance of the practice is no more than about 1 man.Sv or an assessment for the optimization of protection shows that exemption is the optimum option.

EXEMPTED SOURCES AND EXEMPTION LEVELS

I-4. Under the criteria in paras I-1 to I-3, the following sources within practices are automatically exempted without further consideration from the requirements of the Standards, including those for notification, registration or licensing:

[35] See INTERNATIONAL ATOMIC ENERGY AGENCY, Principles for the Exemption of Radiation Sources and Practices from Regulatory Control, Safety Series No. 89, IAEA, Vienna (1988).

(a) radioactive substances for which either the total activity of a given nuclide present on the premises at any one time or the activity concentration used in the practice does not exceed the exemption levels given in Table I-I of Schedule I[36]; and

(b) radiation generators, of a type approved by the Regulatory Authority, and any electronic tube, such as a cathode ray tube for the display of visual images, provided that:

  (i) they do not cause in normal operating conditions an ambient dose equivalent rate or a directional dose equivalent rate, as appropriate, exceeding 1 $\mu Sv \cdot h^{-1}$ at a distance of 0.1 m from any accessible surface of the apparatus; or

  (ii) the maximum energy of the radiation produced is no greater than 5 keV.

I-5. Conditional exemptions may be granted subject to conditions specified by the Regulatory Authority, such as conditions relating to the physical or chemical form and to the use or disposal of the radioactive materials. In particular, such an exemption may be granted for an apparatus containing radioactive substances not otherwise exempted under para. I-4 (a) provided that:

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[36] The guidance exemption levels set forth in Table I-I of Schedule I are subject to the following considerations: (a) They have been derived using a conservative model based on (i) the criteria of para. (I-3) and (ii) a series of limiting (bounding) use and disposal scenarios. The values of activity concentration and total activity represent the lowest values calculated in any scenario for a moderate quantity of material. (See COMMISSION OF THE EUROPEAN COMMUNITIES, Principles and Methods for Establishing Concentrations and Quantities (Exemption Values) below Which Reporting Is Not Required in the European Directive, Radiation Protection 65, Doc. XI-028/93, CEC, Brussels (1993). (b) The application of exemption to natural radionuclides, where these are not excluded, is limited to the incorporation of naturally occurring radionuclides into consumer products or their use as a radioactive source (e.g. Ra-226, Po-210) or for their elemental properties (e.g. thorium, uranium). (c) In the case of more than one radionuclide, the appropriate sum of the ratios of the activity or activity concentration of each radionuclide and the corresponding exempt activity or activity concentration shall be taken into account. (d) Unless the exposure is excluded, exemption for bulk amounts of materials with activity concentrations lower than the guidance exemption levels of Table I-I may nevertheless require further consideration by the Regulatory Authority.

(a) it is of a type approved by the Regulatory Authority;

(b) the radioactive substances are in the form of sealed sources that effectively prevent any contact with radioactive substances or their leakage except that this should not prevent exemption of small quantities of unsealed sources such as those used for radioimmunoassay;

(c) in normal operating conditions it does not cause an ambient dose equivalent rate or a directional dose equivalent rate, as appropriate, exceeding 1 $\mu Sv \cdot h^{-1}$ at a distance of 0.1 m from any accessible surface of the apparatus; and

(d) necessary conditions for disposal have been specified by the Regulatory Authority.

I-6. Radioactive substances from an authorized practice or source whose release to the environment has been authorized, are exempted from any new requirements of notification, registration or licensing unless otherwise specified by the Regulatory Authority.

TABLE I-I. EXEMPTION LEVELS: EXEMPT ACTIVITY CONCENTRATIONS AND EXEMPT ACTIVITIES OF RADIONUCLIDES (ROUNDED) *(see footnote 36)*

Nuclide	Activity concentration (Bq/g)	Activity (Bq)	Nuclide	Activity concentration (Bq/g)	Activity (Bq)
H-3	1×10^6	1×10^9	Fe-52	1×10^1	1×10^6
Be-7	1×10^3	1×10^7	Fe-55	1×10^4	1×10^6
C-14	1×10^4	1×10^7	Fe-59	1×10^1	1×10^6
O-15	1×10^2	1×10^9	Co-55	1×10^1	1×10^6
F-18	1×10^1	1×10^6	Co-56	1×10^1	1×10^5
Na-22	1×10^1	1×10^6	Co-57	1×10^2	1×10^6
Na-24	1×10^1	1×10^5	Co-58	1×10^1	1×10^6
Si-31	1×10^3	1×10^6	Co-58m	1×10^4	1×10^7
P-32	1×10^3	1×10^5	Co-60	1×10^1	1×10^5
P-33	1×10^5	1×10^8	Co-60m	1×10^3	1×10^6
S-35	1×10^5	1×10^8	Co-61	1×10^2	1×10^6
Cl-36	1×10^4	1×10^6	Co-62m	1×10^1	1×10^5
Cl-38	1×10^1	1×10^5	Ni-59	1×10^4	1×10^8
Ar-37	1×10^6	1×10^8	Ni-63	1×10^5	1×10^8
Ar-41	1×10^2	1×10^9	Ni-65	1×10^1	1×10^6
K-40	1×10^2	1×10^6	Cu-64	1×10^2	1×10^6
K-42	1×10^2	1×10^6	Zn-65	1×10^1	1×10^6
K-43	1×10^1	1×10^6	Zn-69	1×10^4	1×10^6
Ca-45	1×10^4	1×10^7	Zn-69m	1×10^2	1×10^6
Ca-47	1×10^1	1×10^6	Ga-72	1×10^1	1×10^5
Sc-46	1×10^1	1×10^6	Ge-71	1×10^4	1×10^8
Sc-47	1×10^2	1×10^6	As-73	1×10^3	1×10^7
Sc-48	1×10^1	1×10^5	As-74	1×10^1	1×10^6
V-48	1×10^1	1×10^5	As-76	1×10^2	1×10^5
Cr-51	1×10^3	1×10^7	As-77	1×10^3	1×10^6
Mn-51	1×10^1	1×10^5	Se-75	1×10^2	1×10^6
Mn-52	1×10^1	1×10^5	Br-82	1×10^1	1×10^6
Mn-52m	1×10^1	1×10^5	Kr-74	1×10^2	1×10^9
Mn-53	1×10^4	1×10^9	Kr-76	1×10^2	1×10^9
Mn-54	1×10^1	1×10^6	Kr-77	1×10^2	1×10^9
Mn-56	1×10^1	1×10^5	Kr-79	1×10^3	1×10^5

TABLE I-I. (cont.)

Nuclide	Activity concentration (Bq/g)	Activity (Bq)	Nuclide	Activity concentration (Bq/g)	Activity (Bq)
Kr-81	1×10^4	1×10^7	Tc-97	1×10^3	1×10^8
Kr-83m	1×10^5	1×10^{12}	Tc-97m	1×10^3	1×10^7
Kr-85	1×10^5	1×10^4	Tc-99	1×10^4	1×10^7
Kr-85m	1×10^3	1×10^{10}	Tc-99m	1×10^2	1×10^7
Kr-87	1×10^2	1×10^9	Ru-97	1×10^2	1×10^7
Kr-88	1×10^2	1×10^9	Ru-103	1×10^2	1×10^6
Rb-86	1×10^2	1×10^5	Ru-105	1×10^1	1×10^6
Sr-85	1×10^2	1×10^6	Ru-106[a]	1×10^2	1×10^5
Sr-85m	1×10^2	1×10^7	Rh-103m	1×10^4	1×10^8
Sr-87m	1×10^2	1×10^6	Rh-105	1×10^2	1×10^7
Sr-89	1×10^3	1×10^6	Pd-103	1×10^3	1×10^8
Sr-90[a]	1×10^2	1×10^4	Pd-109	1×10^3	1×10^6
Sr-91	1×10^1	1×10^5	Ag-105	1×10^2	1×10^6
Sr-92	1×10^1	1×10^6	Ag-110m	1×10^1	1×10^6
Y-90	1×10^3	1×10^5	Ag-111	1×10^3	1×10^6
Y-91	1×10^3	1×10^6	Cd-109	1×10^4	1×10^6
Y-91m	1×10^2	1×10^6	Cd-115	1×10^2	1×10^6
Y-92	1×10^2	1×10^5	Cd-115m	1×10^3	1×10^6
Y-93	1×10^2	1×10^5	In-111	1×10^2	1×10^6
Zr-93[a]	1×10^3	1×10^7	In-113m	1×10^2	1×10^6
Zr-95	1×10^1	1×10^6	In-114m	1×10^2	1×10^6
Zr-97[a]	1×10^1	1×10^5	In-115m	1×10^2	1×10^6
Nb-93m	1×10^4	1×10^7	Sn-113	1×10^3	1×10^7
Nb-94	1×10^1	1×10^6	Sn-125	1×10^2	1×10^5
Nb-95	1×10^1	1×10^6	Sb-122	1×10^2	1×10^4
Nb-97	1×10^1	1×10^6	Sb-124	1×10^1	1×10^6
Nb-98	1×10^1	1×10^5	Sb-125	1×10^2	1×10^6
Mo-90	1×10^1	1×10^6	Te-123m	1×10^2	1×10^7
Mo-93	1×10^3	1×10^8	Te-125m	1×10^3	1×10^7
Mo-99	1×10^2	1×10^6	Te-127	1×10^3	1×10^6
Mo-101	1×10^1	1×10^6	Te-127m	1×10^3	1×10^7
Tc-96	1×10^1	1×10^6	Te-129	1×10^2	1×10^6
Tc-96m	1×10^3	1×10^7	Te-129m	1×10^3	1×10^6

TABLE I-I. (cont.)

Nuclide	Activity concentration (Bq/g)	Activity (Bq)	Nuclide	Activity concentration (Bq/g)	Activity (Bq)
Te-131	1×10^2	1×10^5	Ce-143	1×10^2	1×10^6
Te-131m	1×10^1	1×10^6	Ce-144[a]	1×10^2	1×10^5
Te-132	1×10^2	1×10^7	Pr-142	1×10^2	1×10^5
Te-133	1×10^1	1×10^5	Pr-143	1×10^4	1×10^6
Te-133m	1×10^1	1×10^5	Nd-147	1×10^2	1×10^6
Te-134	1×10^1	1×10^6	Nd-149	1×10^2	1×10^6
I-123	1×10^2	1×10^7	Pm-147	1×10^4	1×10^7
I-125	1×10^3	1×10^6	Pm-149	1×10^3	1×10^6
I-126	1×10^2	1×10^6	Sm-151	1×10^4	1×10^8
I-129	1×10^2	1×10^5	Sm-153	1×10^2	1×10^6
I-130	1×10^1	1×10^6	Eu-152	1×10^1	1×10^6
I-131	1×10^2	1×10^6	Eu-152m	1×10^2	1×10^6
I-132	1×10^1	1×10^5	Eu-154	1×10^1	1×10^6
I-133	1×10^1	1×10^6	Eu-155	1×10^2	1×10^7
I-134	1×10^1	1×10^5	Gd-153	1×10^2	1×10^7
I-135	1×10^1	1×10^6	Gd-159	1×10^3	1×10^6
Xe-131m	1×10^4	1×10^4	Tb-160	1×10^1	1×10^6
Xe-133	1×10^3	1×10^4	Dy-165	1×10^3	1×10^6
Xe-135	1×10^3	1×10^{10}	Dy-166	1×10^3	1×10^6
Cs-129	1×10^2	1×10^5	Ho-166	1×10^3	1×10^5
Cs-131	1×10^3	1×10^6	Er-169	1×10^4	1×10^7
Cs-132	1×10^1	1×10^5	Er-171	1×10^2	1×10^6
Cs-134m	1×10^3	1×10^5	Tm-170	1×10^3	1×10^6
Cs-134	1×10^1	1×10^4	Tm-171	1×10^4	1×10^8
Cs-135	1×10^4	1×10^7	Yb-175	1×10^3	1×10^7
Cs-136	1×10^1	1×10^5	Lu-177	1×10^3	1×10^7
Cs-137[a]	1×10^1	1×10^4	Hf-181	1×10^1	1×10^6
Cs-138	1×10^1	1×10^4	Ta-182	1×10^1	1×10^4
Ba-131	1×10^2	1×10^6	W-181	1×10^3	1×10^7
Ba-140[a]	1×10^1	1×10^5	W-185	1×10^4	1×10^7
La-140	1×10^1	1×10^5	W-187	1×10^2	1×10^6
Ce-139	1×10^2	1×10^6	Re-186	1×10^3	1×10^6
Ce-141	1×10^2	1×10^7	Re-188	1×10^2	1×10^5

TABLE I-I. (cont.)

Nuclide	Activity concentration (Bq/g)	Activity (Bq)	Nuclide	Activity concentration (Bq/g)	Activity (Bq)
Os-185	1×10^1	1×10^6	Rn-222[a]	1×10^1	1×10^8
Os-191	1×10^2	1×10^7	Ra-223[a]	1×10^2	1×10^5
Os-191m	1×10^3	1×10^7	Ra-224[a]	1×10^1	1×10^5
Os-193	1×10^2	1×10^6	Ra-225	1×10^2	1×10^5
Ir-190	1×10^1	1×10^6	Ra-226[a]	1×10^1	1×10^4
Ir-192	1×10^1	1×10^4	Ra-227	1×10^2	1×10^6
Ir-194	1×10^2	1×10^5	Ra-228[a]	1×10^1	1×10^5
Pt-191	1×10^2	1×10^6	Ac-228	1×10^1	1×10^6
Pt-193m	1×10^3	1×10^7	Th-226[a]	1×10^3	1×10^7
Pt-197	1×10^3	1×10^6	Th-227	1×10^1	1×10^4
Pt-197m	1×10^2	1×10^6	Th-228[a]	1×10^0	1×10^4
Au-198	1×10^2	1×10^6	Th-229[a]	1×10^0	1×10^3
Au-199	1×10^2	1×10^6	Th-230	1×10^0	1×10^4
Hg-197	1×10^2	1×10^7	Th-231	1×10^3	1×10^7
Hg-197m	1×10^2	1×10^6	Th-nat	1×10^0	1×10^3
Hg-203	1×10^2	1×10^5	(incl. Th-232)		
Tl-200	1×10^1	1×10^6	Th-234[a]	1×10^3	1×10^5
Tl-201	1×10^2	1×10^6	Pa-230	1×10^1	1×10^6
Tl-202	1×10^2	1×10^6	Pa-231	1×10^0	1×10^3
Tl-204	1×10^4	1×10^4	Pa-233	1×10^2	1×10^7
Pb-203	1×10^2	1×10^6	U-230[a]	1×10^1	1×10^5
Pb-210[a]	1×10^1	1×10^4	U-231	1×10^2	1×10^7
Pb-212[a]	1×10^1	1×10^5	U-232[a]	1×10^0	1×10^3
Bi-206	1×10^1	1×10^5	U-233	1×10^1	1×10^4
Bi-207	1×10^1	1×10^6	U-234	1×10^1	1×10^4
Bi-210	1×10^3	1×10^6	U-235[a]	1×10^1	1×10^4
Bi-212[a]	1×10^1	1×10^5	U-236	1×10^1	1×10^4
Po-203	1×10^1	1×10^6	U-237	1×10^2	1×10^6
Po-205	1×10^1	1×10^6	U-238[a]	1×10^1	1×10^4
Po-207	1×10^1	1×10^6	U-nat	1×10^0	1×10^3
Po-210	1×10^1	1×10^4	U-239	1×10^2	1×10^6
At-211	1×10^3	1×10^7	U-240	1×10^3	1×10^7
Rn-220[a]	1×10^4	1×10^7	U-240[a]	1×10^1	1×10^6

TABLE I-I. (cont.)

Nuclide	Activity concentration (Bq/g)	Activity (Bq)	Nuclide	Activity concentration (Bq/g)	Activity (Bq)
Np-237[a]	1×10^0	1×10^3	Cm-244	1×10^1	1×10^4
Np-239	1×10^2	1×10^7	Cm-245	1×10^0	1×10^3
Np-240	1×10^1	1×10^6	Cm-246	1×10^0	1×10^3
Pu-234	1×10^2	1×10^7	Cm-247	1×10^0	1×10^4
Pu-235	1×10^2	1×10^7	Cm-248	1×10^0	1×10^3
Pu-236	1×10^1	1×10^4	Bk-249	1×10^3	1×10^6
Pu-237	1×10^3	1×10^7	Cf-246	1×10^3	1×10^6
Pu-238	1×10^0	1×10^4	Cf-248	1×10^1	1×10^4
Pu-239	1×10^0	1×10^4	Cf-249	1×10^0	1×10^3
Pu-240	1×10^0	1×10^3	Cf-250	1×10^1	1×10^4
Pu-241	1×10^2	1×10^5	Cf-251	1×10^0	1×10^3
Pu-242	1×10^0	1×10^4	Cf-252	1×10^1	1×10^4
Pu-243	1×10^3	1×10^7	Cf-253	1×10^2	1×10^5
Pu-244	1×10^0	1×10^4	Cf-254	1×10^0	1×10^3
Am-241	1×10^0	1×10^4	Es-253	1×10^2	1×10^5
Am-242	1×10^3	1×10^6	Es-254	1×10^1	1×10^4
Am-242m[a]	1×10^0	1×10^4	Es-254m	1×10^2	1×10^6
Am-243[a]	1×10^0	1×10^3	Fm-254	1×10^4	1×10^7
Cm-242	1×10^2	1×10^5	Fm-255	1×10^3	1×10^6
Cm-243	1×10^0	1×10^4			

[a] Parent nuclides and their progeny included in secular equilibrium are listed in the following:

Sr-90	Y-90
Zr-93	Nb-93m
Zr-97	Nb-97
Ru-106	Rh-106
Cs-137	Ba-137m
Ce-134	La-134
Ce-144	Pr-144
Ba-140	La-140
Bi-212	Tl-208 (0.36), Po-212 (0.64)
Pb-210	Bi-210, Po-210
Pb-212	Bi-212, Tl-208 (0.36), Po-212 (0.64)
Rn-220	Po-216
Rn-222	Po-218, Pb-214, Bi-214, Po-214

Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Ra-228	Ac-228
Th-226	Ra-222, Rn-218, Po-214
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
Th-nat	Ra-228, Ac-228, Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-234	Pa-234m
U-230	Th-226, Ra-222, Rn-218, Po-214
U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
U-235	Th-231
U-238	Th-234, Pa-234m
U-nat	Th-234, Pa-234m, U-234, Th-230, Ra-226, Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
U-240	Np-240m
Np-237	Pa-233
Am-242m	Am-242
Am-243	Np-239

Schedule II

DOSE LIMITS

APPLICATION

II-1. The dose limits specified in Schedule II apply to exposures attributable to practices, with the exceptions of medical exposures and of exposures from natural sources that cannot reasonably be regarded as being under the responsibility of any principal party of the Standards.

II-2. Subject to the requirements set forth in para. 205 for exposure in a workplace to radon above a yearly average concentration of 1000 $Bq \cdot m^{-3}$ [37] in air, the dose limits for occupational exposure and the relevant requirements of Appendix I shall apply.

II-3. The dose limits are not relevant for the control of potential exposures.

II-4. The dose limits are not relevant for decisions on whether and how to undertake an intervention, but workers undertaking an intervention shall be subject to the relevant requirements of Appendix V.

OCCUPATIONAL EXPOSURE

Dose limits

II-5. The occupational exposure of any worker shall be so controlled that the following limits be not exceeded:

(a) an effective dose of 20 mSv per year averaged over five consecutive years[38];
(b) an effective dose of 50 mSv in any single year;

[37] The International Commission on Radiological Protection has recommended that the action levels for occupational exposure to radon can fall in the range 500–1500 $Bq \cdot m^{-3}$. (See INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Protection against Radon-222 at Home and at Work, Publication No. 65, *Ann. ICRP* **23** 2, Pergamon Press, Oxford (1993).)

[38] The start of the averaging period shall be coincident with the first day of the relevant annual period after the date of entry into force of the Standards, with no retroactive averaging.

(c) an equivalent dose to the lens of the eye of 150 mSv in a year; and
(d) an equivalent dose to the extremities (hands and feet) or the skin[39] of 500 mSv in a year.

II-6. For apprentices of 16 to 18 years of age who are training for employment involving exposure to radiation and for students of age 16 to 18 who are required to use sources in the course of their studies, the occupational exposure shall be so controlled that the following limits be not exceeded:

(a) an effective dose of 6 mSv in a year;
(b) an equivalent dose to the lens of the eye of 50 mSv in a year; and
(c) an equivalent dose to the extremities or the skin[39] of 150 mSv in a year.

Special circumstances

II-7. When, in special circumstances[40], a temporary change in the dose limitation requirements is approved pursuant to Appendix I:

(a) the dose averaging period mentioned in para. II-5 (a) may exceptionally be up to 10 consecutive years as specified by the Regulatory Authority, and the effective dose for any worker shall not exceed 20 mSv per year averaged over this period and shall not exceed 50 mSv in any single year, and the circumstances shall be reviewed when the dose accumulated by any worker since the start of the extended averaging period reaches 100 mSv; or
(b) the temporary change in the dose limitation shall be as specified by the Regulatory Authority but shall not exceed 50 mSv in any year and the period of the temporary change shall not exceed 5 years.

PUBLIC EXPOSURE

Dose limits

II-8. The estimated average doses to the relevant critical groups of members of the public that are attributable to practices shall not exceed the following limits:

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[39] The equivalent dose limits for the skin apply to the average dose over 1 cm^2 of the most highly irradiated area of the skin. Skin dose also contributes to the effective dose, this contribution being the average dose to the entire skin multiplied by the tissue weighting factor for the skin.

[40] See Appendix I: the provisions for 'alternative employment' set out in para. 418 may be relevant.

(a) an effective dose of 1 mSv in a year;
(b) in special circumstances, an effective dose of up to 5 mSv in a single year provided that the average dose over five consecutive years does not exceed 1 mSv per year;
(c) an equivalent dose to the lens of the eye of 15 mSv in a year; and
(d) an equivalent dose to the skin of 50 mSv in a year.

Dose limitation for comforters and visitors of patients

II-9. The dose limits set out in this part shall not apply to comforters of patients, i.e., to individuals knowingly exposed while voluntarily helping (other than in their employment or occupation) in the care, support and comfort of patients undergoing medical diagnosis or treatment, or to visitors of such patients. However, the dose of any such comforter or visitor of patients shall be constrained so that it is unlikely that his or her dose will exceed 5 mSv during the period of a patient's diagnostic examination or treatment. The dose to children visiting patients who have ingested radioactive materials should be similarly constrained to less than 1 mSv.

VERIFICATION OF COMPLIANCE WITH DOSE LIMITS

II-10. The dose limits specified in Schedule II apply to the sum of the relevant doses from external exposure in the specified period and the relevant committed doses from intakes in the same period; the period for calculating the committed dose shall normally be 50 years for intakes by adults and to age 70 years for intakes by children.

II-11. For the purpose of demonstrating compliance with dose limits, the sum of the personal dose equivalent from external exposure to penetrating radiation in the specified period and the committed equivalent dose or committed effective dose, as appropriate, from intakes of radioactive substances in the same period shall be used.

II-12. Compliance with the foregoing requirements for application of the dose limits on effective dose shall be determined by either of the following methods:

(a) by comparing the total effective dose with the relevant dose limit, where the total effective dose E_T is calculated according to the following formula:

$$E_T = H_p(d) + \sum_j e(g)_{j,ing} I_{j,ing} + \sum_j e(g)_{j,inh} I_{j,inh}$$

where $H_p(d)$ is the personal dose equivalent from exposure to penetrating radiation[41] during the year; $e(g)_{j,ing}$ and $e(g)_{j,inh}$ are the committed effective dose per unit intake by ingestion and inhalation for radionuclide j by the group of age g; and $I_{j,ing}$ and $I_{j,inh}$ are the intakes via ingestion or inhalation of radionuclide j during the same period; or

(b) by satisfying the following condition:

$$\frac{H_p(d)}{DL} + \sum_j \frac{I_{j,ing}}{I_{j,ing,L}} + \sum_j \frac{I_{j,inh}}{I_{j,inh,L}} \leq 1$$

where DL is the relevant dose limit on effective dose, and $I_{j,ing,L}$ and $I_{j,inh,L}$ are the annual limits on intake (ALI) via ingestion or via inhalation of radionuclide j (i.e. the intakes by the relevant route of radionuclide j that lead to the relevant limit on effective dose); or

(c) by any other approved method.

II-13. Except for radon progeny and thoron progeny, values of the committed effective dose per unit intake for ingestion $e(g)_{j,ing}$ and for inhalation $e(g)_{j,inh}$ are given for occupational exposure in Table II-III and for public exposure in Tables II-VI and II-VII. Values of $I_{j,L}$ may be obtained from the relevant values of the committed effective dose per unit intake by means of the following relationship:

$$I_{j,L} = \frac{DL}{e_j}$$

where DL is the relevant annual dose limit on effective dose and e_j is the relevant value of dose per unit intake for radionuclide j given in Tables II-III, II-VI or II-VII as appropriate.

II-14. For occupational exposure to radionuclides, Table II-III gives ingestion and inhalation dose coefficients: that is, the committed effective dose per unit intake via ingestion corresponding to different gut transfer factors f_1 (i.e. the proportion of the intake transferred to body fluids in the gut) for various chemical forms; and the committed effective dose per unit intake via inhalation for the default lung absorption types (fast, moderate and slow) given in the new model for the respiratory tract (see

[41] The use of the ICRU operational quantity personal dose equivalent, $H_p(d)$, for this purpose is appropriate for all radiations except neutrons in the energy range 1 eV to 30 keV. In situations in which neutrons in this energy range contribute a major fraction of the effective dose, additional information may be necessary to determine the relationship between the value of the personal dose equivalent and the corresponding effective dose.

ICRP Publication No. 66 (1994))[42], with appropriate f_1 values for the component of the intake cleared from the lung to the gastrointestinal tract. These inhalation and ingestion dose coefficients for occupational exposure are consistent with those given in ICRP Publication No. 68 (1994)[42]. Table II-IV gives the f_1 values and Table II-V gives the lung absorption types for various chemical forms of the elements, on the basis that inhalation classes given as days, weeks and years in ICRP Publication No. 30, Parts 1–4, have been designated as absorption types F, M and S (fast, moderate and slow), respectively, as in ICRP Publication No. 68 (1994)[42]. Under certain assumptions $I_{j,L}$ can be used as an ALI for occupational exposure.

II-15. For public exposure to radionuclides, Table II-VI gives ingestion dose coefficients corresponding to different gut transfer factors f_1 for intakes of radionuclides by members of the public. The f_1 values used in the calculations, which are also given in the table, are taken from ICRP Publications Nos 56 (1989), 67 (1993), 69 (1995) and 71 (1996)[42] wherever possible, or otherwise from ICRP Publication No. 30 (Parts 1–4)[42]. Increased f_1 values have been applied to three-month-old infants. Table II-VII gives inhalation dose coefficients for members of the public for different lung absorption types (F, M and S). The relevant ICRP Publications for the source of information on lung absorption types and biokinetic models for systemic

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[42] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Limits for Intakes of Radionuclides by Workers, ICRP Publication No. 30, Part 1, *Ann. ICRP* **2** 3/4, Pergamon Press, Oxford (1979); ICRP, Limits for Intakes of Radionuclides by Workers, ICRP Publication No. 30, Part 2, *Ann. ICRP* **4** 3/4, Pergamon Press, Oxford (1980); ICRP, Limits for Intakes of Radionuclides by Workers, ICRP Publication No. 30, Part 3 (including addendum to Parts 1 and 2), *Ann. ICRP* **6** 2/3, Pergamon Press, Oxford (1981); ICRP, Limits for Intakes of Radionuclides by Workers: An Addendum, ICRP Publication No. 30, Part 4, *Ann. ICRP* **19** 4, Pergamon Press, Oxford (1988);; ICRP, Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 1, ICRP Publication No. 56, *Ann. ICRP* **20** 2, Pergamon Press, Oxford (1989); ICRP, Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 2, Ingestion Dose Coefficients, ICRP Publication No. 67, *Ann. ICRP* **23** 3/4, Elsevier Science, Oxford (1993); ICRP, Human Respiratory Tract Model for Radiological Protection, ICRP Publication No. 66, *Ann. ICRP* **24** 1-3, Elsevier Science, Oxford (1994); ICRP, Dose Coefficients for Intakes of Radionuclides by Workers, ICRP Publication No. 68, *Ann. ICRP* **24** 4, Elsevier Science, Oxford (1994); ICRP, Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 3, Ingestion Dose Coefficients, ICRP Publication No. 69, *Ann. ICRP* **25** 1, Elsevier Science, Oxford (1995); ICRP, Age-Dependent Doses to Members of the Public from Intake of Radionuclides, Part 4, Inhalation Dose Coefficients, ICRP Publication No. 71, *Ann. ICRP* **26**, Elsevier Science, Oxford (1996); ICRP, Age-Dependent Doses to Members of the Public from Intake of Radionuclides, Part 5, Compilation of Ingestion and Inhalation Dose Coefficients, ICRP Publication No. 72, *Ann. ICRP* **26**, Elsevier Science, Oxford (1996); ICRP, Protection against Radon-222 at Home and at Work, ICRP Publication No. 65, *Ann. ICRP* **23** 2, Pergamon Press, Oxford (1993).

activity used for these calculations are given in Table II-VIII. For the 31 elements for which information on lung absorption is given in ICRP Publication No. 71 (1996)[42], dose coefficients are given for the three absorption types, together with a recommended default value for use if, and only if, no specific information is available on the chemical form of the radionuclide. For all these 31 elements, specific age dependent biokinetic models for systemic activity have been developed by the ICRP and information is given in Publications Nos 56, 67, 69 and 71[42]. The radionuclides of these elements are considered to be of principal significance for purposes of environmental radiation protection. For radionuclides of the remaining 60 elements, the biokinetic models used are those given in ICRP Publication No. 30 (Parts 1-4)[42] for workers. The dose calculations for the radionuclides of these additional elements allow for age dependent changes in body mass, geometry and excretion rates, but not for the biokinetics of systemic activity. The results should therefore be used with caution for members of the public. Higher f_1 values have been applied to three-month-old infants. The dose coefficients for the various radionuclides of these additional 60 elements have been calculated on the basis that lung classes given as D, W and Y in ICRP Publication No. 30 have been designated as absorption types F, M and S respectively. Information is given in the relevant ICRP publications on the chemical forms appropriate to the different inhalation classes/types. In general, if no information is available on these parameters, the most restrictive value should be used for comparison with dose limits. These dose coefficients are consistent with those given in ICRP Publication No. 72 (1996)[42].

II-16. Table II-IX gives dose coefficients for gases and vapours for infants, children and adults. The values for adults are appropriate for both workers and members of the public. These dose coefficients are consistent with those given in ICRP Publication Nos 71 (1996) and 72 (1996)[42]. Table II-X gives effective dose rates for exposure of adults to inert gases. The values are applicable to both workers and adult members of the public.

II-17. For exposure to radon progeny, using a conversion coefficient of 1.4 mSv per $mJ \cdot h \cdot m^{-3}$, the dose limits in para. II-5 may be interpreted as follows: 20 mSv corresponds to 14 $mJ \cdot h \cdot m^{-3}$ (4 working level months (WLMs)) and 50 mSv corresponds to 35 $mJ \cdot h \cdot m^{-3}$ (10 WLM). For exposure to radon progeny and thoron progeny, $I_{j,inh}$ and $I_{j,inh,L}$ in the formulas given in para. II-12 may be expressed in terms of potential alpha energy intake, using the relevant limits specified in Tables II-I and II-II (the values are from ICRP Publication No. 65 (1993)[42]); alternatively, $I_{j,inh}$ and $I_{j,inh,L}$ may be replaced by potential alpha energy exposure (often expressed in WLMs), using the relevant limits specified in Tables II-I and II-II.

II-18. The committed equivalent dose in an organ or tissue due to the intake by a given route of any radionuclide may be determined:

(a) by multiplying the estimated intake of the radionuclide via such a route by the appropiate value of the committed equivalent dose per unit intake corresponding to such an organ or tissue; or

(b) by any other approved method.

TABLE II-I. LIMITS ON INTAKE AND EXPOSURE FOR RADON PROGENY AND THORON PROGENY

Quantity	Unit	Value for radon progeny[a]	Value for thoron progeny[b]
Annual average over 5 years			
Potential α-energy intake	J	0.017	0.051
Potential α-energy exposure	$J \cdot h \cdot m^{-3}$ [d]	0.014	0.042
	WLM[c,d]	4.0	12
Maximum in a single year			
Potential α-energy intake	J	0.042	0.127
Potential α-energy exposure	$J \cdot h \cdot m^{-3}$ [d]	0.035	0.105
	WLM	10.0	30

Note: Values are from ICRP Publication No. 65 (see footnote 37).

[a] Radon progeny: short lived decay products of ^{222}Rn: ^{218}Po (RaA), ^{214}Bi (RaC), ^{214}Pb (RaB) and ^{214}Po (RaC′).

[b] Thoron progeny: short lived decay products of ^{220}Rn: ^{216}Po (ThA), ^{212}Pb (ThB), ^{212}Bi (ThC), ^{212}Po (ThC′) and ^{208}Tl (ThC″).

[c] Working level month (WLM): A unit of exposure to radon progeny or thoron progeny. One working level month is 3.54 $mJ \cdot h \cdot m^{-3}$ or 170 WL·h, where one working level (WL) is any combination of radon or thoron progeny in one litre of air that will result in the ultimate emission of 1.3×10^5 MeV of alpha energy. In SI units, the WL is equivalent to 2.1×10^{-5} $J \cdot m^{-3}$.

[d] Conversion coefficients are given in Table II-II.

TABLE II-II. CONVERSION COEFFICIENTS FOR UNITS IN TABLE II-I FOR RADON AND RADON PROGENY

Quantity	Unit	Value
Radon progeny conversion	$(mJ \cdot h \cdot m^{-3})$ per WLM	3.54
Radon progeny/radon exposure conversions (equilibrium factor 0.4)	$(mJ \cdot h \cdot m^{-3})$ per $(Bq \cdot h \cdot m^{-3})$	2.22×10^{-6}
	WLM per $(Bq \cdot h \cdot m^{-3})$	6.28×10^{-7}
Annual exposure to radon progeny per unit radon concentration[a]:		
at home	$(mJ \cdot h \cdot m^{-3})$ per $(Bq \cdot m^{-3})$	1.56×10^{-2}
at work	$(mJ \cdot h \cdot m^{-3})$ per $(Bq \cdot m^{-3})$	4.45×10^{-3}
at home	WLM per $(Bq \cdot m^{-3})$	4.40×10^{-3}
at work	WLM per $(Bq \cdot m^{-3})$	1.26×10^{-3}
Dose conversion convention, effective dose per unit exposure to radon progeny:		
at home	mSv per $(mJ \cdot h \cdot m^{-3})$	1.1
at work	mSv per $(mJ \cdot h \cdot m^{-3})$	1.4
Dose conversion convention, effective dose per unit exposure to radon progeny:		
at home	mSv per WLM	4
at work	mSv per WLM	5
Radon progeny/radon concentration conversion		
with equilibrium factor F = 0.4	WL per $(Bq \cdot m^{-3})$	1.07×10^{-4}
in general	WL per $(Bq \cdot m^{-3})$	2.67×10^{-4}

Note: Values are from ICRP Publication No. 65 (see footnote 37).

[a] Assuming 7000 hours per year indoors or 2000 hours per year at work and an equilibrium factor of 0.4.

TABLE II-III. WORKERS: COMMITTED EFFECTIVE DOSE PER UNIT INTAKE e(g) VIA INHALATION AND VIA INGESTION ($Sv \cdot Bq^{-1}$) FOR WORKERS

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Hydrogen							
Tritiated water	12.3 a					1.000	1.8×10^{-11}
OBT[a]	12.3 a					1.000	4.2×10^{-11}
Beryllium							
Be-7	53.3 d	M	0.005	4.8×10^{-11}	4.3×10^{-11}	0.005	2.8×10^{-11}
		S	0.005	5.2×10^{-11}	4.6×10^{-11}		
Be-10	1.60×10^{6} a	M	0.005	9.1×10^{-9}	6.7×10^{-9}	0.005	1.1×10^{-9}
		S	0.005	3.2×10^{-8}	1.9×10^{-8}		
Carbon							
C-11	0.340 h					1.000	2.4×10^{-11}
C-14	5.73×10^{3} a					1.000	5.8×10^{-10}
Fluorine							
F-18	1.83 h	F	1.000	3.0×10^{-11}	5.4×10^{-11}	1.000	4.9×10^{-11}
		M	1.000	5.7×10^{-11}	8.9×10^{-11}		
		S	1.000	6.0×10^{-11}	9.3×10^{-11}		
Sodium							
Na-22	2.60 a	F	1.000	1.3×10^{-9}	2.0×10^{-9}	1.000	3.2×10^{-9}
Na-24	15.0 h	F	1.000	2.9×10^{-10}	5.3×10^{-10}	1.000	4.3×10^{-10}

Note: Types F, M and S denote fast, moderate and slow absorption from the lung, respectively.

[a] OBT: organically bound tritium.

Magnesium							
Mg-28	20.9 h	F	0.500	6.4×10^{-10}	1.1×10^{-9}	0.500	2.2×10^{-9}
		M	0.500	1.2×10^{-9}	1.7×10^{-9}		
Aluminium							
Al-26	7.16×10^{5} a	F	0.010	1.1×10^{-8}	1.4×10^{-8}	0.010	3.5×10^{-9}
		M	0.010	1.8×10^{-8}	1.2×10^{-8}		
Silicon							
Si-31	2.62 h	F	0.010	2.9×10^{-11}	5.1×10^{-11}	0.010	1.6×10^{-10}
		M	0.010	7.5×10^{-11}	1.1×10^{-10}		
		S	0.010	8.0×10^{-11}	1.1×10^{-10}		
Si-32	4.50×10^{2} a	F	0.010	3.2×10^{-9}	3.7×10^{-9}	0.010	5.6×10^{-10}
		M	0.010	1.5×10^{-8}	9.6×10^{-9}		
		S	0.010	1.1×10^{-7}	5.5×10^{-8}		
Phosphorus							
P-32	14.3 d	F	0.800	8.0×10^{-10}	1.1×10^{-9}	0.800	2.4×10^{-9}
		M	0.800	3.2×10^{-9}	2.9×10^{-9}		
P-33	25.4 d	F	0.800	9.6×10^{-11}	1.4×10^{-10}	0.800	2.4×10^{-10}
		M	0.800	1.4×10^{-9}	1.3×10^{-9}		
Sulphur							
S-35	87.4 d	F	0.800	5.3×10^{-11}	8.0×10^{-11}	0.800	1.4×10^{-10}
(inorganic)		M	0.800	1.3×10^{-9}	1.1×10^{-9}	0.100	1.9×10^{-10}
S-35	87.4 d					1.000	7.7×10^{-10}
(organic)							
Chlorine							
Cl-36	3.01×10^{5} a	F	1.000	3.4×10^{-10}	4.9×10^{-10}	1.000	9.3×10^{-10}
		M	1.000	6.9×10^{-9}	5.1×10^{-9}		
Cl-38	0.620 h	F	1.000	2.7×10^{-11}	4.6×10^{-11}	1.000	1.2×10^{-10}
		M	1.000	4.7×10^{-11}	7.3×10^{-11}		
Cl-39	0.927 h	F	1.000	2.7×10^{-11}	4.8×10^{-11}	1.000	8.5×10^{-11}
		M	1.000	4.8×10^{-11}	7.6×10^{-11}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Potassium							
K-40	1.28×10^{9} a	F	1.000	2.1×10^{-9}	3.0×10^{-9}	1.000	6.2×10^{-9}
K-42	12.4 h	F	1.000	1.3×10^{-10}	2.0×10^{-10}	1.000	4.3×10^{-10}
K-43	22.6 h	F	1.000	1.5×10^{-10}	2.6×10^{-10}	1.000	2.5×10^{-10}
K-44	0.369 h	F	1.000	2.1×10^{-11}	3.7×10^{-11}	1.000	8.4×10^{-11}
K-45	0.333 h	F	1.000	1.6×10^{-11}	2.8×10^{-11}	1.000	5.4×10^{-11}
Calcium							
Ca-41	1.40×10^{5} a	M	0.300	1.7×10^{-10}	1.9×10^{-10}	0.300	2.9×10^{-10}
Ca-45	163 d	M	0.300	2.7×10^{-9}	2.3×10^{-9}	0.300	7.6×10^{-10}
Ca-47	4.53 d	M	0.300	1.8×10^{-9}	2.1×10^{-9}	0.300	1.6×10^{-9}
Scandium							
Sc-43	3.89 h	S	1.0×10^{-4}	1.2×10^{-10}	1.8×10^{-10}	1.0×10^{-4}	1.9×10^{-10}
Sc-44	3.93 h	S	1.0×10^{-4}	1.9×10^{-10}	3.0×10^{-10}	1.0×10^{-4}	3.5×10^{-10}
Sc-44m	2.44 d	S	1.0×10^{-4}	1.5×10^{-9}	2.0×10^{-9}	1.0×10^{-4}	2.4×10^{-9}
Sc-46	83.8 d	S	1.0×10^{-4}	6.4×10^{-9}	4.8×10^{-9}	1.0×10^{-4}	1.5×10^{-9}
Sc-47	3.35 d	S	1.0×10^{-4}	7.0×10^{-10}	7.3×10^{-10}	1.0×10^{-4}	5.4×10^{-10}
Sc-48	1.82 d	S	1.0×10^{-4}	1.1×10^{-9}	1.6×10^{-9}	1.0×10^{-4}	1.7×10^{-9}
Sc-49	0.956 h	S	1.0×10^{-4}	4.1×10^{-11}	6.1×10^{-11}	1.0×10^{-4}	8.2×10^{-11}
Titanium							
Ti-44	47.3 a	F	0.010	6.1×10^{-8}	7.2×10^{-8}	0.010	5.8×10^{-9}
		M	0.010	4.0×10^{-8}	2.7×10^{-8}		
		S	0.010	1.2×10^{-7}	6.2×10^{-8}		

Ti-45	3.08 h	F	0.010	4.6×10^{-11}	8.3×10^{-11}	0.010	1.5×10^{-10}
		M	0.010	9.1×10^{-11}	1.4×10^{-10}		
		S	0.010	9.6×10^{-11}	1.5×10^{-10}		
Vanadium							
V-47	0.543 h	F	0.010	1.9×10^{-11}	3.2×10^{-11}	0.010	6.3×10^{-11}
		M	0.010	3.1×10^{-11}	5.0×10^{-11}		
V-48	16.2 d	F	0.010	1.1×10^{-9}	1.7×10^{-9}	0.010	2.0×10^{-9}
		M	0.010	2.3×10^{-9}	2.7×10^{-9}		
V-49	330 d	F	0.010	2.1×10^{-11}	2.6×10^{-11}	0.010	1.8×10^{-11}
		M	0.010	3.2×10^{-11}	2.3×10^{-11}		
Chromium							
Cr-48	23.0 h	F	0.100	1.0×10^{-10}	1.7×10^{-10}	0.100	2.0×10^{-10}
		M	0.100	2.0×10^{-10}	2.3×10^{-10}	0.010	2.0×10^{-10}
		S	0.100	2.2×10^{-10}	2.5×10^{-10}		
Cr-49	0.702 h	F	0.100	2.0×10^{-11}	3.5×10^{-11}	0.100	6.1×10^{-11}
		M	0.100	3.5×10^{-11}	5.6×10^{-11}	0.010	6.1×10^{-11}
		S	0.100	3.7×10^{-11}	5.9×10^{-11}		
Cr-51	27.7 d	F	0.100	2.1×10^{-11}	3.0×10^{-11}	0.100	3.8×10^{-11}
		M	0.100	3.1×10^{-11}	3.4×10^{-11}	0.010	3.7×10^{-11}
		S	0.100	3.6×10^{-11}	3.6×10^{-11}		
Manganese							
Mn-51	0.770 h	F	0.100	2.4×10^{-11}	4.2×10^{-11}	0.100	9.3×10^{-11}
		M	0.100	4.3×10^{-11}	6.8×10^{-11}		
Mn-52	5.59 d	F	0.100	9.9×10^{-10}	1.6×10^{-9}	0.100	1.8×10^{-9}
		M	0.100	1.4×10^{-9}	1.8×10^{-9}		
Mn-52m	0.352 h	F	0.100	2.0×10^{-11}	3.5×10^{-11}	0.100	6.9×10^{-11}
		M	0.100	3.0×10^{-11}	5.0×10^{-11}		
Mn-53	3.70×10^{6} a	F	0.100	2.9×10^{-11}	3.6×10^{-11}	0.100	3.0×10^{-11}
		M	0.100	5.2×10^{-11}	3.6×10^{-11}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Mn-54	312 d	F	0.100	8.7×10^{-10}	1.1×10^{-9}	0.100	7.1×10^{-10}
		M	0.100	1.5×10^{-9}	1.2×10^{-9}		
Mn-56	2.58 h	F	0.100	6.9×10^{-11}	1.2×10^{-10}	0.100	2.5×10^{-10}
		M	0.100	1.3×10^{-10}	2.0×10^{-10}		
Iron							
Fe-52	8.28 h	F	0.100	4.1×10^{-10}	6.9×10^{-10}	0.100	1.4×10^{-9}
		M	0.100	6.3×10^{-10}	9.5×10^{-10}		
Fe-55	2.70 a	F	0.100	7.7×10^{-10}	9.2×10^{-10}	0.100	3.3×10^{-10}
		M	0.100	3.7×10^{-10}	3.3×10^{-10}		
Fe-59	44.5 d	F	0.100	2.2×10^{-9}	3.0×10^{-9}	0.100	1.8×10^{-9}
		M	0.100	3.5×10^{-9}	3.2×10^{-9}		
Fe-60	1.00×10^{5} a	F	0.100	2.8×10^{-7}	3.3×10^{-7}	0.100	1.1×10^{-7}
		M	0.100	1.3×10^{-7}	1.2×10^{-7}		
Cobalt							
Co-55	17.5 h	M	0.100	5.1×10^{-10}	7.8×10^{-10}	0.100	1.0×10^{-9}
		S	0.050	5.5×10^{-10}	8.3×10^{-10}	0.050	1.1×10^{-9}
Co-56	78.7 d	M	0.100	4.6×10^{-9}	4.0×10^{-9}	0.100	2.5×10^{-9}
		S	0.050	6.3×10^{-9}	4.9×10^{-9}	0.050	2.3×10^{-9}
Co-57	271 d	M	0.100	5.2×10^{-10}	3.9×10^{-10}	0.100	2.1×10^{-10}
		S	0.050	9.4×10^{-10}	6.0×10^{-10}	0.050	1.9×10^{-10}
Co-58	70.8 d	M	0.100	1.5×10^{-9}	1.4×10^{-9}	0.100	7.4×10^{-10}
		S	0.050	2.0×10^{-9}	1.7×10^{-9}	0.050	7.0×10^{-10}
Co-58m	9.15 h	M	0.100	1.3×10^{-11}	1.5×10^{-11}	0.100	2.4×10^{-11}
		S	0.050	1.6×10^{-11}	1.7×10^{-11}	0.050	2.4×10^{-11}

Co-60	5.27 a	M	0.100	9.6×10^{-9}	7.1×10^{-9}	0.100	3.4×10^{-9}
		S	0.050	2.9×10^{-8}	1.7×10^{-8}	0.050	2.5×10^{-9}
Co-60m	0.174 h	M	0.100	1.1×10^{-12}	1.2×10^{-12}	0.100	1.7×10^{-12}
		S	0.050	1.3×10^{-12}	1.2×10^{-12}	0.050	1.7×10^{-12}
Co-61	1.65 h	M	0.100	4.8×10^{-11}	7.1×10^{-11}	0.100	7.4×10^{-11}
		S	0.050	5.1×10^{-11}	7.5×10^{-11}	0.050	7.4×10^{-11}
Co-62m	0.232 h	M	0.100	2.1×10^{-11}	3.6×10^{-11}	0.100	4.7×10^{-11}
		S	0.050	2.2×10^{-11}	3.7×10^{-11}	0.050	4.7×10^{-11}
Nickel							
Ni-56	6.10 d	F	0.050	5.1×10^{-10}	7.9×10^{-10}	0.050	8.6×10^{-10}
		M	0.050	8.6×10^{-10}	9.6×10^{-10}		
Ni-57	1.50 d	F	0.050	2.8×10^{-10}	5.0×10^{-10}	0.050	8.7×10^{-10}
		M	0.050	5.1×10^{-10}	7.6×10^{-10}		
Ni-59	7.50×10^{4} a	F	0.050	1.8×10^{-10}	2.2×10^{-10}	0.050	6.3×10^{-11}
		M	0.050	1.3×10^{-10}	9.4×10^{-11}		
Ni-63	96.0 a	F	0.050	4.4×10^{-10}	5.2×10^{-10}	0.050	1.5×10^{-10}
		M	0.050	4.4×10^{-10}	3.1×10^{-10}		
Ni-65	2.52 h	F	0.050	4.4×10^{-11}	7.5×10^{-11}	0.050	1.8×10^{-10}
		M	0.050	8.7×10^{-11}	1.3×10^{-10}		
Ni-66	2.27 d	F	0.050	4.5×10^{-10}	7.6×10^{-10}	0.050	3.0×10^{-9}
		M	0.050	1.6×10^{-9}	1.9×10^{-9}		
Copper							
Cu-60	0.387 h	F	0.500	2.4×10^{-11}	4.4×10^{-11}	0.500	7.0×10^{-11}
		M	0.500	3.5×10^{-11}	6.0×10^{-11}		
		S	0.500	3.6×10^{-11}	6.2×10^{-11}		
Cu-61	3.41 h	F	0.500	4.0×10^{-11}	7.3×10^{-11}	0.500	1.2×10^{-10}
		M	0.500	7.6×10^{-11}	1.2×10^{-10}		
		S	0.500	8.0×10^{-11}	1.2×10^{-10}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Cu-64	12.7 h	F	0.500	3.8×10^{-11}	6.8×10^{-11}	0.500	1.2×10^{-10}
		M	0.500	1.1×10^{-10}	1.5×10^{-10}		
		S	0.500	1.2×10^{-10}	1.5×10^{-10}		
Cu-67	2.58 d	F	0.500	1.1×10^{-10}	1.8×10^{-10}	0.500	3.4×10^{-10}
		M	0.500	5.2×10^{-10}	5.3×10^{-10}		
		S	0.500	5.8×10^{-10}	5.8×10^{-10}		
Zinc							
Zn-62	9.26 h	S	0.500	4.7×10^{-10}	6.6×10^{-10}	0.500	9.4×10^{-10}
Zn-63	0.635 h	S	0.500	3.8×10^{-11}	6.1×10^{-11}	0.500	7.9×10^{-11}
Zn-65	244 d	S	0.500	2.9×10^{-9}	2.8×10^{-9}	0.500	3.9×10^{-9}
Zn-69	0.950 h	S	0.500	2.8×10^{-11}	4.3×10^{-11}	0.500	3.1×10^{-11}
Zn-69m	13.8 h	S	0.500	2.6×10^{-10}	3.3×10^{-10}	0.500	3.3×10^{-10}
Zn-71m	3.92 h	S	0.500	1.6×10^{-10}	2.4×10^{-10}	0.500	2.4×10^{-10}
Zn-72	1.94 d	S	0.500	1.2×10^{-9}	1.5×10^{-9}	0.500	1.4×10^{-9}
Gallium							
Ga-65	0.253 h	F	0.001	1.2×10^{-11}	2.0×10^{-11}	0.001	3.7×10^{-11}
		M	0.001	1.8×10^{-11}	2.9×10^{-11}		
Ga-66	9.40 h	F	0.001	2.7×10^{-10}	4.7×10^{-10}	0.001	1.2×10^{-9}
		M	0.001	4.6×10^{-10}	7.1×10^{-10}		
Ga-67	3.26 d	F	0.001	6.8×10^{-11}	1.1×10^{-10}	0.001	1.9×10^{-10}
		M	0.001	2.3×10^{-10}	2.8×10^{-10}		
Ga-68	1.13 h	F	0.001	2.8×10^{-11}	4.9×10^{-11}	0.001	1.0×10^{-10}
		M	0.001	5.1×10^{-11}	8.1×10^{-11}		

Ga-70	0.353 h	F	0.001	9.3×10^{-12}	1.6×10^{-11}	0.001	3.1×10^{-11}
		M	0.001	1.6×10^{-11}	2.6×10^{-11}		
Ga-72	14.1 h	F	0.001	3.1×10^{-10}	5.6×10^{-10}	0.001	1.1×10^{-9}
		M	0.001	5.5×10^{-10}	8.4×10^{-10}		
Ga-73	4.91 h	F	0.001	5.8×10^{-11}	1.0×10^{-10}	0.001	2.6×10^{-10}
		M	0.001	1.5×10^{-10}	2.0×10^{-10}		
Germanium							
Ge-66	2.27 h	F	1.000	5.7×10^{-11}	9.9×10^{-11}	1.000	1.0×10^{-10}
		M	1.000	9.2×10^{-11}	1.3×10^{-10}		
Ge-67	0.312 h	F	1.000	1.6×10^{-11}	2.8×10^{-11}	1.000	6.5×10^{-11}
		M	1.000	2.6×10^{-11}	4.2×10^{-11}		
Ge-68	288 d	F	1.000	5.4×10^{-10}	8.3×10^{-10}	1.000	1.3×10^{-9}
		M	1.000	1.3×10^{-8}	7.9×10^{-9}		
Ge-69	1.63 d	F	1.000	1.4×10^{-10}	2.5×10^{-10}	1.000	2.4×10^{-10}
		M	1.000	2.9×10^{-10}	3.7×10^{-10}		
Ge-71	11.8 d	F	1.000	5.0×10^{-12}	7.8×10^{-12}	1.000	1.2×10^{-11}
		M	1.000	1.0×10^{-11}	1.1×10^{-11}		
Ge-75	1.38 h	F	1.000	1.6×10^{-11}	2.7×10^{-11}	1.000	4.6×10^{-11}
		M	1.000	3.7×10^{-11}	5.4×10^{-11}		
Ge-77	11.3 h	F	1.000	1.5×10^{-10}	2.5×10^{-10}	1.000	3.3×10^{-10}
		M	1.000	3.6×10^{-10}	4.5×10^{-10}		
Ge-78	1.45 h	F	1.000	4.8×10^{-11}	8.1×10^{-11}	1.000	1.2×10^{-10}
		M	1.000	9.7×10^{-11}	1.4×10^{-10}		
Arsenic							
As-69	0.253 h	M	0.500	2.2×10^{-11}	3.5×10^{-11}	0.500	5.7×10^{-11}
As-70	0.876 h	M	0.500	7.2×10^{-11}	1.2×10^{-10}	0.500	1.3×10^{-10}
As-71	2.70 d	M	0.500	4.0×10^{-10}	5.0×10^{-10}	0.500	4.6×10^{-10}
As-72	1.08 d	M	0.500	9.2×10^{-10}	1.3×10^{-9}	0.500	1.8×10^{-9}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
As-73	80.3 d	M	0.500	9.3×10^{-10}	6.5×10^{-10}	0.500	2.6×10^{-10}
As-74	17.8 d	M	0.500	2.1×10^{-9}	1.8×10^{-9}	0.500	1.3×10^{-9}
As-76	1.10 d	M	0.500	7.4×10^{-10}	9.2×10^{-10}	0.500	1.6×10^{-9}
As-77	1.62 d	M	0.500	3.8×10^{-10}	4.2×10^{-10}	0.500	4.0×10^{-10}
As-78	1.51 h	M	0.500	9.2×10^{-11}	1.4×10^{-10}	0.500	2.1×10^{-10}
Selenium							
Se-70	0.683 h	F	0.800	4.5×10^{-11}	8.2×10^{-11}	0.800	1.2×10^{-10}
		M	0.800	7.3×10^{-11}	1.2×10^{-10}	0.050	1.4×10^{-10}
Se-73	7.15 h	F	0.800	8.6×10^{-11}	1.5×10^{-10}	0.800	2.1×10^{-10}
		M	0.800	1.6×10^{-10}	2.4×10^{-10}	0.050	3.9×10^{-10}
Se-73m	0.650 h	F	0.800	9.9×10^{-12}	1.7×10^{-11}	0.800	2.8×10^{-11}
		M	0.800	1.8×10^{-11}	2.7×10^{-11}	0.050	4.1×10^{-11}
Se-75	120 d	F	0.800	1.0×10^{-9}	1.4×10^{-9}	0.800	2.6×10^{-9}
		M	0.800	1.4×10^{-9}	1.7×10^{-9}	0.050	4.1×10^{-10}
Se-79	6.50×10^4 a	F	0.800	1.2×10^{-9}	1.6×10^{-9}	0.800	2.9×10^{-9}
		M	0.800	2.9×10^{-9}	3.1×10^{-9}	0.050	3.9×10^{-10}
Se-81	0.308 h	F	0.800	8.6×10^{-12}	1.4×10^{-11}	0.800	2.7×10^{-11}
		M	0.800	1.5×10^{-11}	2.4×10^{-11}	0.050	2.7×10^{-11}
Se-81m	0.954 h	F	0.800	1.7×10^{-11}	3.0×10^{-11}	0.800	5.3×10^{-11}
		M	0.800	4.7×10^{-11}	6.8×10^{-11}	0.050	5.9×10^{-11}
Se-83	0.375 h	F	0.800	1.9×10^{-11}	3.4×10^{-11}	0.800	4.7×10^{-11}
		M	0.800	3.3×10^{-11}	5.3×10^{-11}	0.050	5.1×10^{-11}

Bromine							
Br-74	0.422 h	F	1.000	2.8×10^{-11}	5.0×10^{-11}	1.000	8.4×10^{-11}
		M	1.000	4.1×10^{-11}	6.8×10^{-11}		
Br-74m	0.691 h	F	1.000	4.2×10^{-11}	7.5×10^{-11}	1.000	1.4×10^{-10}
		M	1.000	6.5×10^{-11}	1.1×10^{-10}		
Br-75	1.63 h	F	1.000	3.1×10^{-11}	5.6×10^{-11}	1.000	7.9×10^{-11}
		M	1.000	5.5×10^{-11}	8.5×10^{-11}		
Br-76	16.2 h	F	1.000	2.6×10^{-10}	4.5×10^{-10}	1.000	4.6×10^{-10}
		M	1.000	4.2×10^{-10}	5.8×10^{-10}		
Br-77	2.33 d	F	1.000	6.7×10^{-11}	1.2×10^{-10}	1.000	9.6×10^{-11}
		M	1.000	8.7×10^{-11}	1.3×10^{-10}		
Br-80	0.290 h	F	1.000	6.3×10^{-12}	1.1×10^{-11}	1.000	3.1×10^{-11}
		M	1.000	1.0×10^{-11}	1.7×10^{-11}		
Br-80m	4.42 h	F	1.000	3.5×10^{-11}	5.8×10^{-11}	1.000	1.1×10^{-10}
		M	1.000	7.6×10^{-11}	1.0×10^{-10}		
Br-82	1.47 d	F	1.000	3.7×10^{-10}	6.4×10^{-10}	1.000	5.4×10^{-10}
		M	1.000	6.4×10^{-10}	8.8×10^{-10}		
Br-83	2.39 h	F	1.000	1.7×10^{-11}	2.9×10^{-11}	1.000	4.3×10^{-11}
		M	1.000	4.8×10^{-11}	6.7×10^{-11}		
Br-84	0.530 h	F	1.000	2.3×10^{-11}	4.0×10^{-11}	1.000	8.8×10^{-11}
		M	1.000	3.9×10^{-11}	6.2×10^{-11}		
Rubidium							
Rb-79	0.382 h	F	1.000	1.7×10^{-11}	3.0×10^{-11}	1.000	5.0×10^{-11}
Rb-81	4.58 h	F	1.000	3.7×10^{-11}	6.8×10^{-11}	1.000	5.4×10^{-11}
Rb-81m	0.533 h	F	1.000	7.3×10^{-12}	1.3×10^{-11}	1.000	9.7×10^{-12}
Rb-82m	6.20 h	F	1.000	1.2×10^{-10}	2.2×10^{-10}	1.000	1.3×10^{-10}
Rb-83	86.2 d	F	1.000	7.1×10^{-10}	1.0×10^{-9}	1.000	1.9×10^{-9}
Rb-84	32.8 d	F	1.000	1.1×10^{-9}	1.5×10^{-9}	1.000	2.8×10^{-9}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Rb-86	18.6 d	F	1.000	9.6×10^{-10}	1.3×10^{-9}	1.000	2.8×10^{-9}
Rb-87	4.70×10^{10} a	F	1.000	5.1×10^{-10}	7.6×10^{-10}	1.000	1.5×10^{-9}
Rb-88	0.297 h	F	1.000	1.7×10^{-11}	2.8×10^{-11}	1.000	9.0×10^{-11}
Rb-89	0.253 h	F	1.000	1.4×10^{-11}	2.5×10^{-11}	1.000	4.7×10^{-11}
Strontium							
Sr-80	1.67 h	F	0.300	7.6×10^{-11}	1.3×10^{-10}	0.300	3.4×10^{-10}
		S	0.010	1.4×10^{-10}	2.1×10^{-10}	0.010	3.5×10^{-10}
Sr-81	0.425 h	F	0.300	2.2×10^{-11}	3.9×10^{-11}	0.300	7.7×10^{-11}
		S	0.010	3.8×10^{-11}	6.1×10^{-11}	0.010	7.8×10^{-11}
Sr-82	25.0 d	F	0.300	2.2×10^{-9}	3.3×10^{-9}	0.300	6.1×10^{-9}
		S	0.010	1.0×10^{-8}	7.7×10^{-9}	0.010	6.0×10^{-9}
Sr-83	1.35 d	F	0.300	1.7×10^{-10}	3.0×10^{-10}	0.300	4.9×10^{-10}
		S	0.010	3.4×10^{-10}	4.9×10^{-10}	0.010	5.8×10^{-10}
Sr-85	64.8 d	F	0.300	3.9×10^{-10}	5.6×10^{-10}	0.300	5.6×10^{-10}
		S	0.010	7.7×10^{-10}	6.4×10^{-10}	0.010	3.3×10^{-10}
Sr-85m	1.16 h	F	0.300	3.1×10^{-12}	5.6×10^{-12}	0.300	6.1×10^{-12}
		S	0.010	4.5×10^{-12}	7.4×10^{-12}	0.010	6.1×10^{-12}
Sr-87m	2.80 h	F	0.300	1.2×10^{-11}	2.2×10^{-11}	0.300	3.0×10^{-11}
		S	0.010	2.2×10^{-11}	3.5×10^{-11}	0.010	3.3×10^{-11}
Sr-89	50.5 d	F	0.300	1.0×10^{-9}	1.4×10^{-9}	0.300	2.6×10^{-9}
		S	0.010	7.5×10^{-9}	5.6×10^{-9}	0.010	2.3×10^{-9}
Sr-90	29.1 a	F	0.300	2.4×10^{-8}	3.0×10^{-8}	0.300	2.8×10^{-8}
		S	0.010	1.5×10^{-7}	7.7×10^{-8}	0.010	2.7×10^{-9}

Sr-91	9.50 h	F	0.300	1.7×10^{-10}	2.9×10^{-10}	0.300	6.5×10^{-10}
		S	0.010	4.1×10^{-10}	5.7×10^{-10}	0.010	7.6×10^{-10}
Sr-92	2.71 h	F	0.300	1.1×10^{-10}	1.8×10^{-10}	0.300	4.3×10^{-10}
		S	0.010	2.3×10^{-10}	3.4×10^{-10}	0.010	4.9×10^{-10}
Yttrium							
Y-86	14.7 h	M	1.0×10^{-4}	4.8×10^{-10}	8.0×10^{-10}	1.0×10^{-4}	9.6×10^{-10}
		S	1.0×10^{-4}	4.9×10^{-10}	8.1×10^{-10}		
Y-86m	0.800 h	M	1.0×10^{-4}	2.9×10^{-11}	4.8×10^{-11}	1.0×10^{-4}	5.6×10^{-11}
		S	1.0×10^{-4}	3.0×10^{-11}	4.9×10^{-11}		
Y-87	3.35 d	M	1.0×10^{-4}	3.8×10^{-10}	5.2×10^{-10}	1.0×10^{-4}	5.5×10^{-10}
		S	1.0×10^{-4}	4.0×10^{-10}	5.3×10^{-10}		
Y-88	107 d	M	1.0×10^{-4}	3.9×10^{-9}	3.3×10^{-9}	1.0×10^{-4}	1.3×10^{-9}
		S	1.0×10^{-4}	4.1×10^{-9}	3.0×10^{-9}		
Y-90	2.67 d	M	1.0×10^{-4}	1.4×10^{-9}	1.6×10^{-9}	1.0×10^{-4}	2.7×10^{-9}
		S	1.0×10^{-4}	1.5×10^{-9}	1.7×10^{-9}		
Y-90m	3.19 h	M	1.0×10^{-4}	9.6×10^{-11}	1.3×10^{-10}	1.0×10^{-4}	1.7×10^{-10}
		S	1.0×10^{-4}	1.0×10^{-10}	1.3×10^{-10}		
Y-91	58.5 d	M	1.0×10^{-4}	6.7×10^{-9}	5.2×10^{-9}	1.0×10^{-4}	2.4×10^{-9}
		S	1.0×10^{-4}	8.4×10^{-9}	6.1×10^{-9}		
Y-91m	0.828 h	M	1.0×10^{-4}	1.0×10^{-11}	1.4×10^{-11}	1.0×10^{-4}	1.1×10^{-11}
		S	1.0×10^{-4}	1.1×10^{-11}	1.5×10^{-11}		
Y-92	3.54 h	M	1.0×10^{-4}	1.9×10^{-10}	2.7×10^{-10}	1.0×10^{-4}	4.9×10^{-10}
		S	1.0×10^{-4}	2.0×10^{-10}	2.8×10^{-10}		
Y-93	10.1 h	M	1.0×10^{-4}	4.1×10^{-10}	5.7×10^{-10}	1.0×10^{-4}	1.2×10^{-9}
		S	1.0×10^{-4}	4.3×10^{-10}	6.0×10^{-10}		
Y-94	0.318 h	M	1.0×10^{-4}	2.8×10^{-11}	4.4×10^{-11}	1.0×10^{-4}	8.1×10^{-11}
		S	1.0×10^{-4}	2.9×10^{-11}	4.6×10^{-11}		
Y-95	0.178 h	M	1.0×10^{-4}	1.6×10^{-11}	2.5×10^{-11}	1.0×10^{-4}	4.6×10^{-11}
		S	1.0×10^{-4}	1.7×10^{-11}	2.6×10^{-11}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Zirconium							
Zr-86	16.5 h	F	0.002	3.0×10^{-10}	5.2×10^{-10}	0.002	8.6×10^{-10}
		M	0.002	4.3×10^{-10}	6.8×10^{-10}		
		S	0.002	4.5×10^{-10}	7.0×10^{-10}		
Zr-88	83.4 d	F	0.002	3.5×10^{-9}	4.1×10^{-9}	0.002	3.3×10^{-10}
		M	0.002	2.5×10^{-9}	1.7×10^{-9}		
		S	0.002	3.3×10^{-9}	1.8×10^{-9}		
Zr-89	3.27 d	F	0.002	3.1×10^{-10}	5.2×10^{-10}	0.002	7.9×10^{-10}
		M	0.002	5.3×10^{-10}	7.2×10^{-10}		
		S	0.002	5.5×10^{-10}	7.5×10^{-10}		
Zr-93	1.53×10^{6} a	F	0.002	2.5×10^{-8}	2.9×10^{-8}	0.002	2.8×10^{-10}
		M	0.002	9.6×10^{-9}	6.6×10^{-9}		
		S	0.002	3.1×10^{-9}	1.7×10^{-9}		
Zr-95	64.0 d	F	0.002	2.5×10^{-9}	3.0×10^{-9}	0.002	8.8×10^{-10}
		M	0.002	4.5×10^{-9}	3.6×10^{-9}		
		S	0.002	5.5×10^{-9}	4.2×10^{-9}		
Zr-97	16.9 h	F	0.002	4.2×10^{-10}	7.4×10^{-10}	0.002	2.1×10^{-9}
		M	0.002	9.4×10^{-10}	1.3×10^{-9}		
		S	0.002	1.0×10^{-9}	1.4×10^{-9}		
Niobium							
Nb-88	0.238 h	M	0.010	2.9×10^{-11}	4.8×10^{-11}	0.010	6.3×10^{-11}
		S	0.010	3.0×10^{-11}	5.0×10^{-11}		
Nb-89	2.03 h	M	0.010	1.2×10^{-10}	1.8×10^{-10}	0.010	3.0×10^{-10}
		S	0.010	1.3×10^{-10}	1.9×10^{-10}		

Nb-89	1.10 h	M	0.010	7.1×10^{-11}	1.1×10^{-10}	0.010	1.4×10^{-10}
		S	0.010	7.4×10^{-11}	1.2×10^{-10}		
Nb-90	14.6 h	M	0.010	6.6×10^{-10}	1.0×10^{-9}	0.010	1.2×10^{-9}
		S	0.010	6.9×10^{-10}	1.1×10^{-9}		
Nb-93m	13.6 a	M	0.010	4.6×10^{-10}	2.9×10^{-10}	0.010	1.2×10^{-10}
		S	0.010	1.6×10^{-9}	8.6×10^{-10}		
Nb-94	2.03×10^{4} a	M	0.010	1.0×10^{-8}	7.2×10^{-9}	0.010	1.7×10^{-9}
		S	0.010	4.5×10^{-8}	2.5×10^{-8}		
Nb-95	35.1 d	M	0.010	1.4×10^{-9}	1.3×10^{-9}	0.010	5.8×10^{-10}
		S	0.010	1.6×10^{-9}	1.3×10^{-9}		
Nb-95m	3.61 d	M	0.010	7.6×10^{-10}	7.7×10^{-10}	0.010	5.6×10^{-10}
		S	0.010	8.5×10^{-10}	8.5×10^{-10}		
Nb-96	23.3 h	M	0.010	6.5×10^{-10}	9.7×10^{-10}	0.010	1.1×10^{-9}
		S	0.010	6.8×10^{-10}	1.0×10^{-9}		
Nb-97	1.20 h	M	0.010	4.4×10^{-11}	6.9×10^{-11}	0.010	6.8×10^{-11}
		S	0.010	4.7×10^{-11}	7.2×10^{-11}		
Nb-98	0.858 h	M	0.010	5.9×10^{-11}	9.6×10^{-11}	0.010	1.1×10^{-10}
		S	0.010	6.1×10^{-11}	9.9×10^{-11}		
Molybdenum							
Mo-90	5.67 h	F	0.800	1.7×10^{-10}	2.9×10^{-10}	0.800	3.1×10^{-10}
		S	0.050	3.7×10^{-10}	5.6×10^{-10}	0.050	6.2×10^{-10}
Mo-93	3.50×10^{3} a	F	0.800	1.0×10^{-9}	1.4×10^{-9}	0.800	2.6×10^{-9}
		S	0.050	2.2×10^{-9}	1.2×10^{-9}	0.050	2.0 10-10
Mo-93m	6.85 h	F	0.800	1.0×10^{-10}	1.9×10^{-10}	0.800	1.6×10^{-10}
		S	0.050	1.8×10^{-10}	3.0×10^{-10}	0.050	2.8×10^{-10}
Mo-99	2.75 d	F	0.800	2.3×10^{-10}	3.6×10^{-10}	0.800	7.4×10^{-10}
		S	0.050	9.7×10^{-10}	1.1×10^{-9}	0.050	1.2×10^{-9}
Mo-101	0.244 h	F	0.800	1.5×10^{-11}	2.7×10^{-11}	0.800	4.2×10^{-11}
		S	0.050	2.7×10^{-11}	4.5×10^{-11}	0.050	4.2×10^{-11}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Technetium							
Tc-93	2.75 h	F	0.800	3.4×10^{-11}	6.2×10^{-11}	0.800	4.9×10^{-11}
		M	0.800	3.6×10^{-11}	6.5×10^{-11}		
Tc-93m	0.725 h	F	0.800	1.5×10^{-11}	2.6×10^{-11}	0.800	2.4×10^{-11}
		M	0.800	1.7×10^{-11}	3.1×10^{-11}		
Tc-94	4.88 h	F	0.800	1.2×10^{-10}	2.1×10^{-10}	0.800	1.8×10^{-10}
		M	0.800	1.3×10^{-10}	2.2×10^{-10}		
Tc-94m	0.867 h	F	0.800	4.3×10^{-11}	6.9×10^{-11}	0.800	1.1×10^{-10}
		M	0.800	4.9×10^{-11}	8.0×10^{-11}		
Tc-95	20.0 h	F	0.800	1.0×10^{-10}	1.8×10^{-10}	0.800	1.6×10^{-10}
		M	0.800	1.0×10^{-10}	1.8×10^{-10}		
Tc-95m	61.0 d	F	0.800	3.1×10^{-10}	4.8×10^{-10}	0.800	6.2×10^{-10}
		M	0.800	8.7×10^{-10}	8.6×10^{-10}		
Tc-96	4.28 d	F	0.800	6.0×10^{-10}	9.8×10^{-10}	0.800	1.1×10^{-9}
		M	0.800	7.1×10^{-10}	1.0×10^{-9}		
Tc-96m	0.858 h	F	0.800	6.5×10^{-12}	1.1×10^{-11}	0.800	1.3×10^{-11}
		M	0.800	7.7×10^{-12}	1.1×10^{-11}		
Tc-97	2.60×10^{6} a	F	0.800	4.5×10^{-11}	7.2×10^{-11}	0.800	8.3×10^{-11}
		M	0.800	2.1×10^{-10}	1.6×10^{-10}		
Tc-97m	87.0 d	F	0.800	2.8×10^{-10}	4.0×10^{-10}	0.800	6.6×10^{-10}
		M	0.800	3.1×10^{-9}	2.7×10^{-9}		
Tc-98	4.20×10^{6} a	F	0.800	1.0×10^{-9}	1.5×10^{-9}	0.800	2.3×10^{-9}
		M	0.800	8.1×10^{-9}	6.1×10^{-9}		

Tc-99	2.13×10^{5} a	F	0.800	2.9×10^{-10}	4.0×10^{-10}	0.800	7.8×10^{-10}
		M	0.800	3.9×10^{-9}	3.2×10^{-9}		
Tc-99m	6.02 h	F	0.800	1.2×10^{-11}	2.0×10^{-11}	0.800	2.2×10^{-11}
		M	0.800	1.9×10^{-11}	2.9×10^{-11}		
Tc-101	0.237 h	F	0.800	8.7×10^{-12}	1.5×10^{-11}	0.800	1.9×10^{-11}
		M	0.800	1.3×10^{-11}	2.1×10^{-11}		
Tc-104	0.303 h	F	0.800	2.4×10^{-11}	3.9×10^{-11}	0.800	8.1×10^{-11}
		M	0.800	3.0×10^{-11}	4.8×10^{-11}		
Ruthenium							
Ru-94	0.863 h	F	0.050	2.7×10^{-11}	4.9×10^{-11}	0.050	9.4×10^{-11}
		M	0.050	4.4×10^{-11}	7.2×10^{-11}		
		S	0.050	4.6×10^{-11}	7.4×10^{-11}		
Ru-97	2.90 d	F	0.050	6.7×10^{-11}	1.2×10^{-10}	0.050	1.5×10^{-10}
		M	0.050	1.1×10^{-10}	1.6×10^{-10}		
		S	0.050	1.1×10^{-10}	1.6×10^{-10}		
Ru-103	39.3 d	F	0.050	4.9×10^{-10}	6.8×10^{-10}	0.050	7.3×10^{-10}
		M	0.050	2.3×10^{-9}	1.9×10^{-9}		
		S	0.050	2.8×10^{-9}	2.2×10^{-9}		
Ru-105	4.44 h	F	0.050	7.1×10^{-11}	1.3×10^{-10}	0.050	2.6×10^{-10}
		M	0.050	1.7×10^{-10}	2.4×10^{-10}		
		S	0.050	1.8×10^{-10}	2.5×10^{-10}		
Ru-106	1.01 a	F	0.050	8.0×10^{-9}	9.8×10^{-9}	0.050	7.0×10^{-9}
		M	0.050	2.6×10^{-8}	1.7×10^{-8}		
		S	0.050	6.2×10^{-8}	3.5×10^{-8}		
Rhodium							
Rh-99	16.0 d	F	0.050	3.3×10^{-10}	4.9×10^{-10}	0.050	5.1×10^{-10}
		M	0.050	7.3×10^{-10}	8.2×10^{-10}		
		S	0.050	8.3×10^{-10}	8.9×10^{-10}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Rh-99m	4.70 h	F	0.050	3.0×10^{-11}	5.7×10^{-11}	0.050	6.6×10^{-11}
		M	0.050	4.1×10^{-11}	7.2×10^{-11}		
		S	0.050	4.3×10^{-11}	7.3×10^{-11}		
Rh-100	20.8 h	F	0.050	2.8×10^{-10}	5.1×10^{-10}	0.050	7.1×10^{-10}
		M	0.050	3.6×10^{-10}	6.2×10^{-10}		
		S	0.050	3.7×10^{-10}	6.3×10^{-10}		
Rh-101	3.20 a	F	0.050	1.4×10^{-9}	1.7×10^{-9}	0.050	5.5×10^{-10}
		M	0.050	2.2×10^{-9}	1.7×10^{-9}		
		S	0.050	5.0×10^{-9}	3.1×10^{-9}		
Rh-101m	4.34 d	F	0.050	1.0×10^{-10}	1.7×10^{-10}	0.050	2.2×10^{-10}
		M	0.050	2.0×10^{-10}	2.5×10^{-10}		
		S	0.050	2.1×10^{-10}	2.7×10^{-10}		
Rh-102	2.90 a	F	0.050	7.3×10^{-9}	8.9×10^{-9}	0.050	2.6×10^{-9}
		M	0.050	6.5×10^{-9}	5.0×10^{-9}		
		S	0.050	1.6×10^{-8}	9.0×10^{-9}		
Rh-102m	207 d	F	0.050	1.5×10^{-9}	1.9×10^{-9}	0.050	1.2×10^{-9}
		M	0.050	3.8×10^{-9}	2.7×10^{-9}		
		S	0.050	6.7×10^{-9}	4.2×10^{-9}		
Rh-103m	0.935 h	F	0.050	8.6×10^{-13}	1.2×10^{-12}	0.050	3.8×10^{-12}
		M	0.050	2.3×10^{-12}	2.4×10^{-12}		
		S	0.050	2.5×10^{-12}	2.5×10^{-12}		
Rh-105	1.47 d	F	0.050	8.7×10^{-11}	1.5×10^{-10}	0.050	3.7×10^{-10}
		M	0.050	3.1×10^{-10}	4.1×10^{-10}		
		S	0.050	3.4×10^{-10}	4.4×10^{-10}		

Rh-106m	2.20 h	F	0.050	7.0×10^{-11}	1.3×10^{-10}	0.050	1.6×10^{-10}
		M	0.050	1.1×10^{-10}	1.8×10^{-10}		
		S	0.050	1.2×10^{-10}	1.9×10^{-10}		
Rh-107	0.362 h	F	0.050	9.6×10^{-12}	1.6×10^{-11}	0.050	2.4×10^{-11}
		M	0.050	1.7×10^{-11}	2.7×10^{-11}		
		S	0.050	1.7×10^{-11}	2.8×10^{-11}		
Palladium							
Pd-100	3.63 d	F	0.005	4.9×10^{-10}	7.6×10^{-10}	0.005	9.4×10^{-10}
		M	0.005	7.9×10^{-10}	9.5×10^{-10}		
		S	0.005	8.3×10^{-10}	9.7×10^{-10}		
Pd-101	8.27 h	F	0.005	4.2×10^{-11}	7.5×10^{-11}	0.005	9.4×10^{-11}
		M	0.005	6.2×10^{-11}	9.8×10^{-11}		
		S	0.005	6.4×10^{-11}	1.0×10^{-10}		
Pd-103	17.0 d	F	0.005	9.0×10^{-11}	1.2×10^{-10}	0.005	1.9×10^{-10}
		M	0.005	3.5×10^{-10}	3.0×10^{-10}		
		S	0.005	4.0×10^{-10}	2.9×10^{-10}		
Pd-107	6.50×10^{6} a	F	0.005	2.6×10^{-11}	3.3×10^{-11}	0.005	3.7×10^{-11}
		M	0.005	8.0×10^{-11}	5.2×10^{-11}		
		S	0.005	5.5×10^{-10}	2.9×10^{-10}		
Pd-109	13.4 h	F	0.005	1.2×10^{-10}	2.1×10^{-10}	0.005	5.5×10^{-10}
		M	0.005	3.4×10^{-10}	4.7×10^{-10}		
		S	0.005	3.6×10^{-10}	5.0×10^{-10}		
Silver							
Ag-102	0.215 h	F	0.050	1.4×10^{-11}	2.4×10^{-11}	0.050	4.0×10^{-11}
		M	0.050	1.8×10^{-11}	3.2×10^{-11}		
		S	0.050	1.9×10^{-11}	3.2×10^{-11}		
Ag-103	1.09 h	F	0.050	1.6×10^{-11}	2.8×10^{-11}	0.050	4.3×10^{-11}
		M	0.050	2.7×10^{-11}	4.3×10^{-11}		
		S	0.050	2.8×10^{-11}	4.5×10^{-11}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Ag-104	1.15 h	F	0.050	3.0×10^{-11}	5.7×10^{-11}	0.050	6.0×10^{-11}
		M	0.050	3.9×10^{-11}	6.9×10^{-11}		
		S	0.050	4.0×10^{-11}	7.1×10^{-11}		
Ag-104m	0.558 h	F	0.050	1.7×10^{-11}	3.1×10^{-11}	0.050	5.4×10^{-11}
		M	0.050	2.6×10^{-11}	4.4×10^{-11}		
		S	0.050	2.7×10^{-11}	4.5×10^{-11}		
Ag-105	41.0 d	F	0.050	5.4×10^{-10}	8.0×10^{-10}	0.050	4.7×10^{-10}
		M	0.050	6.9×10^{-10}	7.0×10^{-10}		
		S	0.050	7.8×10^{-10}	7.3×10^{-10}		
Ag-106	0.399 h	F	0.050	9.8×10^{-12}	1.7×10^{-11}	0.050	3.2×10^{-11}
		M	0.050	1.6×10^{-11}	2.6×10^{-11}		
		S	0.050	1.6×10^{-11}	2.7×10^{-11}		
Ag-106m	8.41 d	F	0.050	1.1×10^{-9}	1.6×10^{-9}	0.050	1.5×10^{-9}
		M	0.050	1.1×10^{-9}	1.5×10^{-9}		
		S	0.050	1.1×10^{-9}	1.4×10^{-9}		
Ag-108m	1.27×10^{2} a	F	0.050	6.1×10^{-9}	7.3×10^{-9}	0.050	2.3×10^{-9}
		M	0.050	7.0×10^{-9}	5.2×10^{-9}		
		S	0.050	3.5×10^{-8}	1.9×10^{-8}		
Ag-110m	250 d	F	0.050	5.5×10^{-9}	6.7×10^{-9}	0.050	2.8×10^{-9}
		M	0.050	7.2×10^{-9}	5.9×10^{-9}		
		S	0.050	1.2×10^{-8}	7.3×10^{-9}		
Ag-111	7.45 d	F	0.050	4.1×10^{-10}	5.7×10^{-10}	0.050	1.3×10^{-9}
		M	0.050	1.5×10^{-9}	1.5×10^{-9}		
		S	0.050	1.7×10^{-9}	1.6×10^{-9}		

Ag-112	3.12 h	F	0.050	8.2×10^{-11}	1.4×10^{-10}	0.050	4.3×10^{-10}
		M	0.050	1.7×10^{-10}	2.5×10^{-10}		
		S	0.050	1.8×10^{-10}	2.6×10^{-10}		
Ag-115	0.333 h	F	0.050	1.6×10^{-11}	2.6×10^{-11}	0.050	6.0×10^{-11}
		M	0.050	2.8×10^{-11}	4.3×10^{-11}		
		S	0.050	3.0×10^{-11}	4.4×10^{-11}		
Cadmium							
Cd-104	0.961 h	F	0.050	2.7×10^{-11}	5.0×10^{-11}	0.050	5.8×10^{-11}
		M	0.050	3.6×10^{-11}	6.2×10^{-11}		
		S	0.050	3.7×10^{-11}	6.3×10^{-11}		
Cd-107	6.49 h	F	0.050	2.3×10^{-11}	4.2×10^{-11}	0.050	6.2×10^{-11}
		M	0.050	8.1×10^{-11}	1.0×10^{-10}		
		S	0.050	8.7×10^{-11}	1.1×10^{-10}		
Cd-109	1.27 a	F	0.050	8.1×10^{-9}	9.6×10^{-9}	0.050	2.0×10^{-9}
		M	0.050	6.2×10^{-9}	5.1×10^{-9}		
		S	0.050	5.8×10^{-9}	4.4×10^{-9}		
Cd-113	9.30×10^{15} a	F	0.050	1.2×10^{-7}	1.4×10^{-7}	0.050	2.5×10^{-8}
		M	0.050	5.3×10^{-8}	4.3×10^{-8}		
		S	0.050	2.5×10^{-8}	2.1×10^{-8}		
Cd-113m	13.6 a	F	0.050	1.1×10^{-7}	1.3×10^{-7}	0.050	2.3×10^{-8}
		M	0.050	5.0×10^{-8}	4.0×10^{-8}		
		S	0.050	3.0×10^{-8}	2.4×10^{-8}		
Cd-115	2.23 d	F	0.050	3.7×10^{-10}	5.4×10^{-10}	0.050	1.4×10^{-9}
		M	0.050	9.7×10^{-10}	1.2×10^{-9}		
		S	0.050	1.1×10^{-9}	1.3×10^{-9}		
Cd-115m	44.6 d	F	0.050	5.3×10^{-9}	6.4×10^{-9}	0.050	3.3×10^{-9}
		M	0.050	5.9×10^{-9}	5.5×10^{-9}		
		S	0.050	7.3×10^{-9}	5.5×10^{-9}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Cd-117	2.49 h	F	0.050	7.3×10^{-11}	1.3×10^{-10}	0.050	2.8×10^{-10}
		M	0.050	1.6×10^{-10}	2.4×10^{-10}		
		S	0.050	1.7×10^{-10}	2.5×10^{-10}		
Cd-117m	3.36 h	F	0.050	1.0×10^{-10}	1.9×10^{-10}	0.050	2.8×10^{-10}
		M	0.050	2.0×10^{-10}	3.1×10^{-10}		
		S	0.050	2.1×10^{-10}	3.2×10^{-10}		
Indium							
In-109	4.20 h	F	0.020	3.2×10^{-11}	5.7×10^{-11}	0.020	6.6×10^{-11}
		M	0.020	4.4×10^{-11}	7.3×10^{-11}		
In-110	4.90 h	F	0.020	1.2×10^{-10}	2.2×10^{-10}	0.020	2.4×10^{-10}
		M	0.020	1.4×10^{-10}	2.5×10^{-10}		
In-110	1.15 h	F	0.020	3.1×10^{-11}	5.5×10^{-11}	0.020	1.0×10^{-10}
		M	0.020	5.0×10^{-11}	8.1×10^{-11}		
In-111	2.83 d	F	0.020	1.3×10^{-10}	2.2×10^{-10}	0.020	2.9×10^{-10}
		M	0.020	2.3×10^{-10}	3.1×10^{-10}		
In-112	0.240 h	F	0.020	5.0×10^{-12}	8.6×10^{-12}	0.020	1.0×10^{-11}
		M	0.020	7.8×10^{-12}	1.3×10^{-11}		
In-113m	1.66 h	F	0.020	1.0×10^{-11}	1.9×10^{-11}	0.020	2.8×10^{-11}
		M	0.020	2.0×10^{-11}	3.2×10^{-11}		
In-114m	49.5 d	F	0.020	9.3×10^{-9}	1.1×10^{-8}	0.020	4.1×10^{-9}
		M	0.020	5.9×10^{-9}	5.9×10^{-9}		
In-115	5.10×10^{15} a	F	0.020	3.9×10^{-7}	4.5×10^{-7}	0.020	3.2×10^{-8}
		M	0.020	1.5×10^{-7}	1.1×10^{-7}		
In-115m	4.49 h	F	0.020	2.5×10^{-11}	4.5×10^{-11}	0.020	8.6×10^{-11}
		M	0.020	6.0×10^{-11}	8.7×10^{-11}		

In-116m	0.902 h	F	0.020	3.0×10^{-11}	5.5×10^{-11}	0.020	6.4×10^{-11}
		M	0.020	4.8×10^{-11}	8.0×10^{-11}		
In-117	0.730 h	F	0.020	1.6×10^{-11}	2.8×10^{-11}	0.020	3.1×10^{-11}
		M	0.020	3.0×10^{-11}	4.8×10^{-11}		
In-117m	1.94 h	F	0.020	3.1×10^{-11}	5.5×10^{-11}	0.020	1.2×10^{-10}
		M	0.020	7.3×10^{-11}	1.1×10^{-10}		
In-119m	0.300 h	F	0.020	1.1×10^{-11}	1.8×10^{-11}	0.020	4.7×10^{-11}
		M	0.020	1.8×10^{-11}	2.9×10^{-11}		
Tin							
Sn-110	4.00 h	F	0.020	1.1×10^{-10}	1.9×10^{-10}	0.020	3.5×10^{-10}
		M	0.020	1.6×10^{-10}	2.6×10^{-10}		
Sn-111	0.588 h	F	0.020	8.3×10^{-12}	1.5×10^{-11}	0.020	2.3×10^{-11}
		M	0.020	1.4×10^{-11}	2.2×10^{-11}		
Sn-113	115 d	F	0.020	5.4×10^{-10}	7.9×10^{-10}	0.020	7.3×10^{-10}
		M	0.020	2.5×10^{-9}	1.9×10^{-9}		
Sn-117m	13.6 d	F	0.020	2.9×10^{-10}	3.9×10^{-10}	0.020	7.1×10^{-10}
		M	0.020	2.3×10^{-9}	2.2×10^{-9}		
Sn-119m	293 d	F	0.020	2.9×10^{-10}	3.6×10^{-10}	0.020	3.4×10^{-10}
		M	0.020	2.0×10^{-9}	1.5×10^{-9}		
Sn-121	1.13 d	F	0.020	6.4×10^{-11}	1.0×10^{-10}	0.020	2.3×10^{-10}
		M	0.020	2.2×10^{-10}	2.8×10^{-10}		
Sn-121m	55.0 a	F	0.020	8.0×10^{-10}	9.7×10^{-10}	0.020	3.8×10^{-10}
		M	0.020	4.2×10^{-9}	3.3×10^{-9}		
Sn-123	129 d	F	0.020	1.2×10^{-9}	1.6×10^{-9}	0.020	2.1×10^{-9}
		M	0.020	7.7×10^{-9}	5.6×10^{-9}		
Sn-123m	0.668 h	F	0.020	1.4×10^{-11}	2.4×10^{-11}	0.020	3.8×10^{-11}
		M	0.020	2.8×10^{-11}	4.4×10^{-11}		
Sn-125	9.64 d	F	0.020	9.2×10^{-10}	1.3×10^{-9}	0.020	3.1×10^{-9}
		M	0.020	3.0×10^{-9}	2.8×10^{-9}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Sn-126	1.00×10^5 a	F	0.020	1.1×10^{-8}	1.4×10^{-8}	0.020	4.7×10^{-9}
		M	0.020	2.7×10^{-8}	1.8×10^{-8}		
Sn-127	2.10 h	F	0.020	6.9×10^{-11}	1.2×10^{-10}	0.020	2.0×10^{-10}
		M	0.020	1.3×10^{-10}	2.0×10^{-10}		
Sn-128	0.985 h	F	0.020	5.4×10^{-11}	9.5×10^{-11}	0.020	1.5×10^{-10}
		M	0.020	9.6×10^{-11}	1.5×10^{-10}		
Antimony							
Sb-115	0.530 h	F	0.100	9.2×10^{-12}	1.7×10^{-11}	0.100	2.4×10^{-11}
		M	0.010	1.4×10^{-11}	2.3×10^{-11}		
Sb-116	0.263 h	F	0.100	9.9×10^{-12}	1.8×10^{-11}	0.100	2.6×10^{-11}
		M	0.010	1.4×10^{-11}	2.3×10^{-11}		
Sb-116m	1.00 h	F	0.100	3.5×10^{-11}	6.4×10^{-11}	0.100	6.7×10^{-11}
		M	0.010	5.0×10^{-11}	8.5×10^{-11}		
Sb-117	2.80 h	F	0.100	9.3×10^{-12}	1.7×10^{-11}	0.100	1.8×10^{-11}
		M	0.010	1.7×10^{-11}	2.7×10^{-11}		
Sb-118m	5.00 h	F	0.100	1.0×10^{-10}	1.9×10^{-10}	0.100	2.1×10^{-10}
		M	0.010	1.3×10^{-10}	2.3×10^{-10}		
Sb-119	1.59 d	F	0.100	2.5×10^{-11}	4.5×10^{-11}	0.100	8.1×10^{-11}
		M	0.010	3.7×10^{-11}	5.9×10^{-11}		
Sb-120	5.76 d	F	0.100	5.9×10^{-10}	9.8×10^{-10}	0.100	1.2×10^{-9}
		M	0.010	1.0×10^{-9}	1.3×10^{-9}		
Sb-120	0.265 h	F	0.100	4.9×10^{-12}	8.5×10^{-12}	0.100	1.4×10^{-11}
		M	0.010	7.4×10^{-12}	1.2×10^{-11}		

Sb-122	2.70 d	F	0.100	3.9×10^{-10}	6.3×10^{-10}	0.100	1.7×10^{-9}
		M	0.010	1.0×10^{-9}	1.2×10^{-9}		
Sb-124	60.2 d	F	0.100	1.3×10^{-9}	1.9×10^{-9}	0.100	2.5×10^{-9}
		M	0.010	6.1×10^{-9}	4.7×10^{-9}		
Sb-124m	0.337 h	F	0.100	3.0×10^{-12}	5.3×10^{-12}	0.100	8.0×10^{-12}
		M	0.010	5.5×10^{-12}	8.3×10^{-12}		
Sb-125	2.77 a	F	0.100	1.4×10^{-9}	1.7×10^{-9}	0.100	1.1×10^{-9}
		M	0.010	4.5×10^{-9}	3.3×10^{-9}		
Sb-126	12.4 d	F	0.100	1.1×10^{-9}	1.7×10^{-9}	0.100	2.4×10^{-9}
		M	0.010	2.7×10^{-9}	3.2×10^{-9}		
Sb-126m	0.317 h	F	0.100	1.3×10^{-11}	2.3×10^{-11}	0.100	3.6×10^{-11}
		M	0.010	2.0×10^{-11}	3.3×10^{-11}		
Sb-127	3.85 d	F	0.100	4.6×10^{-10}	7.4×10^{-10}	0.100	1.7×10^{-9}
		M	0.010	1.6×10^{-9}	1.7×10^{-9}		
Sb-128	9.01 h	F	0.100	2.5×10^{-10}	4.6×10^{-10}	0.100	7.6×10^{-10}
		M	0.010	4.2×10^{-10}	6.7×10^{-10}		
Sb-128	0.173 h	F	0.100	1.1×10^{-11}	1.9×10^{-11}	0.100	3.3×10^{-11}
		M	0.010	1.5×10^{-11}	2.6×10^{-11}		
Sb-129	4.32 h	F	0.100	1.1×10^{-10}	2.0×10^{-10}	0.100	4.2×10^{-10}
		M	0.010	2.4×10^{-10}	3.5×10^{-10}		
Sb-130	0.667 h	F	0.100	3.5×10^{-11}	6.3×10^{-11}	0.100	9.1×10^{-11}
		M	0.010	5.4×10^{-11}	9.1×10^{-11}		
Sb-131	0.383 h	F	0.100	3.7×10^{-11}	5.9×10^{-11}	0.100	1.0×10^{-10}
		M	0.010	5.2×10^{-11}	8.3×10^{-11}		
Tellurium							
Te-116	2.49 h	F	0.300	6.3×10^{-11}	1.2×10^{-10}	0.300	1.7×10^{-10}
		M	0.300	1.1×10^{-10}	1.7×10^{-10}		
Te-121	17.0 d	F	0.300	2.5×10^{-10}	3.9×10^{-10}	0.300	4.3×10^{-10}
		M	0.300	3.9×10^{-10}	4.4×10^{-10}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Te-121m	154 d	F	0.300	1.8×10^{-9}	2.3×10^{-9}	0.300	2.3×10^{-9}
		M	0.300	4.2×10^{-9}	3.6×10^{-9}		
Te-123	1.00×10^{13} a	F	0.300	4.0×10^{-9}	5.0×10^{-9}	0.300	4.4×10^{-9}
		M	0.300	2.6×10^{-9}	2.8×10^{-9}		
Te-123m	120 d	F	0.300	9.7×10^{-10}	1.2×10^{-9}	0.300	1.4×10^{-9}
		M	0.300	3.9×10^{-9}	3.4×10^{-9}		
Te-125m	58.0 d	F	0.300	5.1×10^{-10}	6.7×10^{-10}	0.300	8.7×10^{-10}
		M	0.300	3.3×10^{-9}	2.9×10^{-9}		
Te-127	9.35 h	F	0.300	4.2×10^{-11}	7.2×10^{-11}	0.300	1.7×10^{-10}
		M	0.300	1.2×10^{-10}	1.8×10^{-10}		
Te-127m	109 d	F	0.300	1.6×10^{-9}	2.0×10^{-9}	0.300	2.3×10^{-9}
		M	0.300	7.2×10^{-9}	6.2×10^{-9}		
Te-129	1.16 h	F	0.300	1.7×10^{-11}	2.9×10^{-11}	0.300	6.3×10^{-11}
		M	0.300	3.8×10^{-11}	5.7×10^{-11}		
Te-129m	33.6 d	F	0.300	1.3×10^{-9}	1.8×10^{-9}	0.300	3.0×10^{-9}
		M	0.300	6.3×10^{-9}	5.4×10^{-9}		
Te-131	0.417 h	F	0.300	2.3×10^{-11}	4.6×10^{-11}	0.300	8.7×10^{-11}
		M	0.300	3.8×10^{-11}	6.1×10^{-11}		
Te-131m	1.25 d	F	0.300	8.7×10^{-10}	1.2×10^{-9}	0.300	1.9×10^{-9}
		M	0.300	1.1×10^{-9}	1.6×10^{-9}		
Te-132	3.26 d	F	0.300	1.8×10^{-9}	2.4×10^{-9}	0.300	3.7×10^{-9}
		M	0.300	2.2×10^{-9}	3.0×10^{-9}		
Te-133	0.207 h	F	0.300	2.0×10^{-11}	3.8×10^{-11}	0.300	7.2×10^{-11}
		M	0.300	2.7×10^{-11}	4.4×10^{-11}		

Te-133m	0.923 h	F	0.300	8.4×10^{-11}	1.2×10^{-10}	0.300	2.8×10^{-10}
		M	0.300	1.2×10^{-10}	1.9×10^{-10}		
Te-134	0.696 h	F	0.300	5.0×10^{-11}	8.3×10^{-11}	0.300	1.1×10^{-10}
		M	0.300	7.1×10^{-11}	1.1×10^{-10}		
Iodine							
I-120	1.35 h	F	1.000	1.0×10^{-10}	1.9×10^{-10}	1.000	3.4×10^{-10}
I-120m	0.883 h	F	1.000	8.7×10^{-11}	1.4×10^{-10}	1.000	2.1×10^{-10}
I-121	2.12 h	F	1.000	2.8×10^{-11}	3.9×10^{-11}	1.000	8.2×10^{-11}
I-123	13.2 h	F	1.000	7.6×10^{-11}	1.1×10^{-10}	1.000	2.1×10^{-10}
I-124	4.18 d	F	1.000	4.5×10^{-9}	6.3×10^{-9}	1.000	1.3×10^{-8}
I-125	60.1 d	F	1.000	5.3×10^{-9}	7.3×10^{-9}	1.000	1.5×10^{-8}
I-126	13.0 d	F	1.000	1.0×10^{-8}	1.4×10^{-8}	1.000	2.9×10^{-8}
I-128	0.416 h	F	1.000	1.4×10^{-11}	2.2×10^{-11}	1.000	4.6×10^{-11}
I-129	1.57×10^{7} a	F	1.000	3.7×10^{-8}	5.1×10^{-8}	1.000	1.1×10^{-7}
I-130	12.4 h	F	1.000	6.9×10^{-10}	9.6×10^{-10}	1.000	2.0×10^{-9}
I-131	8.04 d	F	1.000	7.6×10^{-9}	1.1×10^{-8}	1.000	2.2×10^{-8}
I-132	2.30 h	F	1.000	9.6×10^{-11}	2.0×10^{-10}	1.000	2.9×10^{-10}
I-132m	1.39 h	F	1.000	8.1×10^{-11}	1.1×10^{-10}	1.000	2.2×10^{-10}
I-133	20.8 h	F	1.000	1.5×10^{-9}	2.1×10^{-9}	1.000	4.3×10^{-9}
I-134	0.876 h	F	1.000	4.8×10^{-11}	7.9×10^{-11}	1.000	1.1×10^{-10}
I-135	6.61 h	F	1.000	3.3×10^{-10}	4.6×10^{-10}	1.000	9.3×10^{-10}
Caesium							
Cs-125	0.750 h	F	1.000	1.3×10^{-11}	2.3×10^{-11}	1.000	3.5×10^{-11}
Cs-127	6.25 h	F	1.000	2.2×10^{-11}	4.0×10^{-11}	1.000	2.4×10^{-11}
Cs-129	1.34 d	F	1.000	4.5×10^{-11}	8.1×10^{-11}	1.000	6.0×10^{-11}
Cs-130	0.498 h	F	1.000	8.4×10^{-12}	1.5×10^{-11}	1.000	2.8×10^{-11}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Cs-131	9.69 d	F	1.000	2.8×10^{-11}	4.5×10^{-11}	1.000	5.8×10^{-11}
Cs-132	6.48 d	F	1.000	2.4×10^{-10}	3.8×10^{-10}	1.000	5.0×10^{-10}
Cs-134	2.06 a	F	1.000	6.8×10^{-9}	9.6×10^{-9}	1.000	1.9×10^{-8}
Cs-134m	2.90 h	F	1.000	1.5×10^{-11}	2.6×10^{-11}	1.000	2.0×10^{-11}
Cs-135	2.30×10^{6} a	F	1.000	7.1×10^{-10}	9.9×10^{-10}	1.000	2.0×10^{-9}
Cs-135m	0.883 h	F	1.000	1.3×10^{-11}	2.4×10^{-11}	1.000	1.9×10^{-11}
Cs-136	13.1 d	F	1.000	1.3×10^{-9}	1.9×10^{-9}	1.000	3.0×10^{-9}
Cs-137	30.0 a	F	1.000	4.8×10^{-9}	6.7×10^{-9}	1.000	1.3×10^{-8}
Cs-138	0.536 h	F	1.000	2.6×10^{-11}	4.6×10^{-11}	1.000	9.2×10^{-11}
Barium							
Ba-126	1.61 h	F	0.100	7.8×10^{-11}	1.2×10^{-10}	0.100	2.6×10^{-10}
Ba-128	2.43 d	F	0.100	8.0×10^{-10}	1.3×10^{-9}	0.100	2.7×10^{-9}
Ba-131	11.8 d	F	0.100	2.3×10^{-10}	3.5×10^{-10}	0.100	4.5×10^{-10}
Ba-131m	0.243 h	F	0.100	4.1×10^{-12}	6.4×10^{-12}	0.100	4.9×10^{-12}
Ba-133	10.7 a	F	0.100	1.5×10^{-9}	1.8×10^{-9}	0.100	1.0×10^{-9}
Ba-133m	1.62 d	F	0.100	1.9×10^{-10}	2.8×10^{-10}	0.100	5.5×10^{-10}
Ba-135m	1.20 d	F	0.100	1.5×10^{-10}	2.3×10^{-10}	0.100	4.5×10^{-10}
Ba-139	1.38 h	F	0.100	3.5×10^{-11}	5.5×10^{-11}	0.100	1.2×10^{-10}
Ba-140	12.7 d	F	0.100	1.0×10^{-9}	1.6×10^{-9}	0.100	2.5×10^{-9}
Ba-141	0.305 h	F	0.100	2.2×10^{-11}	3.5×10^{-11}	0.100	7.0×10^{-11}
Ba-142	0.177 h	F	0.100	1.6×10^{-11}	2.7×10^{-11}	0.100	3.5×10^{-11}

Lanthanum							
La-131	0.983 h	F	5.0×10^{-4}	1.4×10^{-11}	2.4×10^{-11}	5.0×10^{-4}	3.5×10^{-11}
		M	5.0×10^{-4}	2.3×10^{-11}	3.6×10^{-11}		
La-132	4.80 h	F	5.0×10^{-4}	1.1×10^{-10}	2.0×10^{-10}	5.0×10^{-4}	3.9×10^{-10}
		M	5.0×10^{-4}	1.7×10^{-10}	2.8×10^{-10}		
La-135	19.5 h	F	5.0×10^{-4}	1.1×10^{-11}	2.0×10^{-11}	5.0×10^{-4}	3.0×10^{-11}
		M	5.0×10^{-4}	1.5×10^{-11}	2.5×10^{-11}		
La-137	6.00×10^{4} a	F	5.0×10^{-4}	8.6×10^{-9}	1.0×10^{-8}	5.0×10^{-4}	8.1×10^{-11}
		M	5.0×10^{-4}	3.4×10^{-9}	2.3×10^{-9}		
La-138	1.35×10^{11} a	F	5.0×10^{-4}	1.5×10^{-7}	1.8×10^{-7}	5.0×10^{-4}	1.1×10^{-9}
		M	5.0×10^{-4}	6.1×10^{-8}	4.2×10^{-8}		
La-140	1.68 d	F	5.0×10^{-4}	6.0×10^{-10}	1.0×10^{-9}	5.0×10^{-4}	2.0×10^{-9}
		M	5.0×10^{-4}	1.1×10^{-9}	1.5×10^{-9}		
La-141	3.93 h	F	5.0×10^{-4}	6.7×10^{-11}	1.1×10^{-10}	5.0×10^{-4}	3.6×10^{-10}
		M	5.0×10^{-4}	1.5×10^{-10}	2.2×10^{-10}		
La-142	1.54 h	F	5.0×10^{-4}	5.6×10^{-11}	1.0×10^{-10}	5.0×10^{-4}	1.8×10^{-10}
		M	5.0×10^{-4}	9.3×10^{-11}	1.5×10^{-10}		
La-143	0.237 h	F	5.0×10^{-4}	1.2×10^{-11}	2.0×10^{-11}	5.0×10^{-4}	5.6×10^{-11}
		M	5.0×10^{-4}	2.2×10^{-11}	3.3×10^{-11}		
Cerium							
Ce-134	3.00 d	M	5.0×10^{-4}	1.3×10^{-9}	1.5×10^{-9}	5.0×10^{-4}	2.5×10^{-9}
		S	5.0×10^{-4}	1.3×10^{-9}	1.6×10^{-9}		
Ce-135	17.6 h	M	5.0×10^{-4}	4.9×10^{-10}	7.3×10^{-10}	5.0×10^{-4}	7.9×10^{-10}
		S	5.0×10^{-4}	5.1×10^{-10}	7.6×10^{-10}		
Ce-137	9.00 h	M	5.0×10^{-4}	1.0×10^{-11}	1.8×10^{-11}	5.0×10^{-4}	2.5×10^{-11}
		S	5.0×10^{-4}	1.1×10^{-11}	1.9×10^{-11}		
Ce-137m	1.43 d	M	5.0×10^{-4}	4.0×10^{-10}	5.5×10^{-10}	5.0×10^{-4}	5.4×10^{-10}
		S	5.0×10^{-4}	4.3×10^{-10}	5.9×10^{-10}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Ce-139	138 d	M	5.0×10^{-4}	1.6×10^{-9}	1.3×10^{-9}	5.0×10^{-4}	2.6×10^{-10}
		S	5.0×10^{-4}	1.8×10^{-9}	1.4×10^{-9}		
Ce-141	32.5 d	M	5.0×10^{-4}	3.1×10^{-9}	2.7×10^{-9}	5.0×10^{-4}	7.1×10^{-10}
		S	5.0×10^{-4}	3.6×10^{-9}	3.1×10^{-9}		
Ce-143	1.38 d	M	5.0×10^{-4}	7.4×10^{-10}	9.5×10^{-10}	5.0×10^{-4}	1.1×10^{-9}
		S	5.0×10^{-4}	8.1×10^{-10}	1.0×10^{-9}		
Ce-144	284 d	M	5.0×10^{-4}	3.4×10^{-8}	2.3×10^{-8}	5.0×10^{-4}	5.2×10^{-9}
		S	5.0×10^{-4}	4.9×10^{-8}	2.9×10^{-8}		
Praseodymium							
Pr-136	0.218 h	M	5.0×10^{-4}	1.4×10^{-11}	2.4×10^{-11}	5.0×10^{-4}	3.3×10^{-11}
		S	5.0×10^{-4}	1.5×10^{-11}	2.5×10^{-11}		
Pr-137	1.28 h	M	5.0×10^{-4}	2.1×10^{-11}	3.4×10^{-11}	5.0×10^{-4}	4.0×10^{-11}
		S	5.0×10^{-4}	2.2×10^{-11}	3.5×10^{-11}		
Pr-138m	2.10 h	M	5.0×10^{-4}	7.6×10^{-11}	1.3×10^{-10}	5.0×10^{-4}	1.3×10^{-10}
		S	5.0×10^{-4}	7.9×10^{-11}	1.3×10^{-10}		
Pr-139	4.51 h	M	5.0×10^{-4}	1.9×10^{-11}	2.9×10^{-11}	5.0×10^{-4}	3.1×10^{-11}
		S	5.0×10^{-4}	2.0×10^{-11}	3.0×10^{-11}		
Pr-142	19.1 h	M	5.0×10^{-4}	5.3×10^{-10}	7.0×10^{-10}	5.0×10^{-4}	1.3×10^{-9}
		S	5.0×10^{-4}	5.6×10^{-10}	7.4×10^{-10}		
Pr-142m	0.243 h	M	5.0×10^{-4}	6.7×10^{-12}	8.9×10^{-12}	5.0×10^{-4}	1.7×10^{-11}
		S	5.0×10^{-4}	7.1×10^{-12}	9.4×10^{-12}		
Pr-143	13.6 d	M	5.0×10^{-4}	2.1×10^{-9}	1.9×10^{-9}	5.0×10^{-4}	1.2×10^{-9}
		S	5.0×10^{-4}	2.3×10^{-9}	2.2×10^{-9}		

Pr-144	0.288 h	M	5.0×10^{-4}	1.8×10^{-11}	2.9×10^{-11}	5.0×10^{-4}	5.0×10^{-11}
		S	5.0×10^{-4}	1.9×10^{-11}	3.0×10^{-11}		
Pr-145	5.98 h	M	5.0×10^{-4}	1.6×10^{-10}	2.5×10^{-10}	5.0×10^{-4}	3.9×10^{-10}
		S	5.0×10^{-4}	1.7×10^{-10}	2.6×10^{-10}		
Pr-147	0.227 h	M	5.0×10^{-4}	1.8×10^{-11}	2.9×10^{-11}	5.0×10^{-4}	3.3×10^{-11}
		S	5.0×10^{-4}	1.9×10^{-11}	3.0×10^{-11}		
Neodymium							
Nd-136	0.844 h	M	5.0×10^{-4}	5.3×10^{-11}	8.5×10^{-11}	5.0×10^{-4}	9.9×10^{-11}
		S	5.0×10^{-4}	5.6×10^{-11}	8.9×10^{-11}		
Nd-138	5.04 h	M	5.0×10^{-4}	2.4×10^{-10}	3.7×10^{-10}	5.0×10^{-4}	6.4×10^{-10}
		S	5.0×10^{-4}	2.6×10^{-10}	3.8×10^{-10}		
Nd-139	0.495 h	M	5.0×10^{-4}	1.0×10^{-11}	1.7×10^{-11}	5.0×10^{-4}	2.0×10^{-11}
		S	5.0×10^{-4}	1.1×10^{-11}	1.7×10^{-11}		
Nd-139m	5.50 h	M	5.0×10^{-4}	1.5×10^{-10}	2.5×10^{-10}	5.0×10^{-4}	2.5×10^{-10}
		S	5.0×10^{-4}	1.6×10^{-10}	2.5×10^{-10}		
Nd-141	2.49 h	M	5.0×10^{-4}	5.1×10^{-12}	8.5×10^{-12}	5.0×10^{-4}	8.3×10^{-12}
		S	5.0×10^{-4}	5.3×10^{-12}	8.8×10^{-12}		
Nd-147	11.0 d	M	5.0×10^{-4}	2.0×10^{-9}	1.9×10^{-9}	5.0×10^{-4}	1.1×10^{-9}
		S	5.0×10^{-4}	2.3×10^{-9}	2.1×10^{-9}		
Nd-149	1.73 h	M	5.0×10^{-4}	8.5×10^{-11}	1.2×10^{-10}	5.0×10^{-4}	1.2×10^{-10}
		S	5.0×10^{-4}	9.0×10^{-11}	1.3×10^{-10}		
Nd-151	0.207 h	M	5.0×10^{-4}	1.7×10^{-11}	2.8×10^{-11}	5.0×10^{-4}	3.0×10^{-11}
		S	5.0×10^{-4}	1.8×10^{-11}	2.9×10^{-11}		
Promethium							
Pm-141	0.348 h	M	5.0×10^{-4}	1.5×10^{-11}	2.4×10^{-11}	5.0×10^{-4}	3.6×10^{-11}
		S	5.0×10^{-4}	1.6×10^{-11}	2.5×10^{-11}		
Pm-143	265 d	M	5.0×10^{-4}	1.4×10^{-9}	9.6×10^{-10}	5.0×10^{-4}	2.3×10^{-10}
		S	5.0×10^{-4}	1.3×10^{-9}	8.3×10^{-10}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Pm-144	363 d	M	5.0×10^{-4}	7.8×10^{-9}	5.4×10^{-9}	5.0×10^{-4}	9.7×10^{-10}
		S	5.0×10^{-4}	7.0×10^{-9}	3.9×10^{-9}		
Pm-145	17.7 a	M	5.0×10^{-4}	3.4×10^{-9}	2.4×10^{-9}	5.0×10^{-4}	1.1×10^{-10}
		S	5.0×10^{-4}	2.1×10^{-9}	1.2×10^{-9}		
Pm-146	5.53 a	M	5.0×10^{-4}	1.9×10^{-8}	1.3×10^{-8}	5.0×10^{-4}	9.0×10^{-10}
		S	5.0×10^{-4}	1.6×10^{-8}	9.0×10^{-9}		
Pm-147	2.62 a	M	5.0×10^{-4}	4.7×10^{-9}	3.5×10^{-9}	5.0×10^{-4}	2.6×10^{-10}
		S	5.0×10^{-4}	4.6×10^{-9}	3.2×10^{-9}		
Pm-148	5.37 d	M	5.0×10^{-4}	2.0×10^{-9}	2.1×10^{-9}	5.0×10^{-4}	2.7×10^{-9}
		S	5.0×10^{-4}	2.1×10^{-9}	2.2×10^{-9}		
Pm-148m	41.3 d	M	5.0×10^{-4}	4.9×10^{-9}	4.1×10^{-9}	5.0×10^{-4}	1.8×10^{-9}
		S	5.0×10^{-4}	5.4×10^{-9}	4.3×10^{-9}		
Pm-149	2.21 d	M	5.0×10^{-4}	6.6×10^{-10}	7.6×10^{-10}	5.0×10^{-4}	9.9×10^{-10}
		S	5.0×10^{-4}	7.2×10^{-10}	8.2×10^{-10}		
Pm-150	2.68 h	M	5.0×10^{-4}	1.3×10^{-10}	2.0×10^{-10}	5.0×10^{-4}	2.6×10^{-10}
		S	5.0×10^{-4}	1.4×10^{-10}	2.1×10^{-10}		
Pm-151	1.18 d	M	5.0×10^{-4}	4.2×10^{-10}	6.1×10^{-10}	5.0×10^{-4}	7.3×10^{-10}
		S	5.0×10^{-4}	4.5×10^{-10}	6.4×10^{-10}		
Samarium							
Sm-141	0.170 h	M	5.0×10^{-4}	1.6×10^{-11}	2.7×10^{-11}	5.0×10^{-4}	3.9×10^{-11}
Sm-141m	0.377 h	M	5.0×10^{-4}	3.4×10^{-11}	5.6×10^{-11}	5.0×10^{-4}	6.5×10^{-11}
Sm-142	1.21 h	M	5.0×10^{-4}	7.4×10^{-11}	1.1×10^{-10}	5.0×10^{-4}	1.9×10^{-10}
Sm-145	340 d	M	5.0×10^{-4}	1.5×10^{-9}	1.1×10^{-9}	5.0×10^{-4}	2.1×10^{-10}

Sm-146	1.03×10^{8} a	M	5.0×10^{-4}	9.9×10^{-6}	6.7×10^{-6}	5.0×10^{-4}	5.4×10^{-8}
Sm-147	1.06×10^{11} a	M	5.0×10^{-4}	8.9×10^{-6}	6.1×10^{-6}	5.0×10^{-4}	4.9×10^{-8}
Sm-151	90.0 a	M	5.0×10^{-4}	3.7×10^{-9}	2.6×10^{-9}	5.0×10^{-4}	9.8×10^{-11}
Sm-153	1.95 d	M	5.0×10^{-4}	6.1×10^{-10}	6.8×10^{-10}	5.0×10^{-4}	7.4×10^{-10}
Sm-155	0.368 h	M	5.0×10^{-4}	1.7×10^{-11}	2.8×10^{-11}	5.0×10^{-4}	2.9×10^{-11}
Sm-156	9.40 h	M	5.0×10^{-4}	2.1×10^{-10}	2.8×10^{-10}	5.0×10^{-4}	2.5×10^{-10}
Europium							
Eu-145	5.94 d	M	5.0×10^{-4}	5.6×10^{-10}	7.3×10^{-10}	5.0×10^{-4}	7.5×10^{-10}
Eu-146	4.61 d	M	5.0×10^{-4}	8.2×10^{-10}	1.2×10^{-9}	5.0×10^{-4}	1.3×10^{-9}
Eu-147	24.0 d	M	5.0×10^{-4}	1.0×10^{-9}	1.0×10^{-9}	5.0×10^{-4}	4.4×10^{-10}
Eu-148	54.5 d	M	5.0×10^{-4}	2.7×10^{-9}	2.3×10^{-9}	5.0×10^{-4}	1.3×10^{-9}
Eu-149	93.1 d	M	5.0×10^{-4}	2.7×10^{-10}	2.3×10^{-10}	5.0×10^{-4}	1.0×10^{-10}
Eu-150	34.2 a	M	5.0×10^{-4}	5.0×10^{-8}	3.4×10^{-8}	5.0×10^{-4}	1.3×10^{-9}
Eu-150	12.6 h	M	5.0×10^{-4}	1.9×10^{-10}	2.8×10^{-10}	5.0×10^{-4}	3.8×10^{-10}
Eu-152	13.3 a	M	5.0×10^{-4}	3.9×10^{-8}	2.7×10^{-8}	5.0×10^{-4}	1.4×10^{-9}
Eu-152m	9.32 h	M	5.0×10^{-4}	2.2×10^{-10}	3.2×10^{-10}	5.0×10^{-4}	5.0×10^{-10}
Eu-154	8.80 a	M	5.0×10^{-4}	5.0×10^{-8}	3.5×10^{-8}	5.0×10^{-4}	2.0×10^{-9}
Eu-155	4.96 a	M	5.0×10^{-4}	6.5×10^{-9}	4.7×10^{-9}	5.0×10^{-4}	3.2×10^{-10}
Eu-156	15.2 d	M	5.0×10^{-4}	3.3×10^{-9}	3.0×10^{-9}	5.0×10^{-4}	2.2×10^{-9}
Eu-157	15.1 h	M	5.0×10^{-4}	3.2×10^{-10}	4.4×10^{-10}	5.0×10^{-4}	6.0×10^{-10}
Eu-158	0.765 h	M	5.0×10^{-4}	4.8×10^{-11}	7.5×10^{-11}	5.0×10^{-4}	9.4×10^{-11}
Gadolinium							
Gd-145	0.382 h	F	5.0×10^{-4}	1.5×10^{-11}	2.6×10^{-11}	5.0×10^{-4}	4.4×10^{-11}
		M	5.0×10^{-4}	2.1×10^{-11}	3.5×10^{-11}		
Gd-146	48.3 d	F	5.0×10^{-4}	4.4×10^{-9}	5.2×10^{-9}	5.0×10^{-4}	9.6×10^{-10}
		M	5.0×10^{-4}	6.0×10^{-9}	4.6×10^{-9}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Gd-147	1.59 d	F	5.0×10^{-4}	2.7×10^{-10}	4.5×10^{-10}	5.0×10^{-4}	6.1×10^{-10}
		M	5.0×10^{-4}	4.1×10^{-10}	5.9×10^{-10}		
Gd-148	93.0 a	F	5.0×10^{-4}	2.5×10^{-5}	3.0×10^{-5}	5.0×10^{-4}	5.5×10^{-8}
		M	5.0×10^{-4}	1.1×10^{-5}	7.2×10^{-6}		
Gd-149	9.40 d	F	5.0×10^{-4}	2.6×10^{-10}	4.5×10^{-10}	5.0×10^{-4}	4.5×10^{-10}
		M	5.0×10^{-4}	7.0×10^{-10}	7.9×10^{-10}		
Gd-151	120 d	F	5.0×10^{-4}	7.8×10^{-10}	9.3×10^{-10}	5.0×10^{-4}	2.0×10^{-10}
		M	5.0×10^{-4}	8.1×10^{-10}	6.5×10^{-10}		
Gd-152	1.08×10^{14} a	F	5.0×10^{-4}	1.9×10^{-5}	2.2×10^{-5}	5.0×10^{-4}	4.1×10^{-8}
		M	5.0×10^{-4}	7.4×10^{-6}	5.0×10^{-6}		
Gd-153	242 d	F	5.0×10^{-4}	2.1×10^{-9}	2.5×10^{-9}	5.0×10^{-4}	2.7×10^{-10}
		M	5.0×10^{-4}	1.9×10^{-9}	1.4×10^{-9}		
Gd-159	18.6 h	F	5.0×10^{-4}	1.1×10^{-10}	1.8×10^{-10}	5.0×10^{-4}	4.9×10^{-10}
		M	5.0×10^{-4}	2.7×10^{-10}	3.9×10^{-10}		
Terbium							
Tb-147	1.65 h	M	5.0×10^{-4}	7.9×10^{-11}	1.2×10^{-10}	5.0×10^{-4}	1.6×10^{-10}
Tb-149	4.15 h	M	5.0×10^{-4}	4.3×10^{-9}	3.1×10^{-9}	5.0×10^{-4}	2.5×10^{-10}
Tb-150	3.27 h	M	5.0×10^{-4}	1.1×10^{-10}	1.8×10^{-10}	5.0×10^{-4}	2.5×10^{-10}
Tb-151	17.6 h	M	5.0×10^{-4}	2.3×10^{-10}	3.3×10^{-10}	5.0×10^{-4}	3.4×10^{-10}
Tb-153	2.34 d	M	5.0×10^{-4}	2.0×10^{-10}	2.4×10^{-10}	5.0×10^{-4}	2.5×10^{-10}
Tb-154	21.4 h	M	5.0×10^{-4}	3.8×10^{-10}	6.0×10^{-10}	5.0×10^{-4}	6.5×10^{-10}
Tb-155	5.32 d	M	5.0×10^{-4}	2.1×10^{-10}	2.5×10^{-10}	5.0×10^{-4}	2.1×10^{-10}
Tb-156	5.34 d	M	5.0×10^{-4}	1.2×10^{-9}	1.4×10^{-9}	5.0×10^{-4}	1.2×10^{-9}

Tb-156m	1.02 d	M	5.0×10^{-4}	2.0×10^{-10}	2.3×10^{-10}	5.0×10^{-4}	1.7×10^{-10}
Tb-156m	5.00 h	M	5.0×10^{-4}	9.2×10^{-11}	1.3×10^{-10}	5.0×10^{-4}	8.1×10^{-11}
Tb-157	1.50×10^{2} a	M	5.0×10^{-4}	1.1×10^{-9}	7.9×10^{-10}	5.0×10^{-4}	3.4×10^{-11}
Tb-158	1.50×10^{2} a	M	5.0×10^{-4}	4.3×10^{-8}	3.0×10^{-8}	5.0×10^{-4}	1.1×10^{-9}
Tb-160	72.3 d	M	5.0×10^{-4}	6.6×10^{-9}	5.4×10^{-9}	5.0×10^{-4}	1.6×10^{-9}
Tb-161	6.91 d	M	5.0×10^{-4}	1.2×10^{-9}	1.2×10^{-9}	5.0×10^{-4}	7.2×10^{-10}
Dysprosium							
Dy-155	10.0 h	M	5.0×10^{-4}	8.0×10^{-11}	1.2×10^{-10}	5.0×10^{-4}	1.3×10^{-10}
Dy-157	8.10 h	M	5.0×10^{-4}	3.2×10^{-11}	5.5×10^{-11}	5.0×10^{-4}	6.1×10^{-11}
Dy-159	144 d	M	5.0×10^{-4}	3.5×10^{-10}	2.5×10^{-10}	5.0×10^{-4}	1.0×10^{-10}
Dy-165	2.33 h	M	5.0×10^{-4}	6.1×10^{-11}	8.7×10^{-11}	5.0×10^{-4}	1.1×10^{-10}
Dy-166	3.40 d	M	5.0×10^{-4}	1.8×10^{-9}	1.8×10^{-9}	5.0×10^{-4}	1.6×10^{-9}
Holmium							
Ho-155	0.800 h	M	5.0×10^{-4}	2.0×10^{-11}	3.2×10^{-11}	5.0×10^{-4}	3.7×10^{-11}
Ho-157	0.210 h	M	5.0×10^{-4}	4.5×10^{-12}	7.6×10^{-12}	5.0×10^{-4}	6.5×10^{-12}
Ho-159	0.550 h	M	5.0×10^{-4}	6.3×10^{-12}	1.0×10^{-11}	5.0×10^{-4}	7.9×10^{-12}
Ho-161	2.50 h	M	5.0×10^{-4}	6.3×10^{-12}	1.0×10^{-11}	5.0×10^{-4}	1.3×10^{-11}
Ho-162	0.250 h	M	5.0×10^{-4}	2.9×10^{-12}	4.5×10^{-12}	5.0×10^{-4}	3.3×10^{-12}
Ho-162m	1.13 h	M	5.0×10^{-4}	2.2×10^{-11}	3.3×10^{-11}	5.0×10^{-4}	2.6×10^{-11}
Ho-164	0.483 h	M	5.0×10^{-4}	8.6×10^{-12}	1.3×10^{-11}	5.0×10^{-4}	9.5×10^{-12}
Ho-164m	0.625 h	M	5.0×10^{-4}	1.2×10^{-11}	1.6×10^{-11}	5.0×10^{-4}	1.6×10^{-11}
Ho-166	1.12 d	M	5.0×10^{-4}	6.6×10^{-10}	8.3×10^{-10}	5.0×10^{-4}	1.4×10^{-9}
Ho-166m	1.20×10^{3} a	M	5.0×10^{-4}	1.1×10^{-7}	7.8×10^{-8}	5.0×10^{-4}	2.0×10^{-9}
Ho-167	3.10 h	M	5.0×10^{-4}	7.1×10^{-11}	1.0×10^{-10}	5.0×10^{-4}	8.3×10^{-11}
Erbium							
Er-161	3.24 h	M	5.0×10^{-4}	5.1×10^{-11}	8.5×10^{-11}	5.0×10^{-4}	8.0×10^{-11}
Er-165	10.4 h	M	5.0×10^{-4}	8.3×10^{-12}	1.4×10^{-11}	5.0×10^{-4}	1.9×10^{-11}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Er-169	9.30 d	M	5.0×10^{-4}	9.8×10^{-10}	9.2×10^{-10}	5.0×10^{-4}	3.7×10^{-10}
Er-171	7.52 h	M	5.0×10^{-4}	2.2×10^{-10}	3.0×10^{-10}	5.0×10^{-4}	3.6×10^{-10}
Er-172	2.05 d	M	5.0×10^{-4}	1.1×10^{-9}	1.2×10^{-9}	5.0×10^{-4}	1.0×10^{-9}
Thulium							
Tm-162	0.362 h	M	5.0×10^{-4}	1.6×10^{-11}	2.7×10^{-11}	5.0×10^{-4}	2.9×10^{-11}
Tm-166	7.70 h	M	5.0×10^{-4}	1.8×10^{-10}	2.8×10^{-10}	5.0×10^{-4}	2.8×10^{-10}
Tm-167	9.24 d	M	5.0×10^{-4}	1.1×10^{-9}	1.0×10^{-9}	5.0×10^{-4}	5.6×10^{-10}
Tm-170	129 d	M	5.0×10^{-4}	6.6×10^{-9}	5.2×10^{-9}	5.0×10^{-4}	1.3×10^{-9}
Tm-171	1.92 a	M	5.0×10^{-4}	1.3×10^{-9}	9.1×10^{-10}	5.0×10^{-4}	1.1×10^{-10}
Tm-172	2.65 d	M	5.0×10^{-4}	1.1×10^{-9}	1.4×10^{-9}	5.0×10^{-4}	1.7×10^{-9}
Tm-173	8.24 h	M	5.0×10^{-4}	1.8×10^{-10}	2.6×10^{-10}	5.0×10^{-4}	3.1×10^{-10}
Tm-175	0.253 h	M	5.0×10^{-4}	1.9×10^{-11}	3.1×10^{-11}	5.0×10^{-4}	2.7×10^{-11}
Ytterbium							
Yb-162	0.315 h	M	5.0×10^{-4}	1.4×10^{-11}	2.2×10^{-11}	5.0×10^{-4}	2.3×10^{-11}
		S	5.0×10^{-4}	1.4×10^{-11}	2.3×10^{-11}		
Yb-166	2.36 d	M	5.0×10^{-4}	7.2×10^{-10}	9.1×10^{-10}	5.0×10^{-4}	9.5×10^{-10}
		S	5.0×10^{-4}	7.6×10^{-10}	9.5×10^{-10}		
Yb-167	0.292 h	M	5.0×10^{-4}	6.5×10^{-12}	9.0×10^{-12}	5.0×10^{-4}	6.7×10^{-12}
		S	5.0×10^{-4}	6.9×10^{-12}	9.5×10^{-12}		
Yb-169	32.0 d	M	5.0×10^{-4}	2.4×10^{-9}	2.1×10^{-9}	5.0×10^{-4}	7.1×10^{-10}
		S	5.0×10^{-4}	2.8×10^{-9}	2.4×10^{-9}		
Yb-175	4.19 d	M	5.0×10^{-4}	6.3×10^{-10}	6.4×10^{-10}	5.0×10^{-4}	4.4×10^{-10}
		S	5.0×10^{-4}	7.0×10^{-10}	7.0×10^{-10}		

Yb-177	1.90 h	M	5.0×10^{-4}	6.4×10^{-11}	8.8×10^{-11}	5.0×10^{-4}	9.7×10^{-11}
		S	5.0×10^{-4}	6.9×10^{-11}	9.4×10^{-11}		
Yb-178	1.23 h	M	5.0×10^{-4}	7.1×10^{-11}	1.0×10^{-10}	5.0×10^{-4}	1.2×10^{-10}
		S	5.0×10^{-4}	7.6×10^{-11}	1.1×10^{-10}		
Lutetium							
Lu-169	1.42 d	M	5.0×10^{-4}	3.5×10^{-10}	4.7×10^{-10}	5.0×10^{-4}	4.6×10^{-10}
		S	5.0×10^{-4}	3.8×10^{-10}	4.9×10^{-10}		
Lu-170	2.00 d	M	5.0×10^{-4}	6.4×10^{-10}	9.3×10^{-10}	5.0×10^{-4}	9.9×10^{-10}
		S	5.0×10^{-4}	6.7×10^{-10}	9.5×10^{-10}		
Lu-171	8.22 d	M	5.0×10^{-4}	7.6×10^{-10}	8.8×10^{-10}	5.0×10^{-4}	6.7×10^{-10}
		S	5.0×10^{-4}	8.3×10^{-10}	9.3×10^{-10}		
Lu-172	6.70 d	M	5.0×10^{-4}	1.4×10^{-9}	1.7×10^{-9}	5.0×10^{-4}	1.3×10^{-9}
		S	5.0×10^{-4}	1.5×10^{-9}	1.8×10^{-9}		
Lu-173	1.37 a	M	5.0×10^{-4}	2.0×10^{-9}	1.5×10^{-9}	5.0×10^{-4}	2.6×10^{-10}
		S	5.0×10^{-4}	2.3×10^{-9}	1.4×10^{-9}		
Lu-174	3.31 a	M	5.0×10^{-4}	4.0×10^{-9}	2.9×10^{-9}	5.0×10^{-4}	2.7×10^{-10}
		S	5.0×10^{-4}	3.9×10^{-9}	2.5×10^{-9}		
Lu-174m	142 d	M	5.0×10^{-4}	3.4×10^{-9}	2.4×10^{-9}	5.0×10^{-4}	5.3×10^{-10}
		S	5.0×10^{-4}	3.8×10^{-9}	2.6×10^{-9}		
Lu-176	3.60×10^{10} a	M	5.0×10^{-4}	6.6×10^{-8}	4.6×10^{-8}	5.0×10^{-4}	1.8×10^{-9}
		S	5.0×10^{-4}	5.2×10^{-8}	3.0×10^{-8}		
Lu-176m	3.68 h	M	5.0×10^{-4}	1.1×10^{-10}	1.5×10^{-10}	5.0×10^{-4}	1.7×10^{-10}
		S	5.0×10^{-4}	1.2×10^{-10}	1.6×10^{-10}		
Lu-177	6.71 d	M	5.0×10^{-4}	1.0×10^{-9}	1.0×10^{-9}	5.0×10^{-4}	5.3×10^{-10}
		S	5.0×10^{-4}	1.1×10^{-9}	1.1×10^{-9}		
Lu-177m	161 d	M	5.0×10^{-4}	1.2×10^{-8}	1.0×10^{-8}	5.0×10^{-4}	1.7×10^{-9}
		S	5.0×10^{-4}	1.5×10^{-8}	1.2×10^{-8}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Lu-178	0.473 h	M	5.0×10^{-4}	2.5×10^{-11}	3.9×10^{-11}	5.0×10^{-4}	4.7×10^{-11}
		S	5.0×10^{-4}	2.6×10^{-11}	4.1×10^{-11}		
Lu-178m	0.378 h	M	5.0×10^{-4}	3.3×10^{-11}	5.4×10^{-11}	5.0×10^{-4}	3.8×10^{-11}
		S	5.0×10^{-4}	3.5×10^{-11}	5.6×10^{-11}		
Lu-179	4.59 h	M	5.0×10^{-4}	1.1×10^{-10}	1.6×10^{-10}	5.0×10^{-4}	2.1×10^{-10}
		S	5.0×10^{-4}	1.2×10^{-10}	1.6×10^{-10}		
Hafnium							
Hf-170	16.0 h	F	0.002	1.7×10^{-10}	2.9×10^{-10}	0.002	4.8×10^{-10}
		M	0.002	3.2×10^{-10}	4.3×10^{-10}		
Hf-172	1.87 a	F	0.002	3.2×10^{-8}	3.7×10^{-8}	0.002	1.0×10^{-9}
		M	0.002	1.9×10^{-8}	1.3×10^{-8}		
Hf-173	24.0 h	F	0.002	7.9×10^{-11}	1.3×10^{-10}	0.002	2.3×10^{-10}
		M	0.002	1.6×10^{-10}	2.2×10^{-10}		
Hf-175	70.0 d	F	0.002	7.2×10^{-10}	8.7×10^{-10}	0.002	4.1×10^{-10}
		M	0.002	1.1×10^{-9}	8.8×10^{-10}		
Hf-177m	0.856 h	F	0.002	4.7×10^{-11}	8.4×10^{-11}	0.002	8.1×10^{-11}
		M	0.002	9.2×10^{-11}	1.5×10^{-10}		
Hf-178m	31.0 a	F	0.002	2.6×10^{-7}	3.1×10^{-7}	0.002	4.7×10^{-9}
		M	0.002	1.1×10^{-7}	7.8×10^{-8}		
Hf-179m	25.1 d	F	0.002	1.1×10^{-9}	1.4×10^{-9}	0.002	1.2×10^{-9}
		M	0.002	3.6×10^{-9}	3.2×10^{-9}		
Hf-180m	5.50 h	F	0.002	6.4×10^{-11}	1.2×10^{-10}	0.002	1.7×10^{-10}
		M	0.002	1.4×10^{-10}	2.0×10^{-10}		

Hf-181	42.4 d	F	0.002	1.4×10^{-9}	1.8×10^{-9}	0.002	1.1×10^{-9}
		M	0.002	4.7×10^{-9}	4.1×10^{-9}		
Hf-182	9.00×10^{6} a	F	0.002	3.0×10^{-7}	3.6×10^{-7}	0.002	3.0×10^{-9}
		M	0.002	1.2×10^{-7}	8.3×10^{-8}		
Hf-182m	1.02 h	F	0.002	2.3×10^{-11}	4.0×10^{-11}	0.002	4.2×10^{-11}
		M	0.002	4.7×10^{-11}	7.1×10^{-11}		
Hf-183	1.07 h	F	0.002	2.6×10^{-11}	4.4×10^{-11}	0.002	7.3×10^{-11}
		M	0.002	5.8×10^{-11}	8.3×10^{-11}		
Hf-184	4.12 h	F	0.002	1.3×10^{-10}	2.3×10^{-10}	0.002	5.2×10^{-10}
		M	0.002	3.3×10^{-10}	4.5×10^{-10}		
Tantalum							
Ta-172	0.613 h	M	0.001	3.4×10^{-11}	5.5×10^{-11}	0.001	5.3×10^{-11}
		S	0.001	3.6×10^{-11}	5.7×10^{-11}		
Ta-173	3.65 h	M	0.001	1.1×10^{-10}	1.6×10^{-10}	0.001	1.9×10^{-10}
		S	0.001	1.2×10^{-10}	1.6×10^{-10}		
Ta-174	1.20 h	M	0.001	4.2×10^{-11}	6.3×10^{-11}	0.001	5.7×10^{-11}
		S	0.001	4.4×10^{-11}	6.6×10^{-11}		
Ta-175	10.5 h	M	0.001	1.3×10^{-10}	2.0×10^{-10}	0.001	2.1×10^{-10}
		S	0.001	1.4×10^{-10}	2.0×10^{-10}		
Ta-176	8.08 h	M	0.001	2.0×10^{-10}	3.2×10^{-10}	0.001	3.1×10^{-10}
		S	0.001	2.1×10^{-10}	3.3×10^{-10}		
Ta-177	2.36 d	M	0.001	9.3×10^{-11}	1.2×10^{-10}	0.001	1.1×10^{-10}
		S	0.001	1.0×10^{-10}	1.3×10^{-10}		
Ta-178	2.20 h	M	0.001	6.6×10^{-11}	1.0×10^{-10}	0.001	7.8×10^{-11}
		S	0.001	6.9×10^{-11}	1.1×10^{-10}		
Ta-179	1.82 a	M	0.001	2.0×10^{-10}	1.3×10^{-10}	0.001	6.5×10^{-11}
		S	0.001	5.2×10^{-10}	2.9×10^{-10}		
Ta-180	1.00×10^{13} a	M	0.001	6.0×10^{-9}	4.6×10^{-9}	0.001	8.4×10^{-10}
		S	0.001	2.4×10^{-8}	1.4×10^{-8}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Ta-180m	8.10 h	M	0.001	4.4×10^{-11}	5.8×10^{-11}	0.001	5.4×10^{-11}
		S	0.001	4.7×10^{-11}	6.2×10^{-11}		
Ta-182	115 d	M	0.001	7.2×10^{-9}	5.8×10^{-9}	0.001	1.5×10^{-9}
		S	0.001	9.7×10^{-9}	7.4×10^{-9}		
Ta-182m	0.264 h	M	0.001	2.1×10^{-11}	3.4×10^{-11}	0.001	1.2×10^{-11}
		S	0.001	2.2×10^{-11}	3.6×10^{-11}		
Ta-183	5.10 d	M	0.001	1.8×10^{-9}	1.8×10^{-9}	0.001	1.3×10^{-9}
		S	0.001	2.0×10^{-9}	2.0×10^{-9}		
Ta-184	8.70 h	M	0.001	4.1×10^{-10}	6.0×10^{-10}	0.001	6.8×10^{-10}
		S	0.001	4.4×10^{-10}	6.3×10^{-10}		
Ta-185	0.816 h	M	0.001	4.6×10^{-11}	6.8×10^{-11}	0.001	6.8×10^{-11}
		S	0.001	4.9×10^{-11}	7.2×10^{-11}		
Ta-186	0.175 h	M	0.001	1.8×10^{-11}	3.0×10^{-11}	0.001	3.3×10^{-11}
		S	0.001	1.9×10^{-11}	3.1×10^{-11}		
Tungsten							
W-176	2.30 h	F	0.300	4.4×10^{-11}	7.6×10^{-11}	0.300	1.0×10^{-10}
						0.010	1.1×10^{-10}
W-177	2.25 h	F	0.300	2.6×10^{-11}	4.6×10^{-11}	0.300	5.8×10^{-11}
						0.010	6.1×10^{-11}
W-178	21.7 d	F	0.300	7.6×10^{-11}	1.2×10^{-10}	0.300	2.2×10^{-10}
						0.010	2.5×10^{-10}
W-179	0.625 h	F	0.300	9.9×10^{-13}	1.8×10^{-12}	0.300	3.3×10^{-12}
						0.010	3.3×10^{-12}

W-181	121 d	F	0.300	2.8×10^{-11}	4.3×10^{-11}	0.300	7.6×10^{-11}
						0.010	8.2×10^{-11}
W-185	75.1 d	F	0.300	1.4×10^{-10}	2.2×10^{-10}	0.300	4.4×10^{-10}
						0.010	5.0×10^{-10}
W-187	23.9 h	F	0.300	2.0×10^{-10}	3.3×10^{-10}	0.300	6.3×10^{-10}
						0.010	7.1×10^{-10}
W-188	69.4 d	F	0.300	5.9×10^{-10}	8.4×10^{-10}	0.300	2.1×10^{-9}
						0.010	2.3×10^{-9}
Rhenium							
Re-177	0.233 h	F	0.800	1.0×10^{-11}	1.7×10^{-11}	0.800	2.2×10^{-11}
		M	0.800	1.4×10^{-11}	2.2×10^{-11}		
Re-178	0.220 h	F	0.800	1.1×10^{-11}	1.8×10^{-11}	0.800	2.5×10^{-11}
		M	0.800	1.5×10^{-11}	2.4×10^{-11}		
Re-181	20.0 h	F	0.800	1.9×10^{-10}	3.0×10^{-10}	0.800	4.2×10^{-10}
		M	0.800	2.5×10^{-10}	3.7×10^{-10}		
Re-182	2.67 d	F	0.800	6.8×10^{-10}	1.1×10^{-9}	0.800	1.4×10^{-9}
		M	0.800	1.3×10^{-9}	1.7×10^{-9}		
Re-182	12.7 h	F	0.800	1.5×10^{-10}	2.4×10^{-10}	0.800	2.7×10^{-10}
		M	0.800	2.0×10^{-10}	3.0×10^{-10}		
Re-184	38.0 d	F	0.800	4.6×10^{-10}	7.0×10^{-10}	0.800	1.0×10^{-9}
		M	0.800	1.8×10^{-9}	1.8×10^{-9}		
Re-184m	165 d	F	0.800	6.1×10^{-10}	8.8×10^{-10}	0.800	1.5×10^{-9}
		M	0.800	6.1×10^{-9}	4.8×10^{-9}		
Re-186	3.78 d	F	0.800	5.3×10^{-10}	7.3×10^{-10}	0.800	1.5×10^{-9}
		M	0.800	1.1×10^{-9}	1.2×10^{-9}		
Re-186m	2.00×10^{5} a	F	0.800	8.5×10^{-10}	1.2×10^{-9}	0.800	2.2×10^{-9}
		M	0.800	1.1×10^{-8}	7.9×10^{-9}		
Re-187	5.00×10^{10} a	F	0.800	1.9×10^{-12}	2.6×10^{-12}	0.800	5.1×10^{-12}
		M	0.800	6.0×10^{-12}	4.6×10^{-12}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Re-188	17.0 h	F	0.800	4.7×10^{-10}	6.6×10^{-10}	0.800	1.4×10^{-9}
		M	0.800	5.5×10^{-10}	7.4×10^{-10}		
Re-188m	0.3 10 h	F	0.800	1.0×10^{-11}	1.6×10^{-11}	0.800	3.0×10^{-11}
		M	0.800	1.4×10^{-11}	2.0×10^{-11}		
Re-189	1.01 d	F	0.800	2.7×10^{-10}	4.3×10^{-10}	0.800	7.8×10^{-10}
		M	0.800	4.3×10^{-10}	6.0×10^{-10}		
Osmium							
Os-180	0.366 h	F	0.010	8.8×10^{-12}	1.6×10^{-11}	0.010	1.7×10^{-11}
		M	0.010	1.4×10^{-11}	2.4×10^{-11}		
		S	0.010	1.5×10^{-11}	2.5×10^{-11}		
Os-181	1.75 h	F	0.010	3.6×10^{-11}	6.4×10^{-11}	0.010	8.9×10^{-11}
		M	0.010	6.3×10^{-11}	9.6×10^{-11}		
		S	0.010	6.6×10^{-11}	1.0×10^{-10}		
Os-182	22.0 h	F	0.010	1.9×10^{-10}	3.2×10^{-10}	0.010	5.6×10^{-10}
		M	0.010	3.7×10^{-10}	5.0×10^{-10}		
		S	0.010	3.9×10^{-10}	5.2×10^{-10}		
Os-185	94.0 d	F	0.010	1.1×10^{-9}	1.4×10^{-9}	0.010	5.1×10^{-10}
		M	0.010	1.2×10^{-9}	1.0×10^{-9}		
		S	0.010	1.5×10^{-9}	1.1×10^{-9}		
Os-189m	6.00 h	F	0.010	2.7×10^{-12}	5.2×10^{-12}	0.010	1.8×10^{-11}
		M	0.010	5.1×10^{-12}	7.6×10^{-12}		
		S	0.010	5.4×10^{-12}	7.9×10^{-12}		
Os-191	15.4 d	F	0.010	2.5×10^{-10}	3.5×10^{-10}	0.010	5.7×10^{-10}
		M	0.010	1.5×10^{-9}	1.3×10^{-9}		
		S	0.010	1.8×10^{-9}	1.5×10^{-9}		

Os-191m	13.0 h	F	0.010	2.6×10^{-11}	4.1×10^{-11}	0.010	9.6×10^{-11}
		M	0.010	1.3×10^{-10}	1.3×10^{-10}		
		S	0.010	1.5×10^{-10}	1.4×10^{-10}		
Os-193	1.25 d	F	0.010	1.7×10^{-10}	2.8×10^{-10}	0.010	8.1×10^{-10}
		M	0.010	4.7×10^{-10}	6.4×10^{-10}		
		S	0.010	5.1×10^{-10}	6.8×10^{-10}		
Os-194	6.00 a	F	0.010	1.1×10^{-8}	1.3×10^{-8}	0.010	2.4×10^{-9}
		M	0.010	2.0×10^{-8}	1.3×10^{-8}		
		S	0.010	7.9×10^{-8}	4.2×10^{-8}		
Iridium							
Ir-182	0.250 h	F	0.010	1.5×10^{-11}	2.6×10^{-11}	0.010	4.8×10^{-11}
		M	0.010	2.4×10^{-11}	3.9×10^{-11}		
		S	0.010	2.5×10^{-11}	4.0×10^{-11}		
Ir-184	3.02 h	F	0.010	6.7×10^{-11}	1.2×10^{-10}	0.010	1.7×10^{-10}
		M	0.010	1.1×10^{-10}	1.8×10^{-10}		
		S	0.010	1.2×10^{-10}	1.9×10^{-10}		
Ir-185	14.0 h	F	0.010	8.8×10^{-11}	1.5×10^{-10}	0.010	2.6×10^{-10}
		M	0.010	1.8×10^{-10}	2.5×10^{-10}		
		S	0.010	1.9×10^{-10}	2.6×10^{-10}		
Ir-186	15.8 h	F	0.010	1.8×10^{-10}	3.3×10^{-10}	0.010	4.9×10^{-10}
		M	0.010	3.2×10^{-10}	4.8×10^{-10}		
		S	0.010	3.3×10^{-10}	5.0×10^{-10}		
Ir-186	1.75 h	F	0.010	2.5×10^{-11}	4.5×10^{-11}	0.010	6.1×10^{-11}
		M	0.010	4.3×10^{-11}	6.9×10^{-11}		
		S	0.010	4.5×10^{-11}	7.1×10^{-11}		
Ir-187	10.5 h	F	0.010	4.0×10^{-11}	7.2×10^{-11}	0.010	1.2×10^{-10}
		M	0.010	7.5×10^{-11}	1.1×10^{-10}		
		S	0.010	7.9×10^{-11}	1.2×10^{-10}		
Ir-188	1.73 d	F	0.010	2.6×10^{-10}	4.4×10^{-10}	0.010	6.3×10^{-10}
		M	0.010	4.1×10^{-10}	6.0×10^{-10}		
		S	0.010	4.3×10^{-10}	6.2×10^{-10}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Ir-189	13.3 d	F	0.010	1.1×10^{-10}	1.7×10^{-10}	0.010	2.4×10^{-10}
		M	0.010	4.8×10^{-10}	4.1×10^{-10}		
		S	0.010	5.5×10^{-10}	4.6×10^{-10}		
Ir-190	12.1 d	F	0.010	7.9×10^{-10}	1.2×10^{-9}	0.010	1.2×10^{-9}
		M	0.010	2.0×10^{-9}	2.3×10^{-9}		
		S	0.010	2.3×10^{-9}	2.5×10^{-9}		
Ir-190m	3.10 h	F	0.010	5.3×10^{-11}	9.7×10^{-11}	0.010	1.2×10^{-10}
		M	0.010	8.3×10^{-11}	1.4×10^{-10}		
		S	0.010	8.6×10^{-11}	1.4×10^{-10}		
Ir-190m	1.20 h	F	0.010	3.7×10^{-12}	5.6×10^{-12}	0.010	8.0×10^{-12}
		M	0.010	9.0×10^{-12}	1.0×10^{-11}		
		S	0.010	1.0×10^{-11}	1.1×10^{-11}		
Ir-192	74.0 d	F	0.010	1.8×10^{-9}	2.2×10^{-9}	0.010	1.4×10^{-9}
		M	0.010	4.9×10^{-9}	4.1×10^{-9}		
		S	0.010	6.2×10^{-9}	4.9×10^{-9}		
Ir-192m	2.41×10^{2} a	F	0.010	4.8×10^{-9}	5.6×10^{-9}	0.010	3.1×10^{-10}
		M	0.010	5.4×10^{-9}	3.4×10^{-9}		
		S	0.010	3.6×10^{-8}	1.9×10^{-8}		
Ir-193m	11.9 d	F	0.010	1.0×10^{-10}	1.6×10^{-10}	0.010	2.7×10^{-10}
		M	0.010	1.0×10^{-9}	9.1×10^{-10}		
		S	0.010	1.2×10^{-9}	1.0×10^{-9}		
Ir-194	19.1 h	F	0.010	2.2×10^{-10}	3.6×10^{-10}	0.010	1.3×10^{-9}
		M	0.010	5.3×10^{-10}	7.1×10^{-10}		
		S	0.010	5.6×10^{-10}	7.5×10^{-10}		

Ir-194m	171 d	F	0.010	5.4×10^{-9}	6.5×10^{-9}	0.010	2.1×10^{-9}
		M	0.010	8.5×10^{-9}	6.5×10^{-9}		
		S	0.010	1.2×10^{-8}	8.2×10^{-9}		
Ir-195	2.50 h	F	0.010	2.6×10^{-11}	4.5×10^{-11}	0.010	1.0×10^{-10}
		M	0.010	6.7×10^{-11}	9.6×10^{-11}		
		S	0.010	7.2×10^{-11}	1.0×10^{-10}		
Ir-195m	3.80 h	F	0.010	6.5×10^{-11}	1.1×10^{-10}	0.010	2.1×10^{-10}
		M	0.010	1.6×10^{-10}	2.3×10^{-10}		
		S	0.010	1.7×10^{-10}	2.4×10^{-10}		
Platinum							
Pt-186	2.00 h	F	0.010	3.6×10^{-11}	6.6×10^{-11}	0.010	9.3×10^{-11}
Pt-188	10.2 d	F	0.010	4.3×10^{-10}	6.3×10^{-10}	0.010	7.6×10^{-10}
Pt-189	10.9 h	F	0.010	4.1×10^{-11}	7.3×10^{-11}	0.010	1.2×10^{-10}
Pt-191	2.80 d	F	0.010	1.1×10^{-10}	1.9×10^{-10}	0.010	3.4×10^{-10}
Pt-193	50.0 a	F	0.010	2.1×10^{-11}	2.7×10^{-11}	0.010	3.1×10^{-11}
Pt-193m	4.33 d	F	0.010	1.3×10^{-10}	2.1×10^{-10}	0.010	4.5×10^{-10}
Pt-195m	4.02 d	F	0.010	1.9×10^{-10}	3.1×10^{-10}	0.010	6.3×10^{-10}
Pt-197	18.3 h	F	0.010	9.1×10^{-11}	1.6×10^{-10}	0.010	4.0×10^{-10}
Pt-197m	1.57 h	F	0.010	2.5×10^{-11}	4.3×10^{-11}	0.010	8.4×10^{-11}
Pt-199	0.513 h	F	0.010	1.3×10^{-11}	2.2×10^{-11}	0.010	3.9×10^{-11}
Pt-200	12.5 h	F	0.010	2.4×10^{-10}	4.0×10^{-10}	0.010	1.2×10^{-9}
Gold							
Au-193	17.6 h	F	0.100	3.9×10^{-11}	7.1×10^{-11}	0.100	1.3×10^{-10}
		M	0.100	1.1×10^{-10}	1.5×10^{-10}		
		S	0.100	1.2×10^{-10}	1.6×10^{-10}		
Au-194	1.64 d	F	0.100	1.5×10^{-10}	2.8×10^{-10}	0.100	4.2×10^{-10}
		M	0.100	2.4×10^{-10}	3.7×10^{-10}		
		S	0.100	2.5×10^{-10}	3.8×10^{-10}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Au-195	183 d	F	0.100	7.1×10^{-11}	1.2×10^{-10}	0.100	2.5×10^{-10}
		M	0.100	1.0×10^{-9}	8.0×10^{-10}		
		S	0.100	1.6×10^{-9}	1.2×10^{-9}		
Au-198	2.69 d	F	0.100	2.3×10^{-10}	3.9×10^{-10}	0.100	1.0×10^{-9}
		M	0.100	7.6×10^{-10}	9.8×10^{-10}		
		S	0.100	8.4×10^{-10}	1.1×10^{-9}		
Au-198m	2.30 d	F	0.100	3.4×10^{-10}	5.9×10^{-10}	0.100	1.3×10^{-9}
		M	0.100	1.7×10^{-9}	2.0×10^{-9}		
		S	0.100	1.9×10^{-9}	1.9×10^{-9}		
Au-199	3.14 d	F	0.100	1.1×10^{-10}	1.9×10^{-10}	0.100	4.4×10^{-10}
		M	0.100	6.8×10^{-10}	6.8×10^{-10}		
		S	0.100	7.5×10^{-10}	7.6×10^{-10}		
Au-200	0.807 h	F	0.100	1.7×10^{-11}	3.0×10^{-11}	0.100	6.8×10^{-11}
		M	0.100	3.5×10^{-11}	5.3×10^{-11}		
		S	0.100	3.6×10^{-11}	5.6×10^{-11}		
Au-200m	18.7 h	F	0.100	3.2×10^{-10}	5.7×10^{-10}	0.100	1.1×10^{-9}
		M	0.100	6.9×10^{-10}	9.8×10^{-10}		
		S	0.100	7.3×10^{-10}	1.0×10^{-9}		
Au-201	0.440 h	F	0.100	9.2×10^{-12}	1.6×10^{-11}	0.100	2.4×10^{-11}
		M	0.100	1.7×10^{-11}	2.8×10^{-11}		
		S	0.100	1.8×10^{-11}	2.9×10^{-11}		
Mercury							
Hg-193	3.50 h	F	0.400	2.6×10^{-11}	4.7×10^{-11}	1.000	3.1×10^{-11}
(organic)						0.400	6.6×10^{-11}
Hg-193	3.50 h	F	0.020	2.8×10^{-11}	5.0×10^{-11}	0.020	8.2×10^{-11}
(inorganic)		M	0.020	7.5×10^{-11}	1.0×10^{-10}		

Hg-193m	11.1 h	F	0.400	1.1×10^{-10}	2.0×10^{-10}	1.000	1.3×10^{-10}
(organic)						0.400	3.0×10^{-10}
Hg-193m	11.1 h	F	0.020	1.2×10^{-10}	2.3×10^{-10}	0.020	4.0×10^{-10}
(inorganic)		M	0.020	2.6×10^{-10}	3.8×10^{-10}		
Hg-194	2.60×10^{2} a	F	0.400	1.5×10^{-8}	1.9×10^{-8}	1.000	5.1×10^{-8}
(organic)						0.400	2.1×10^{-8}
Hg-194	2.60×10^{2} a	F	0.020	1.3×10^{-8}	1.5×10^{-8}	0.020	1.4×10^{-9}
(inorganic)		M	0.020	7.8×10^{-9}	5.3×10^{-9}		
Hg-195	9.90 h	F	0.400	2.4×10^{-11}	4.4×10^{-11}	1.000	3.4×10^{-11}
(organic)						0.400	7.5×10^{-11}
Hg-195	9.90 h	F	0.020	2.7×10^{-11}	4.8×10^{-11}	0.020	9.7×10^{-11}
(inorganic)		M	0.020	7.2×10^{-11}	9.2×10^{-11}		
Hg-195m	1.73 d	F	0.400	1.3×10^{-10}	2.2×10^{-10}	1.000	2.2×10^{-10}
(organic)						0.400	4.1×10^{-10}
Hg-195m	1.73 d	F	0.020	1.5×10^{-10}	2.6×10^{-10}	0.020	5.6×10^{-10}
(inorganic)		M	0.020	5.1×10^{-10}	6.5×10^{-10}		
Hg-197	2.67 d	F	0.400	5.0×10^{-11}	8.5×10^{-11}	1.000	9.9×10^{-11}
(organic)						0.400	1.7×10^{-10}
Hg-197	2.67 d	F	0.020	6.0×10^{-11}	1.0×10^{-10}	0.020	2.3×10^{-10}
(inorganic)		M	0.020	2.9×10^{-10}	2.8×10^{-10}		
Hg-197m	23.8 h	F	0.400	1.0×10^{-10}	1.8×10^{-10}	1.000	1.5×10^{-10}
(organic)						0.400	3.4×10^{-10}
Hg-197m	23.8 h	F	0.020	1.2×10^{-10}	2.1×10^{-10}	0.020	4.7×10^{-10}
(inorganic)		M	0.020	5.1×10^{-10}	6.6×10^{-10}		
Hg-199m	0.7 10 h	F	0.400	1.6×10^{-11}	2.7×10^{-11}	1.000	2.8×10^{-11}
(organic)						0.400	3.1×10^{-11}
Hg-199m	0.7 10 h	F	0.020	1.6×10^{-11}	2.7×10^{-11}	0.020	3.1×10^{-11}
(inorganic)		M	0.020	3.3×10^{-11}	5.2×10^{-11}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Hg-203 (organic)	46.6 d	F	0.400	5.7×10^{-10}	7.5×10^{-10}	1.000	1.9×10^{-9}
						0.400	1.1×10^{-9}
Hg-203 (inorganic)	46.6 d	F	0.020	4.7×10^{-10}	5.9×10^{-10}	0.020	5.4×10^{-10}
		M	0.020	2.3×10^{-9}	1.9×10^{-9}		
Thallium							
Tl-194	0.550 h	F	1.000	4.8×10^{-12}	8.9×10^{-12}	1.000	8.1×10^{-12}
Tl-194m	0.546 h	F	1.000	2.0×10^{-11}	3.6×10^{-11}	1.000	4.0×10^{-11}
Tl-195	1.16 h	F	1.000	1.6×10^{-11}	3.0×10^{-11}	1.000	2.7×10^{-11}
Tl-197	2.84 h	F	1.000	1.5×10^{-11}	2.7×10^{-11}	1.000	2.3×10^{-11}
Tl-198	5.30 h	F	1.000	6.6×10^{-11}	1.2×10^{-10}	1.000	7.3×10^{-11}
Tl-198m	1.87 h	F	1.000	4.0×10^{-11}	7.3×10^{-11}	1.000	5.4×10^{-11}
Tl-199	7.42 h	F	1.000	2.0×10^{-11}	3.7×10^{-11}	1.000	2.6×10^{-11}
Tl-200	1.09 d	F	1.000	1.4×10^{-10}	2.5×10^{-10}	1.000	2.0×10^{-10}
Tl-201	3.04 d	F	1.000	4.7×10^{-11}	7.6×10^{-11}	1.000	9.5×10^{-11}
Tl-202	12.2 d	F	1.000	2.0×10^{-10}	3.1×10^{-10}	1.000	4.5×10^{-10}
Tl-204	3.78 a	F	1.000	4.4×10^{-10}	6.2×10^{-10}	1.000	1.3×10^{-9}
Lead							
Pb-195m	0.263 h	F	0.200	1.7×10^{-11}	3.0×10^{-11}	0.200	2.9×10^{-11}
Pb-198	2.40 h	F	0.200	4.7×10^{-11}	8.7×10^{-11}	0.200	1.0×10^{-10}
Pb-199	1.50 h	F	0.200	2.6×10^{-11}	4.8×10^{-11}	0.200	5.4×10^{-11}
Pb-200	21.5 h	F	0.200	1.5×10^{-10}	2.6×10^{-10}	0.200	4.0×10^{-10}
Pb-201	9.40 h	F	0.200	6.5×10^{-11}	1.2×10^{-10}	0.200	1.6×10^{-10}

Pb-202	3.00×10^{5} a	F	0.200	1.1×10^{-8}	1.4×10^{-8}	0.200	8.7×10^{-9}
Pb-202m	3.62 h	F	0.200	6.7×10^{-11}	1.2×10^{-10}	0.200	1.3×10^{-10}
Pb-203	2.17 d	F	0.200	9.1×10^{-11}	1.6×10^{-10}	0.200	2.4×10^{-10}
Pb-205	1.43×10^{7} a	F	0.200	3.4×10^{-10}	4.1×10^{-10}	0.200	2.8×10^{-10}
Pb-209	3.25 h	F	0.200	1.8×10^{-11}	3.2×10^{-11}	0.200	5.7×10^{-11}
Pb-210	22.3 a	F	0.200	8.9×10^{-7}	1.1×10^{-6}	0.200	6.8×10^{-7}
Pb-211	0.601 h	F	0.200	3.9×10^{-9}	5.6×10^{-9}	0.200	1.8×10^{-10}
Pb-212	10.6 h	F	0.200	1.9×10^{-8}	3.3×10^{-8}	0.200	5.9×10^{-9}
Pb-214	0.447 h	F	0.200	2.9×10^{-9}	4.8×10^{-9}	0.200	1.4×10^{-10}
Bismuth							
Bi-200	0.606 h	F	0.050	2.4×10^{-11}	4.2×10^{-11}	0.050	5.1×10^{-11}
		M	0.050	3.4×10^{-11}	5.6×10^{-11}		
Bi-201	1.80 h	F	0.050	4.7×10^{-11}	8.3×10^{-11}	0.050	1.2×10^{-10}
		M	0.050	7.0×10^{-11}	1.1×10^{-10}		
Bi-202	1.67 h	F	0.050	4.6×10^{-11}	8.4×10^{-11}	0.050	8.9×10^{-11}
		M	0.050	5.8×10^{-11}	1.0×10^{-10}		
Bi-203	11.8 h	F	0.050	2.0×10^{-10}	3.6×10^{-10}	0.050	4.8×10^{-10}
		M	0.050	2.8×10^{-10}	4.5×10^{-10}		
Bi-205	15.3 d	F	0.050	4.0×10^{-10}	6.8×10^{-10}	0.050	9.0×10^{-10}
		M	0.050	9.2×10^{-10}	1.0×10^{-9}		
Bi-206	6.24 d	F	0.050	7.9×10^{-10}	1.3×10^{-9}	0.050	1.9×10^{-9}
		M	0.050	1.7×10^{-9}	2.1×10^{-9}		
Bi-207	38.0 a	F	0.050	5.2×10^{-10}	8.4×10^{-10}	0.050	1.3×10^{-9}
		M	0.050	5.2×10^{-9}	3.2×10^{-9}		
Bi-210	5.01 d	F	0.050	1.1×10^{-9}	1.4×10^{-9}	0.050	1.3×10^{-9}
		M	0.050	8.4×10^{-8}	6.0×10^{-8}		
Bi-210m	3.00×10^{6} a	F	0.050	4.5×10^{-8}	5.3×10^{-8}	0.050	1.5×10^{-8}
		M	0.050	3.1×10^{-6}	2.1×10^{-6}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Bi-212	1.01 h	F	0.050	9.3×10^{-9}	1.5×10^{-8}	0.050	2.6×10^{-10}
		M	0.050	3.0×10^{-8}	3.9×10^{-8}		
Bi-213	0.761 h	F	0.050	1.1×10^{-8}	1.8×10^{-8}	0.050	2.0×10^{-10}
		M	0.050	2.9×10^{-8}	4.1×10^{-8}		
Bi-214	0.332 h	F	0.050	7.2×10^{-9}	1.2×10^{-8}	0.050	1.1×10^{-10}
		M	0.050	1.4×10^{-8}	2.1×10^{-8}		
Polonium							
Po-203	0.612 h	F	0.100	2.5×10^{-11}	4.5×10^{-11}	0.100	5.2×10^{-11}
		M	0.100	3.6×10^{-11}	6.1×10^{-11}		
Po-205	1.80 h	F	0.100	3.5×10^{-11}	6.0×10^{-11}	0.100	5.9×10^{-11}
		M	0.100	6.4×10^{-11}	8.9×10^{-11}		
Po-207	5.83 h	F	0.100	6.3×10^{-11}	1.2×10^{-10}	0.100	1.4×10^{-10}
		M	0.100	8.4×10^{-11}	1.5×10^{-10}		
Po-210	138 d	F	0.100	6.0×10^{-7}	7.1×10^{-7}	0.100	2.4×10^{-7}
		M	0.100	3.0×10^{-6}	2.2×10^{-6}		
Astatine							
At-207	1.80 h	F	1.000	3.5×10^{-10}	4.4×10^{-10}	1.000	2.3×10^{-10}
		M	1.000	2.1×10^{-9}	1.9×10^{-9}		
At-211	7.21 h	F	1.000	1.6×10^{-8}	2.7×10^{-8}	1.000	1.1×10^{-8}
		M	1.000	9.8×10^{-8}	1.1×10^{-7}		
Francium							
Fr-222	0.240 h	F	1.000	1.4×10^{-8}	2.1×10^{-8}	1.000	7.1×10^{-10}
Fr-223	0.363 h	F	1.000	9.1×10^{-10}	1.3×10^{-9}	1.000	2.3×10^{-9}

Radium							
Ra-223	11.4 d	M	0.200	6.9×10^{-6}	5.7×10^{-6}	0.200	1.0×10^{-7}
Ra-224	3.66 d	M	0.200	2.9×10^{-6}	2.4×10^{-6}	0.200	6.5×10^{-8}
Ra-225	14.8 d	M	0.200	5.8×10^{-6}	4.8×10^{-6}	0.200	9.5×10^{-8}
Ra-226	1.60×10^{3} a	M	0.200	3.2×10^{-6}	2.2×10^{-6}	0.200	2.8×10^{-7}
Ra-227	0.703 h	M	0.200	2.8×10^{-10}	2.1×10^{-10}	0.200	8.4×10^{-11}
Ra-228	5.75 a	M	0.200	2.6×10^{-6}	1.7×10^{-6}	0.200	6.7×10^{-7}
Actinium							
Ac-224	2.90 h	F	5.0×10^{-4}	1.1×10^{-8}	1.3×10^{-8}	5.0×10^{-4}	7.0×10^{-10}
		M	5.0×10^{-4}	1.0×10^{-7}	8.9×10^{-8}		
		S	5.0×10^{-4}	1.2×10^{-7}	9.9×10^{-8}		
Ac-225	10.0 d	F	5.0×10^{-4}	8.7×10^{-7}	1.0×10^{-6}	5.0×10^{-4}	2.4×10^{-8}
		M	5.0×10^{-4}	6.9×10^{-6}	5.7×10^{-6}		
		S	5.0×10^{-4}	7.9×10^{-6}	6.5×10^{-6}		
Ac-226	1.21 d	F	5.0×10^{-4}	9.5×10^{-8}	2.2×10^{-7}	5.0×10^{-4}	1.0×10^{-8}
		M	5.0×10^{-4}	1.1×10^{-6}	9.2×10^{-7}		
		S	5.0×10^{-4}	1.2×10^{-6}	1.0×10^{-6}		
Ac-227	21.8 a	F	5.0×10^{-4}	5.4×10^{-4}	6.3×10^{-4}	5.0×10^{-4}	1.1×10^{-6}
		M	5.0×10^{-4}	2.1×10^{-4}	1.5×10^{-4}		
		S	5.0×10^{-4}	6.6×10^{-5}	4.7×10^{-5}		
Ac-228	6.13 h	F	5.0×10^{-4}	2.5×10^{-8}	2.9×10^{-8}	5.0×10^{-4}	4.3×10^{-10}
		M	5.0×10^{-4}	1.6×10^{-8}	1.2×10^{-8}		
		S	5.0×10^{-4}	1.4×10^{-8}	1.2×10^{-8}		
Thorium							
Th-226	0.515 h	M	5.0×10^{-4}	5.5×10^{-8}	7.4×10^{-8}	5.0×10^{-4}	3.5×10^{-10}
		S	2.0×10^{-4}	5.9×10^{-8}	7.8×10^{-8}	2.0×10^{-4}	3.6×10^{-10}
Th-227	18.7 d	M	5.0×10^{-4}	7.8×10^{-6}	6.2×10^{-6}	5.0×10^{-4}	8.9×10^{-9}
		S	2.0×10^{-4}	9.6×10^{-6}	7.6×10^{-6}	2.0×10^{-4}	8.4×10^{-9}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Th-228	1.91 a	M	5.0×10^{-4}	3.1×10^{-5}	2.3×10^{-5}	5.0×10^{-4}	7.0×10^{-8}
		S	2.0×10^{-4}	3.9×10^{-5}	3.2×10^{-5}	2.0×10^{-4}	3.5×10^{-8}
Th-229	7.34×10^3 a	M	5.0×10^{-4}	9.9×10^{-5}	6.9×10^{-5}	5.0×10^{-4}	4.8×10^{-7}
		S	2.0×10^{-4}	6.5×10^{-5}	4.8×10^{-5}	2.0×10^{-4}	2.0×10^{-7}
Th-230	7.70×10^4 a	M	5.0×10^{-4}	4.0×10^{-5}	2.8×10^{-5}	5.0×10^{-4}	2.1×10^{-7}
		S	2.0×10^{-4}	1.3×10^{-5}	7.2×10^{-6}	2.0×10^{-4}	8.7×10^{-8}
Th-231	1.06 d	M	5.0×10^{-4}	2.9×10^{-10}	3.7×10^{-10}	5.0×10^{-4}	3.4×10^{-10}
		S	2.0×10^{-4}	3.2×10^{-10}	4.0×10^{-10}	2.0×10^{-4}	3.4×10^{-10}
Th-232	1.40×10^{10} a	M	5.0×10^{-4}	4.2×10^{-5}	2.9×10^{-5}	5.0×10^{-4}	2.2×10^{-7}
		S	2.0×10^{-4}	2.3×10^{-5}	1.2×10^{-5}	2.0×10^{-4}	9.2×10^{-8}
Th-234	24.1 d	M	5.0×10^{-4}	6.3×10^{-9}	5.3×10^{-9}	5.0×10^{-4}	3.4×10^{-9}
		S	2.0×10^{-4}	7.3×10^{-9}	5.8×10^{-9}	2.0×10^{-4}	3.4×10^{-9}
Protactinium							
Pa-227	0.638 h	M	5.0×10^{-4}	7.0×10^{-8}	9.0×10^{-8}	5.0×10^{-4}	4.5×10^{-10}
		S	5.0×10^{-4}	7.6×10^{-8}	9.7×10^{-8}		
Pa-228	22.0 h	M	5.0×10^{-4}	5.9×10^{-8}	4.6×10^{-8}	5.0×10^{-4}	7.8×10^{-10}
		S	5.0×10^{-4}	6.9×10^{-8}	5.1×10^{-8}		
Pa-230	17.4 d	M	5.0×10^{-4}	5.6×10^{-7}	4.6×10^{-7}	5.0×10^{-4}	9.2×10^{-10}
		S	5.0×10^{-4}	7.1×10^{-7}	5.7×10^{-7}		
Pa-231	3.27×10^4 a	M	5.0×10^{-4}	1.3×10^{-4}	8.9×10^{-5}	5.0×10^{-4}	7.1×10^{-7}
		S	5.0×10^{-4}	3.2×10^{-5}	1.7×10^{-5}		
Pa-232	1.31 d	M	5.0×10^{-4}	9.5×10^{-9}	6.8×10^{-9}	5.0×10^{-4}	7.2×10^{-10}
		S	5.0×10^{-4}	3.2×10^{-9}	2.0×10^{-9}		

Pa-233	27.0 d	M	5.0×10^{-4}	3.1×10^{-9}	2.8×10^{-9}	5.0×10^{-4}	8.7×10^{-10}
		S	5.0×10^{-4}	3.7×10^{-9}	3.2×10^{-9}		
Pa-234	6.70 h	M	5.0×10^{-4}	3.8×10^{-10}	5.5×10^{-10}	5.0×10^{-4}	5.1×10^{-10}
		S	5.0×10^{-4}	4.0×10^{-10}	5.8×10^{-10}		
Uranium							
U-230	20.8 d	F	0.020	3.6×10^{-7}	4.2×10^{-7}	0.020	5.5×10^{-8}
		M	0.020	1.2×10^{-5}	1.0×10^{-5}	0.002	2.8×10^{-8}
		S	0.002	1.5×10^{-5}	1.2×10^{-5}		
U-231	4.20 d	F	0.020	8.3×10^{-11}	1.4×10^{-10}	0.020	2.8×10^{-10}
		M	0.020	3.4×10^{-10}	3.7×10^{-10}	0.002	2.8×10^{-10}
		S	0.002	3.7×10^{-10}	4.0×10^{-10}		
U-232	72.0 a	F	0.020	4.0×10^{-6}	4.7×10^{-6}	0.020	3.3×10^{-7}
		M	0.020	7.2×10^{-6}	4.8×10^{-6}	0.002	3.7×10^{-8}
		S	0.002	3.5×10^{-5}	2.6×10^{-5}		
U-233	1.58×10^{5} a	F	0.020	5.7×10^{-7}	6.6×10^{-7}	0.020	5.0×10^{-8}
		M	0.020	3.2×10^{-6}	2.2×10^{-6}	0.002	8.5×10^{-9}
		S	0.002	8.7×10^{-6}	6.9×10^{-6}		
U-234	2.44×10^{5} a	F	0.020	5.5×10^{-7}	6.4×10^{-7}	0.020	4.9×10^{-8}
		M	0.020	3.1×10^{-6}	2.1×10^{-6}	0.002	8.3×10^{-9}
		S	0.002	8.5×10^{-6}	6.8×10^{-6}		
U-235	7.04×10^{8} a	F	0.020	5.1×10^{-7}	6.0×10^{-7}	0.020	4.6×10^{-8}
		M	0.020	2.8×10^{-6}	1.8×10^{-6}	0.002	8.3×10^{-9}
		S	0.002	7.7×10^{-6}	6.1×10^{-6}		
U-236	2.34×10^{7} a	F	0.020	5.2×10^{-7}	6.1×10^{-7}	0.020	4.6×10^{-8}
		M	0.020	2.9×10^{-6}	1.9×10^{-6}	0.002	7.9×10^{-9}
		S	0.002	7.9×10^{-6}	6.3×10^{-6}		
U-237	6.75 d	F	0.020	1.9×10^{-10}	3.3×10^{-10}	0.020	7.6×10^{-10}
		M	0.020	1.6×10^{-9}	1.5×10^{-9}	0.002	7.7×10^{-10}
		S	0.002	1.8×10^{-9}	1.7×10^{-9}		

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
U-238	4.47×10^{9} a	F	0.020	4.9×10^{-7}	5.8×10^{-7}	0.020	4.4×10^{-8}
		M	0.020	2.6×10^{-6}	1.6×10^{-6}	0.002	7.6×10^{-9}
		S	0.002	7.3×10^{-6}	5.7×10^{-6}		
U-239	0.392 h	F	0.020	1.1×10^{-11}	1.8×10^{-11}	0.020	2.7×10^{-11}
		M	0.020	2.3×10^{-11}	3.3×10^{-11}	0.002	2.8×10^{-11}
		S	0.002	2.4×10^{-11}	3.5×10^{-11}		
U-240	14.1 h	F	0.020	2.1×10^{-10}	3.7×10^{-10}	0.020	1.1×10^{-9}
		M	0.020	5.3×10^{-10}	7.9×10^{-10}	0.002	1.1×10^{-9}
		S	0.002	5.7×10^{-10}	8.4×10^{-10}		
Neptunium							
Np-232	0.245 h	M	5.0×10^{-4}	4.7×10^{-11}	3.5×10^{-11}	5.0×10^{-4}	9.7×10^{-12}
Np-233	0.603 h	M	5.0×10^{-4}	1.7×10^{-12}	3.0×10^{-12}	5.0×10^{-4}	2.2×10^{-12}
Np-234	4.40 d	M	5.0×10^{-4}	5.4×10^{-10}	7.3×10^{-10}	5.0×10^{-4}	8.1×10^{-10}
Np-235	1.08 a	M	5.0×10^{-4}	4.0×10^{-10}	2.7×10^{-10}	5.0×10^{-4}	5.3×10^{-11}
Np-236	1.15×10^{5} a	M	5.0×10^{-4}	3.0×10^{-6}	2.0×10^{-6}	5.0×10^{-4}	1.7×10^{-8}
Np-236	22.5 h	M	5.0×10^{-4}	5.0×10^{-9}	3.6×10^{-9}	5.0×10^{-4}	1.9×10^{-10}
Np-237	2.14×10^{6} a	M	5.0×10^{-4}	2.1×10^{-5}	1.5×10^{-5}	5.0×10^{-4}	1.1×10^{-7}
Np-238	2.12 d	M	5.0×10^{-4}	2.0×10^{-9}	1.7×10^{-9}	5.0×10^{-4}	9.1×10^{-10}
Np-239	2.36 d	M	5.0×10^{-4}	9.0×10^{-10}	1.1×10^{-9}	5.0×10^{-4}	8.0×10^{-10}
Np-240	1.08 h	M	5.0×10^{-4}	8.7×10^{-11}	1.3×10^{-10}	5.0×10^{-4}	8.2×10^{-11}
Plutonium							
Pu-234	8.80 h	M	5.0×10^{-4}	1.9×10^{-8}	1.6×10^{-8}	5.0×10^{-4}	1.6×10^{-10}
		S	1.0×10^{-5}	2.2×10^{-8}	1.8×10^{-8}	1.0×10^{-5}	1.5×10^{-10}
						1.0×10^{-4}	1.6×10^{-10}

Pu-235	0.422 h	M	5.0×10^{-4}	1.5×10^{-12}	2.5×10^{-12}	5.0×10^{-4}	2.1×10^{-12}
		S	1.0×10^{-5}	1.6×10^{-12}	2.6×10^{-12}	1.0×10^{-5}	2.1×10^{-12}
						1.0×10^{-4}	2.1×10^{-12}
Pu-236	2.85 a	M	5.0×10^{-4}	1.8×10^{-5}	1.3×10^{-5}	5.0×10^{-4}	8.6×10^{-8}
		S	1.0×10^{-5}	9.6×10^{-6}	7.4×10^{-6}	1.0×10^{-5}	6.3×10^{-9}
						1.0×10^{-4}	2.1×10^{-8}
Pu-237	45.3 d	M	5.0×10^{-4}	3.3×10^{-10}	2.9×10^{-10}	5.0×10^{-4}	1.0×10^{-10}
		S	1.0×10^{-5}	3.6×10^{-10}	3.0×10^{-10}	1.0×10^{-5}	1.0×10^{-10}
						1.0×10^{-4}	1.0×10^{-10}
Pu-238	87.7 a	M	5.0×10^{-4}	4.3×10^{-5}	3.0×10^{-5}	5.0×10^{-4}	2.3×10^{-7}
		S	1.0×10^{-5}	1.5×10^{-5}	1.1×10^{-5}	1.0×10^{-5}	8.8×10^{-9}
						1.0×10^{-4}	4.9×10^{-8}
Pu-239	2.41×10^{4} a	M	5.0×10^{-4}	4.7×10^{-5}	3.2×10^{-5}	5.0×10^{-4}	2.5×10^{-7}
		S	1.0×10^{-5}	1.5×10^{-5}	8.3×10^{-6}	1.0×10^{-5}	9.0×10^{-9}
						1.0×10^{-4}	5.3×10^{-8}
Pu-240	6.54×10^{3} a	M	5.0×10^{-4}	4.7×10^{-5}	3.2×10^{-5}	5.0×10^{-4}	2.5×10^{-7}
		S	1.0×10^{-5}	1.5×10^{-5}	8.3×10^{-6}	1.0×10^{-5}	9.0×10^{-9}
						1.0×10^{-4}	5.3×10^{-8}
Pu-241	14.4 a	M	5.0×10^{-4}	8.5×10^{-7}	5.8×10^{-7}	5.0×10^{-4}	4.7×10^{-9}
		S	1.0×10^{-5}	1.6×10^{-7}	8.4×10^{-8}	1.0×10^{-5}	1.1×10^{-10}
						1.0×10^{-4}	9.6×10^{-10}
Pu-242	3.76×10^{5} a	M	5.0×10^{-4}	4.4×10^{-5}	3.1×10^{-5}	5.0×10^{-4}	2.4×10^{-7}
		S	1.0×10^{-5}	1.4×10^{-5}	7.7×10^{-6}	1.0×10^{-5}	8.6×10^{-9}
						1.0×10^{-4}	5.0×10^{-8}
Pu-243	4.95 h	M	5.0×10^{-4}	8.2×10^{-11}	1.1×10^{-10}	5.0×10^{-4}	8.5×10^{-11}
		S	1.0×10^{-5}	8.5×10^{-11}	1.1×10^{-10}	1.0×10^{-5}	8.5×10^{-11}
						1.0×10^{-4}	8.5×10^{-11}
Pu-244	8.26×10^{7} a	M	5.0×10^{-4}	4.4×10^{-5}	3.0×10^{-5}	5.0×10^{-4}	2.4×10^{-7}
		S	1.0×10^{-5}	1.3×10^{-5}	7.4×10^{-6}	1.0×10^{-5}	1.1×10^{-8}
						1.0×10^{-4}	5.2×10^{-8}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	e(g)
Pu-245	10.5 h	M	5.0×10^{-4}	4.5×10^{-10}	6.1×10^{-10}	5.0×10^{-4}	7.2×10^{-10}
		S	1.0×10^{-5}	4.8×10^{-10}	6.5×10^{-10}	1.0×10^{-5}	7.2×10^{-10}
						1.0×10^{-4}	7.2×10^{-10}
Pu-246	10.9 d	M	5.0×10^{-4}	7.0×10^{-9}	6.5×10^{-9}	5.0×10^{-4}	3.3×10^{-9}
		S	1.0×10^{-5}	7.6×10^{-9}	7.0×10^{-9}	1.0×10^{-5}	3.3×10^{-9}
						1.0×10^{-4}	3.3×10^{-9}
Americium							
Am-237	1.22 h	M	5.0×10^{-4}	2.5×10^{-11}	3.6×10^{-11}	5.0×10^{-4}	1.8×10^{-11}
Am-238	1.63 h	M	5.0×10^{-4}	8.5×10^{-11}	6.6×10^{-11}	5.0×10^{-4}	3.2×10^{-11}
Am-239	11.9 h	M	5.0×10^{-4}	2.2×10^{-10}	2.9×10^{-10}	5.0×10^{-4}	2.4×10^{-10}
Am-240	2.12 d	M	5.0×10^{-4}	4.4×10^{-10}	5.9×10^{-10}	5.0×10^{-4}	5.8×10^{-10}
Am-241	4.32×10^{2} a	M	5.0×10^{-4}	3.9×10^{-5}	2.7×10^{-5}	5.0×10^{-4}	2.0×10^{-7}
Am-242	16.0 h	M	5.0×10^{-4}	1.6×10^{-8}	1.2×10^{-8}	5.0×10^{-4}	3.0×10^{-10}
Am-242m	1.52×10^{2} a	M	5.0×10^{-4}	3.5×10^{-5}	2.4×10^{-5}	5.0×10^{-4}	1.9×10^{-7}
Am-243	7.38×10^{3} a	M	5.0×10^{-4}	3.9×10^{-5}	2.7×10^{-5}	5.0×10^{-4}	2.0×10^{-7}
Am-244	10.1 h	M	5.0×10^{-4}	1.9×10^{-9}	1.5×10^{-9}	5.0×10^{-4}	4.6×10^{-10}
Am-244m	0.433 h	M	5.0×10^{-4}	7.9×10^{-11}	6.2×10^{-11}	5.0×10^{-4}	2.9×10^{-11}
Am-245	2.05 h	M	5.0×10^{-4}	5.3×10^{-11}	7.6×10^{-11}	5.0×10^{-4}	6.2×10^{-11}
Am-246	0.650 h	M	5.0×10^{-4}	6.8×10^{-11}	1.1×10^{-10}	5.0×10^{-4}	5.8×10^{-11}
Am-246m	0.417 h	M	5.0×10^{-4}	2.3×10^{-11}	3.8×10^{-11}	5.0×10^{-4}	3.4×10^{-11}
Curium							
Cm-238	2.40 h	M	5.0×10^{-4}	4.1×10^{-9}	4.8×10^{-9}	5.0×10^{-4}	8.0×10^{-11}
Cm-240	27.0 d	M	5.0×10^{-4}	2.9×10^{-6}	2.3×10^{-6}	5.0×10^{-4}	7.6×10^{-9}

Cm-241	32.8 d	M	5.0×10^{-4}	3.4×10^{-8}	2.6×10^{-8}	5.0×10^{-4}	9.1×10^{-10}
Cm-242	163 d	M	5.0×10^{-4}	4.8×10^{-6}	3.7×10^{-6}	5.0×10^{-4}	1.2×10^{-8}
Cm-243	28.5 a	M	5.0×10^{-4}	2.9×10^{-5}	2.0×10^{-5}	5.0×10^{-4}	1.5×10^{-7}
Cm-244	18.1 a	M	5.0×10^{-4}	2.5×10^{-5}	1.7×10^{-5}	5.0×10^{-4}	1.2×10^{-7}
Cm-245	8.50×10^{3} a	M	5.0×10^{-4}	4.0×10^{-5}	2.7×10^{-5}	5.0×10^{-4}	2.1×10^{-7}
Cm-246	4.73×10^{3} a	M	5.0×10^{-4}	4.0×10^{-5}	2.7×10^{-5}	5.0×10^{-4}	2.1×10^{-7}
Cm-247	1.56×10^{7} a	M	5.0×10^{-4}	3.6×10^{-5}	2.5×10^{-5}	5.0×10^{-4}	1.9×10^{-7}
Cm-248	3.39×10^{5} a	M	5.0×10^{-4}	1.4×10^{-4}	9.5×10^{-5}	5.0×10^{-4}	7.7×10^{-7}
Cm-249	1.07 h	M	5.0×10^{-4}	3.2×10^{-11}	5.1×10^{-11}	5.0×10^{-4}	3.1×10^{-11}
Cm-250	6.90×10^{3} a	M	5.0×10^{-4}	7.9×10^{-4}	5.4×10^{-4}	5.0×10^{-4}	4.4×10^{-6}
Berkelium							
Bk-245	4.94 d	M	5.0×10^{-4}	2.0×10^{-9}	1.8×10^{-9}	5.0×10^{-4}	5.7×10^{-10}
Bk-246	1.83 d	M	5.0×10^{-4}	3.4×10^{-10}	4.6×10^{-10}	5.0×10^{-4}	4.8×10^{-10}
Bk-247	1.38×10^{3} a	M	5.0×10^{-4}	6.5×10^{-5}	4.5×10^{-5}	5.0×10^{-4}	3.5×10^{-7}
Bk-249	320 d	M	5.0×10^{-4}	1.5×10^{-7}	1.0×10^{-7}	5.0×10^{-4}	9.7×10^{-10}
Bk-250	3.22 h	M	5.0×10^{-4}	9.6×10^{-10}	7.1×10^{-10}	5.0×10^{-4}	1.4×10^{-10}
Californium							
Cf-244	0.323 h	M	5.0×10^{-4}	1.3×10^{-8}	1.8×10^{-8}	5.0×10^{-4}	7.0×10^{-11}
Cf-246	1.49 d	M	5.0×10^{-4}	4.2×10^{-7}	3.5×10^{-7}	5.0×10^{-4}	3.3×10^{-9}
Cf-248	334 d	M	5.0×10^{-4}	8.2×10^{-6}	6.1×10^{-6}	5.0×10^{-4}	2.8×10^{-8}
Cf-249	3.50×10^{2} a	M	5.0×10^{-4}	6.6×10^{-5}	4.5×10^{-5}	5.0×10^{-4}	3.5×10^{-7}
Cf-250	13.1 a	M	5.0×10^{-4}	3.2×10^{-5}	2.2×10^{-5}	5.0×10^{-4}	1.6×10^{-7}
Cf-251	8.98×10^{2} a	M	5.0×10^{-4}	6.7×10^{-5}	4.6×10^{-5}	5.0×10^{-4}	3.6×10^{-7}
Cf-252	2.64 a	M	5.0×10^{-4}	1.8×10^{-5}	1.3×10^{-5}	5.0×10^{-4}	9.0×10^{-8}
Cf-253	17.8 d	M	5.0×10^{-4}	1.2×10^{-6}	1.0×10^{-6}	5.0×10^{-4}	1.4×10^{-9}
Cf-254	60.5 d	M	5.0×10^{-4}	3.7×10^{-5}	2.2×10^{-5}	5.0×10^{-4}	4.0×10^{-7}

TABLE II-III. (cont.)

Nuclide	Physical half-life	Inhalation				Ingestion	
		Type	f_1	$e(g)_{1\,\mu m}$	$e(g)_{5\,\mu m}$	f_1	$e(g)$
Einsteinium							
Es-250	2.10 h	M	5.0×10^{-4}	5.9×10^{-10}	4.2×10^{-10}	5.0×10^{-4}	2.1×10^{-11}
Es-251	1.38 d	M	5.0×10^{-4}	2.0×10^{-9}	1.7×10^{-9}	5.0×10^{-4}	1.7×10^{-10}
Es-253	20.5 d	M	5.0×10^{-4}	2.5×10^{-6}	2.1×10^{-6}	5.0×10^{-4}	6.1×10^{-9}
Es-254	276 d	M	5.0×10^{-4}	8.0×10^{-6}	6.0×10^{-6}	5.0×10^{-4}	2.8×10^{-8}
Es-254m	1.64 d	M	5.0×10^{-4}	4.4×10^{-7}	3.7×10^{-7}	5.0×10^{-4}	4.2×10^{-9}
Fermium							
Fm-252	22.7 h	M	5.0×10^{-4}	3.0×10^{-7}	2.6×10^{-7}	5.0×10^{-4}	2.7×10^{-9}
Fm-253	3.00 d	M	5.0×10^{-4}	3.7×10^{-7}	3.0×10^{-7}	5.0×10^{-4}	9.1×10^{-10}
Fm-254	3.24 h	M	5.0×10^{-4}	5.6×10^{-8}	7.7×10^{-8}	5.0×10^{-4}	4.4×10^{-10}
Fm-255	20.1 h	M	5.0×10^{-4}	2.5×10^{-7}	2.6×10^{-7}	5.0×10^{-4}	2.5×10^{-9}
Fm-257	101 d	M	5.0×10^{-4}	6.6×10^{-6}	5.2×10^{-6}	5.0×10^{-4}	1.5×10^{-8}
Mendelevium							
Md-257	5.20 h	M	5.0×10^{-4}	2.3×10^{-8}	2.0×10^{-8}	5.0×10^{-4}	1.2×10^{-10}
Md-258	55.0 d	M	5.0×10^{-4}	5.5×10^{-6}	4.4×10^{-6}	5.0×10^{-4}	1.3×10^{-8}

TABLE II-IV. COMPOUNDS AND VALUES OF GUT TRANSFER FACTOR f_1 USED TO CALCULATE COMMITTED EFFECTIVE DOSE PER UNIT INTAKE VIA INGESTION FOR WORKERS

Element	Gut transfer factor f_1	Compounds
Hydrogen	1.000	Tritiated water (ingested)
	1.000	Organically bound tritium
Beryllium	0.005	All compounds
Carbon	1.000	Labelled organic compounds
Fluorine	1.000	All compounds
Sodium	1.000	All compounds
Magnesium	0.500	All compounds
Aluminium	0.010	All compounds
Silicon	0.010	All compounds
Phosphorus	0.800	All compounds
Sulphur	0.800	Inorganic compounds
	0.100	Elemental sulphur
	1.000	Organic sulphur
Chlorine	1.000	All compounds
Potassium	1.000	All compounds
Calcium	0.300	All compounds
Scandium	1.0×10^{-4}	All compounds
Titanium	0.010	All compounds
Vanadium	0.010	All compounds
Chromium	0.100	Hexavalent compounds
	0.010	Trivalent compounds
Manganese	0.100	All compounds
Iron	0.100	All compounds
Cobalt	0.100	All unspecified compounds
	0.050	Oxides, hydroxides and inorganic compounds
Nickel	0.050	All compounds
Copper	0.500	All compounds
Zinc	0.500	All compounds
Gallium	0.001	All compounds

TABLE II-IV. (cont.)

Element	Gut transfer factor f_1	Compounds
Germanium	1.000	All compounds
Arsenic	0.500	All compounds
Selenium	0.800	All unspecified compounds
	0.050	Elemental selenium and selenides
Bromine	1.000	All compounds
Rubidium	1.000	All compounds
Strontium	0.300	All unspecified compounds
	0.010	Strontium titanate ($SrTiO_3$)
Yttrium	1.0×10^{-4}	All compounds
Zirconium	0.002	All compounds
Niobium	0.010	All compounds
Molybdenum	0.800	All unspecified compounds
	0.050	Molybdenum sulphide
Technetium	0.800	All compounds
Ruthenium	0.050	All compounds
Rhodium	0.050	All compounds
Palladium	0.005	All compounds
Silver	0.050	All compounds
Cadmium	0.050	All inorganic compounds
Indium	0.020	All compounds
Tin	0.020	All compounds
Antimony	0.100	All compounds
Tellurium	0.300	All compounds
Iodine	1.000	All compounds
Caesium	1.000	All compounds
Barium	0.100	All compounds
Lanthanum	5.0×10^{-4}	All compounds
Cerium	5.0×10^{-4}	All compounds
Praseodymium	5.0×10^{-4}	All compounds
Neodymium	5.0×10^{-4}	All compounds

TABLE II-IV. (cont.)

Element	Gut transfer factor f_1	Compounds
Promethium	5.0×10^{-4}	All compounds
Samarium	5.0×10^{-4}	All compounds
Europium	5.0×10^{-4}	All compounds
Gadolinium	5.0×10^{-4}	All compounds
Terbium	5.0×10^{-4}	All compounds
Dysprosium	5.0×10^{-4}	All compounds
Holmium	5.0×10^{-4}	All compounds
Erbium	5.0×10^{-4}	All compounds
Thulium	5.0×10^{-4}	All compounds
Ytterbium	5.0×10^{-4}	All compounds
Lutetium	5.0×10^{-4}	All compounds
Hafnium	0.002	All compounds
Tantalum	0.001	All compounds
Tungsten	0.300	All unspecified compounds
	0.010	Tungstic acid
Rhenium	0.800	All compounds
Osmium	0.010	All compounds
Iridium	0.010	All compounds
Platinum	0.010	All compounds
Gold	0.100	All compounds
Mercury	0.020	All inorganic compounds
Mercury	1.000	Methyl mercury
	0.400	All unspecified organic compounds
Thallium	1.000	All compounds
Lead	0.200	All compounds
Bismuth	0.050	All compounds
Polonium	0.100	All compounds
Astatine	1.000	All compounds
Francium	1.000	All compounds
Radium	0.200	All compounds

TABLE II-IV. (cont.)

Element	Gut transfer factor f_1	Compounds
Actinium	5.0×10^{-4}	All compounds
Thorium	5.0×10^{-4}	All unspecified compounds
	2.0×10^{-4}	Oxides and hydroxides
Protactinium	5.0×10^{-4}	All compounds
Uranium	0.020	All unspecified compounds
	0.002	Most tetravalent compounds, e.g., UO_2, U_3O_8, UF_4
Neptunium	5.0×10^{-4}	All compounds
Plutonium	5.0×10^{-4}	All unspecified compounds
	1.0×10^{-4}	Nitrates
	1.0×10^{-5}	Insoluble oxides
Americium	5.0×10^{-4}	All compounds
Curium	5.0×10^{-4}	All compounds
Berkelium	5.0×10^{-4}	All compounds
Californium	5.0×10^{-4}	All compounds
Einsteinium	5.0×10^{-4}	All compounds
Fermium	5.0×10^{-4}	All compounds
Mendelevium	5.0×10^{-4}	All compounds

TABLE II-V. COMPOUNDS, LUNG ABSORPTION TYPES AND VALUES OF GUT TRANSFER FACTOR f_1 USED TO CALCULATE COMMITTED EFFECTIVE DOSE PER UNIT INTAKE VIA INHALATION FOR WORKERS

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Beryllium	M	0.005	All unspecified compounds
	S	0.005	Oxides, halides and nitrates
Fluorine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
	S	1.000	Determined by combining cation
Sodium	F	1.000	All compounds
Magnesium	F	0.500	All unspecified compounds
	M	0.500	Oxides, hydroxides, carbides, halides and nitrates
Aluminium	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides, halides, nitrates and metallic aluminium
Silicon	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides and nitrates
	S	0.010	Aluminosilicate glass aerosol
Phosphorus	F	0.800	All unspecified compounds
	M	0.800	Some phosphates: determined by combining cation
Sulphur	F	0.800	Sulphides and sulphates: determined by combining cation
	M	0.800	Elemental sulphur. Sulphides and sulphates: determined by combining cation
Chlorine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
Potassium	F	1.000	All compounds
Calcium	M	0.300	All compounds
Scandium	S	1.0×10^{-4}	All compounds
Titanium	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides, halides and nitrates
	S	0.010	Strontium titanate ($SrTiO_3$)
Vanadium	F	0.010	All unspecified compounds
	M	0.010	Oxides, hydroxides, carbides and halides
Chromium	F	0.100	All unspecified compounds
	M	0.100	Halides and nitrates
	S	0.100	Oxides and hydroxides

Note: Types F, M and S denote fast, moderate and slow absorption from the lung, respectively.

TABLE II-V. (cont.)

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Manganese	F	0.100	All unspecified compounds
	M	0.100	Oxides, hydroxides, halides and nitrates
Iron	F	0.100	All unspecified compounds
	M	0.100	Oxides, hydroxides and halides
Cobalt	M	0.100	All unspecified compounds
	S	0.050	Oxides, hydroxides, halides and nitrates
Nickel	F	0.050	All unspecified compounds
	M	0.050	Oxides, hydroxides and carbides
Copper	F	0.500	All unspecified inorganic compounds
	M	0.500	Sulphides, halides and nitrates
	S	0.500	Oxides and hydroxides
Zinc	S	0.500	All compounds
Gallium	F	0.001	All unspecified compounds
	M	0.001	Oxides, hydroxides, carbides, halides and nitrates
Germanium	F	1.000	All unspecified compounds
	M	1.000	Oxides, sulphides and halides
Arsenic	M	0.500	All compounds
Selenium	F	0.800	All unspecified inorganic compounds
	M	0.800	Elemental selenium, oxides, hydroxides and carbides
Bromine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
Rubidium	F	1.000	All compounds
Strontium	F	0.300	All unspecified compounds
	S	0.010	Strontium titanate ($SrTiO_3$)
Yttrium	M	1.0×10^{-4}	All unspecified compounds
	S	1.0×10^{-4}	Oxides and hydroxides
Zirconium	F	0.002	All unspecified compounds
	M	0.002	Oxides, hydroxides, halides and nitrates
	S	0.002	Zirconium carbide
Niobium	M	0.010	All unspecified compounds
	S	0.010	Oxides and hydroxides
Molybdenum	F	0.800	All unspecified compounds
	S	0.050	Molybdenum sulphide, oxides and hydroxides
Technetium	F	0.800	All unspecified compounds
	M	0.800	Oxides, hydroxides, halides and nitrates

TABLE II-V. (cont.)

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Ruthenium	F	0.050	All unspecified compounds
	M	0.050	Halides
	S	0.050	Oxides and hydroxides
Rhodium	F	0.050	All unspecified compounds
	M	0.050	Halides
	S	0.050	Oxides and hydroxides
Palladium	F	0.005	All unspecified compounds
	M	0.005	Nitrates and halides
	S	0.005	Oxides and hydroxides
Silver	F	0.050	All unspecified compounds and metallic silver
	M	0.050	Nitrates and sulphides
	S	0.050	Oxides, hydroxides and carbides
Cadmium	F	0.050	All unspecified compounds
	M	0.050	Sulphides, halides and nitrates
	S	0.050	Oxides and hydroxides
Indium	F	0.020	All unspecified compounds
	M	0.020	Oxides, hydroxides, halides and nitrates
Tin	F	0.020	All unspecified compounds
	M	0.020	Stannic phosphate, sulphides, oxides, hydroxides, halides and nitrates
Antimony	F	0.100	All unspecified compounds
	M	0.010	Oxides, hydroxides, halides, sulphides, sulphates and nitrates
Tellurium	F	0.300	All unspecified compounds
	M	0.300	Oxides, hydroxides and nitrates
Iodine	F	1.000	All compounds
Caesium	F	1.000	All compounds
Barium	F	0.100	All compounds
Lanthanum	F	5.0×10^{-4}	All unspecified compounds
	M	5.0×10^{-4}	Oxides and hydroxides
Cerium	M	5.0×10^{-4}	All unspecified compounds
	S	5.0×10^{-4}	Oxides, hydroxides and fluorides
Praseodymium	M	5.0×10^{-4}	All unspecified compounds
	S	5.0×10^{-4}	Oxides, hydroxides, carbides and fluorides
Neodymium	M	5.0×10^{-4}	All unspecified compounds
	S	5.0×10^{-4}	Oxides, hydroxides, carbides and fluorides

TABLE II-V. (cont.)

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Promethium	M	5.0×10^{-4}	All unspecified compounds
	S	5.0×10^{-4}	Oxides, hydroxides, carbides and fluorides
Samarium	M	5.0×10^{-4}	All compounds
Europium	M	5.0×10^{-4}	All compounds
Gadolinium	F	5.0×10^{-4}	All unspecified compounds
	M	5.0×10^{-4}	Oxides, hydroxides and fluorides
Terbium	M	5.0×10^{-4}	All compounds
Dysprosium	M	5.0×10^{-4}	All compounds
Holmium	M	5.0×10^{-4}	All unspecified compounds
Erbium	M	5.0×10^{-4}	All compounds
Thulium	M	5.0×10^{-4}	All compounds
Ytterbium	M	5.0×10^{-4}	All unspecified compounds
	S	5.0×10^{-4}	Oxides, hydroxides and fluorides
Lutetium	M	5.0×10^{-4}	All unspecified compounds
	S	5.0×10^{-4}	Oxides, hydroxides and fluorides
Hafnium	F	0.002	All unspecified compounds
	M	0.002	Oxides, hydroxides, halides, carbides and nitrates
Tantalum	M	0.001	All unspecified compounds
	S	0.001	Elemental tantalum, oxides, hydroxides, halides, carbides, nitrates and nitrides
Tungsten	F	0.300	All compounds
Rhenium	F	0.800	All unspecified compounds
	M	0.800	Oxides, hydroxides, halides and nitrates
Osmium	F	0.010	All unspecified compounds
	M	0.010	Halides and nitrates
	S	0.010	Oxides and hydroxides
Iridium	F	0.010	All unspecified compounds
	M	0.010	Metallic iridium, halides and nitrates
	S	0.010	Oxides and hydroxides
Platinum	F	0.010	All compounds
Gold	F	0.100	All unspecified compounds
	M	0.100	Halides and nitrates
	S	0.100	Oxides and hydroxides
Mercury	F	0.020	Sulphates
	M	0.020	Oxides, hydroxides, halides, nitrates and sulphides

TABLE II-V. (cont.)

Element	Absorption type(s)	Gut transfer factor f_1	Compounds
Mercury	F	0.400	All organic compounds
Thallium	F	1.000	All compounds
Lead	F	0.200	All compounds
Bismuth	F	0.050	Bismuth nitrate
	M	0.050	All unspecified compounds
Polonium	F	0.100	All unspecified compounds
	M	0.100	Oxides, hydroxides and nitrates
Astatine	F	1.000	Determined by combining cation
	M	1.000	Determined by combining cation
Francium	F	1.000	All compounds
Radium	M	0.200	All compounds
Actinium	F	5.0×10^{-4}	All unspecified compounds
	M	5.0×10^{-4}	Halides and nitrates
	S	5.0×10^{-4}	Oxides and hydroxides
Thorium	M	5.0×10^{-4}	All unspecified compounds
	S	2.0×10^{-4}	Oxides and hydroxides
Protactinium	M	5.0×10^{-4}	All unspecified compounds
	S	5.0×10^{-4}	Oxides and hydroxides
Uranium	F	0.020	Most hexavalent compounds, e.g., UF_6 , UO_2F_2 and $UO_2(NO_3)_2$
	M	0.020	Less soluble compounds, e.g., UO_3, UF_4, UCl_4 and most other hexavalent compounds
	S	0.002	Highly insoluble compounds, e.g., UO_2 and U_3O_8
Neptunium	M	5.0×10^{-4}	All compounds
Plutonium	M	5.0×10^{-4}	All unspecified compounds
	S	1.0×10^{-5}	Insoluble oxides
Americium	M	5.0×10^{-4}	All compounds
Curium	M	5.0×10^{-4}	All compounds
Berkelium	M	5.0×10^{-4}	All compounds
Californium	M	5.0×10^{-4}	All compounds
Einsteinium	M	5.0×10^{-4}	All compounds
Fermium	M	5.0×10^{-4}	All compounds
Mendelevium	M	5.0×10^{-4}	All compounds

TABLE II-VI. INGESTION: COMMITTED EFFECTIVE DOSE PER UNIT INTAKE e(g) VIA INGESTION ($Sv \cdot Bq^{-1}$) FOR MEMBERS OF THE PUBLIC

Nuclide	Physical half-life	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
		f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Hydrogen									
Tritiated water	12.3 a	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}
OBT[a]	12.3 a	1.000	1.2×10^{-10}	1.000	1.2×10^{-10}	7.3×10^{-11}	5.7×10^{-11}	4.2×10^{-11}	4.2×10^{-11}
Beryllium									
Be-7	53.3 d	0.020	1.8×10^{-10}	0.005	1.3×10^{-10}	7.7×10^{-11}	5.3×10^{-11}	3.5×10^{-11}	2.8×10^{-11}
Be-10	1.60×10^{6} a	0.020	1.4×10^{-8}	0.005	8.0×10^{-9}	4.1×10^{-9}	2.4×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Carbon									
C-11	0.340 h	1.000	2.6×10^{-10}	1.000	1.5×10^{-10}	7.3×10^{-11}	4.3×10^{-11}	3.0×10^{-11}	2.4×10^{-11}
C-14	5.73×10^{3} a	1.000	1.4×10^{-9}	1.000	1.6×10^{-9}	9.9×10^{-10}	8.0×10^{-10}	5.7×10^{-10}	5.8×10^{-10}
Fluorine									
F-18	1.83 h	1.000	5.2×10^{-10}	1.000	3.0×10^{-10}	1.5×10^{-10}	9.1×10^{-11}	6.2×10^{-11}	4.9×10^{-11}
Sodium									
Na-22	2.60 a	1.000	2.1×10^{-8}	1.000	1.5×10^{-8}	8.4×10^{-9}	5.5×10^{-9}	3.7×10^{-9}	3.2×10^{-9}
Na-24	15.0 h	1.000	3.5×10^{-9}	1.000	2.3×10^{-9}	1.2×10^{-9}	7.7×10^{-10}	5.2×10^{-10}	4.3×10^{-10}
Magnesium									
Mg-28	20.9 h	1.000	1.2×10^{-8}	0.500	1.4×10^{-8}	7.4×10^{-9}	4.5×10^{-9}	2.7×10^{-9}	2.2×10^{-9}
Aluminium									
Al-26	7.16×10^{5} a	0.020	3.4×10^{-8}	0.010	2.1×10^{-8}	1.1×10^{-8}	7.1×10^{-9}	4.3×10^{-9}	3.5×10^{-9}

[a] OBT: organically bound tritium.

Silicon									
Si-31	2.62 h	0.020	1.9×10^{-9}	0.010	1.0×10^{-9}	5.1×10^{-10}	3.0×10^{-10}	1.8×10^{-10}	1.6×10^{-10}
Si-32	4.50×10^{2} a	0.020	7.3×10^{-9}	0.010	4.1×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	7.0×10^{-10}	5.6×10^{-10}
Phosphorus									
P-32	14.3 d	1.000	3.1×10^{-8}	0.800	1.9×10^{-8}	9.4×10^{-9}	5.3×10^{-9}	3.1×10^{-9}	2.4×10^{-9}
P-33	25.4 d	1.000	2.7×10^{-9}	0.800	1.8×10^{-9}	9.1×10^{-10}	5.3×10^{-10}	3.1×10^{-10}	2.4×10^{-10}
Sulphur									
S-35 (inorganic)	87.4 d	1.000	1.3×10^{-9}	1.000	8.7×10^{-10}	4.4×10^{-10}	2.7×10^{-10}	1.6×10^{-10}	1.3×10^{-10}
S-35 (organic)	87.4 d	1.000	7.7×10^{-9}	1.000	5.4×10^{-9}	2.7×10^{-9}	1.6×10^{-9}	9.5×10^{-10}	7.7×10^{-10}
Chlorine									
Cl-36	3.01×10^{5} a	1.000	9.8×10^{-9}	1.000	6.3×10^{-9}	3.2×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	9.3×10^{-10}
Cl-38	0.620 h	1.000	1.4×10^{-9}	1.000	7.7×10^{-10}	3.8×10^{-10}	2.2×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Cl-39	0.927 h	1.000	9.7×10^{-10}	1.000	5.5×10^{-10}	2.7×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	8.5×10^{-11}
Potassium									
K-40	1.28×10^{9} a	1.000	6.2×10^{-8}	1.000	4.2×10^{-8}	2.1×10^{-8}	1.3×10^{-8}	7.6×10^{-9}	6.2×10^{-9}
K-42	12.4 h	1.000	5.1×10^{-9}	1.000	3.0×10^{-9}	1.5×10^{-9}	8.6×10^{-10}	5.4×10^{-10}	4.3×10^{-10}
K-43	22.6 h	1.000	2.3×10^{-9}	1.000	1.4×10^{-9}	7.6×10^{-10}	4.7×10^{-10}	3.0×10^{-10}	2.5×10^{-10}
K-44	0.369 h	1.000	1.0×10^{-9}	1.000	5.5×10^{-10}	2.7×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	8.4×10^{-11}
K-45	0.333 h	1.000	6.2×10^{-10}	1.000	3.5×10^{-10}	1.7×10^{-10}	9.9×10^{-11}	6.8×10^{-11}	5.4×10^{-11}
Calcium[a]									
Ca-41	1.40×10^{5} a	0.600	1.2×10^{-9}	0.300	5.2×10^{-10}	3.9×10^{-10}	4.8×10^{-10}	5.0×10^{-10}	1.9×10^{-10}
Ca-45	163 d	0.600	1.1×10^{-8}	0.300	4.9×10^{-9}	2.6×10^{-9}	1.8×10^{-9}	1.3×10^{-9}	7.1×10^{-10}
Ca-47	4.53 d	0.600	1.3×10^{-8}	0.300	9.3×10^{-9}	4.9×10^{-9}	3.0×10^{-9}	1.8×10^{-9}	1.6×10^{-9}

[a] The f_1 value for calcium for 1 to 15 year olds is 0.4.

TABLE II-VI. (cont.)

Nuclide	Physical half-life	Age g ≤ 1 a		f_1 for	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
		f_1	e(g)	g > 1 a	e(g)	e(g)	e(g)	e(g)	e(g)
Scandium									
Sc-43	3.89 h	0.001	1.8×10^{-9}	1.0×10^{-4}	1.2×10^{-9}	6.1×10^{-10}	3.7×10^{-10}	2.3×10^{-10}	1.9×10^{-10}
Sc-44	3.93 h	0.001	3.5×10^{-9}	1.0×10^{-4}	2.2×10^{-9}	1.2×10^{-9}	7.1×10^{-10}	4.4×10^{-10}	3.5×10^{-10}
Sc-44m	2.44 d	0.001	24×10^{-8}	1.0×10^{-4}	1.6×10^{-8}	8.3×10^{-9}	5.1×10^{-9}	3.1×10^{-9}	2.4×10^{-9}
Sc-46	83.8 d	0.001	1.1×10^{-8}	1.0×10^{-4}	7.9×10^{-9}	4.4×10^{-9}	2.9×10^{-9}	1.8×10^{-9}	1.5×10^{-9}
Sc-47	3.35 d	0.001	6.1×10^{-9}	1.0×10^{-4}	3.9×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	6.8×10^{-10}	5.4×10^{-10}
Sc-48	1.82 d	0.001	1.3×10^{-8}	1.0×10^{-4}	9.3×10^{-9}	5.1×10^{-9}	3.3×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
Sc-49	0.956 h	0.001	1.0×10^{-9}	1.0×10^{-4}	5.7×10^{-10}	2.8×10^{-10}	1.6×10^{-10}	1.0×10^{-10}	8.2×10^{-11}
Titanium									
Ti-44	47.3 a	0.020	5.5×10^{-8}	0.010	3.1×10^{-8}	1.7×10^{-8}	1.1×10^{-8}	6.9×10^{-9}	5.8×10^{-9}
Ti-45	3.08 h	0.020	1.6×10^{-9}	0.010	9.8×10^{-10}	5.0×10^{-10}	3.1×10^{-10}	1.9×10^{-10}	1.5×10^{-10}
Vanadium									
V-47	0.543 h	0.020	7.3×10^{-10}	0.010	4.1×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	8.0×10^{-11}	6.3×10^{-11}
V-48	16.2 d	0.020	1.5×10^{-8}	0.010	1.1×10^{-8}	5.9×10^{-9}	3.9×10^{-9}	2.5×10^{-9}	2.0×10^{-9}
V-49	330 d	0.020	2.2×10^{-10}	0.010	1.4×10^{-10}	6.9×10^{-11}	4.0×10^{-11}	2.3×10^{-11}	1.8×10^{-11}
Chromium									
Cr-48	23.0 h	0.200	1.4×10^{-9}	0.100	9.9×10^{-10}	5.7×10^{-10}	3.8×10^{-10}	2.5×10^{-10}	2.0×10^{-10}
		0.020	1.4×10^{-9}	0.010	9.9×10^{-10}	5.7×10^{-10}	3.8×10^{-10}	2.5×10^{-10}	2.0×10^{-10}
Cr-49	0.702 h	0.200	6.8×10^{-10}	0.100	3.9×10^{-10}	2.0×10^{-10}	1.1×10^{-10}	7.7×10^{-11}	6.1×10^{-11}
		0.020	6.8×10^{-10}	0.010	3.9×10^{-10}	2.0×10^{-10}	1.1×10^{-10}	7.7×10^{-11}	6.1×10^{-11}
Cr-51	27.7 d	0.200	3.5×10^{-10}	0.100	2.3×10^{-10}	1.2×10^{-10}	7.8×10^{-11}	4.8×10^{-11}	3.8×10^{-11}
		0.200	3.3×10^{-10}	0.010	2.2×10^{-10}	1.2×10^{-10}	7.5×10^{-11}	4.6×10^{-11}	3.7×10^{-11}

Manganese									
Mn-51	0.770 h	0.200	1.1×10^{-9}	0.100	6.1×10^{-10}	3.0×10^{-10}	1.8×10^{-10}	1.2×10^{-10}	9.3×10^{-11}
Mn-52	5.59 d	0.200	1.2×10^{-8}	0.100	8.8×10^{-9}	5.1×10^{-9}	3.4×10^{-9}	2.2×10^{-9}	1.8×10^{-9}
Mn-52m	0.352 h	0.200	7.8×10^{-10}	0.100	4.4×10^{-10}	2.2×10^{-10}	1.3×10^{-10}	8.8×10^{-11}	6.9×10^{-11}
Mn-53	3.70×10^{6} a	0.200	4.1×10^{-10}	0.100	2.2×10^{-10}	1.1×10^{-10}	6.5×10^{-11}	3.7×10^{-11}	3.0×10^{-11}
Mn-54	312 d	0.200	5.4×10^{-9}	0.100	3.1×10^{-9}	1.9×10^{-9}	1.3×10^{-9}	8.7×10^{-10}	7.1×10^{-10}
Mn-56	2.58 h	0.200	2.7×10^{-9}	0.100	1.7×10^{-9}	8.5×10^{-10}	5.1×10^{-10}	3.2×10^{-10}	2.5×10^{-10}
Iron[a]									
Fe-52	8.28 h	0.600	1.3×10^{-8}	0.100	9.1×10^{-9}	4.6×10^{-9}	2.8×10^{-9}	1.7×10^{-9}	1.4×10^{-9}
Fe-55	2.70 a	0.600	7.6×10^{-9}	0.100	2.4×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	7.7×10^{-10}	3.3×10^{-10}
Fe-59	44.5 d	0.600	3.9×10^{-8}	0.100	1.3×10^{-8}	7.5×10^{-9}	4.7×10^{-9}	3.1×10^{-9}	1.8×10^{-9}
Fe-60	1.00×10^{5} a	0.600	7.9×10^{-7}	0.100	2.7×10^{-7}	2.7×10^{-7}	2.5×10^{-7}	2.3×10^{-7}	1.1×10^{-7}
Cobalt[b]									
Co-55	17.5 h	0.600	6.0×10^{-9}	0.100	5.5×10^{-9}	2.9×10^{-9}	1.8×10^{-9}	1.1×10^{-9}	1.0×10^{-9}
Co-56	78.7 d	0.600	2.5×10^{-8}	0.100	1.5×10^{-8}	8.8×10^{-9}	5.8×10^{-9}	3.8×10^{-9}	2.5×10^{-9}
Co-57	271 d	0.600	2.9×10^{-9}	0.100	1.6×10^{-9}	8.9×10^{-10}	5.8×10^{-10}	3.7×10^{-10}	2.1×10^{-10}
Co-58	70.8 d	0.600	7.3×10^{-9}	0.100	4.4×10^{-9}	2.6×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	7.4×10^{-10}
Co-58m	9.15 h	0.600	2.0×10^{-10}	0.100	1.5×10^{-10}	7.8×10^{-11}	4.7×10^{-11}	2.8×10^{-11}	2.4×10^{-11}
Co-60	5.27 a	0.600	5.4×10^{-8}	0.100	2.7×10^{-8}	1.7×10^{-8}	1.1×10^{-8}	7.9×10^{-9}	3.4×10^{-9}
Co-60m	0.174 h	0.600	2.2×10^{-11}	0.100	1.2×10^{-11}	5.7×10^{-12}	3.2×10^{-12}	2.2×10^{-12}	1.7×10^{-12}
Co-61	1.65 h	0.600	8.2×10^{-10}	0.100	5.1×10^{-10}	2.5×10^{-10}	1.4×10^{-10}	9.2×10^{-11}	7.4×10^{-11}
Co-62m	0.232 h	0.600	5.3×10^{-10}	0.100	3.0×10^{-10}	1.5×10^{-10}	8.7×10^{-11}	6.0×10^{-11}	4.7×10^{-11}
Nickel									
Ni-56	6.10 d	0.100	5.3×10^{-9}	0.050	4.0×10^{-9}	2.3×10^{-9}	1.6×10^{-9}	1.1×10^{-9}	8.6×10^{-10}
Ni-57	1.50 d	0.100	6.8×10^{-9}	0.050	4.9×10^{-9}	2.7×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	8.7×10^{-10}

[a] The f_1 value for iron for 1 to 15 year olds is 0.2.
[b] The f_1 value for cobalt for 1 to 15 year olds is 0.3.

TABLE II-VI. (cont.)

Nuclide	Physical half-life	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a e(g)	Age 2–7 a e(g)	Age 7–12 a e(g)	Age 12–17 a e(g)	Age > 17 a e(g)
		f_1	e(g)						
Ni-59	7.50×10^4 a	0.100	6.4×10^{-10}	0.050	3.4×10^{-10}	1.9×10^{-10}	1.1×10^{-10}	7.3×10^{-11}	6.3×10^{-11}
Ni-63	96.0 a	0.100	1.6×10^{-9}	0.050	8.4×10^{-10}	4.6×10^{-10}	2.8×10^{-10}	1.8×10^{-10}	1.5×10^{-10}
Ni-65	2.52 h	0.100	2.1×10^{-9}	0.050	1.3×10^{-9}	6.3×10^{-10}	3.8×10^{-10}	2.3×10^{-10}	1.8×10^{-10}
Ni-66	2.27 d	0.100	3.3×10^{-8}	0.050	2.2×10^{-8}	1.1×10^{-8}	6.6×10^{-9}	3.7×10^{-9}	3.0×10^{-9}
Copper									
Cu-60	0.387 h	1.000	7.0×10^{-10}	0.500	4.2×10^{-10}	2.2×10^{-10}	1.3×10^{-10}	8.9×10^{-11}	7.0×10^{-11}
Cu-61	3.41 h	1.000	7.1×10^{-10}	0.500	7.5×10^{-10}	3.9×10^{-10}	2.3×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Cu-64	12.7 h	1.000	5.2×10^{-10}	0.500	8.3×10^{-10}	4.2×10^{-10}	2.5×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Cu-67	2.58 d	1.000	2.1×10^{-9}	0.500	2.4×10^{-9}	1.2×10^{-9}	7.2×10^{-10}	4.2×10^{-10}	3.4×10^{-10}
Zinc									
Zn-62	9.26 h	1.000	4.2×10^{-9}	0.500	6.5×10^{-9}	3.3×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	9.4×10^{-10}
Zn-63	0.635 h	1.000	8.7×10^{-10}	0.500	5.2×10^{-10}	2.6×10^{-10}	1.5×10^{-10}	1.0×10^{-10}	7.9×10^{-11}
Zn-65	244 d	1.000	3.6×10^{-8}	0.500	1.6×10^{-8}	9.7×10^{-9}	6.4×10^{-9}	4.5×10^{-9}	3.9×10^{-9}
Zn-69	0.950 h	1.000	3.5×10^{-10}	0.500	2.2×10^{-10}	1.1×10^{-10}	6.0×10^{-11}	3.9×10^{-11}	3.1×10^{-11}
Zn-69m	13.8 h	1.000	1.3×10^{-9}	0.500	2.3×10^{-9}	1.2×10^{-9}	7.0×10^{-10}	4.1×10^{-10}	3.3×10^{-10}
Zn-71m	3.92 h	1.000	1.4×10^{-9}	0.500	1.5×10^{-9}	7.8×10^{-10}	4.8×10^{-10}	3.0×10^{-10}	2.4×10^{-10}
Zn-72	1.94 d	1.000	8.7×10^{-9}	0.500	8.6×10^{-9}	4.5×10^{-9}	2.8×10^{-9}	1.7×10^{-9}	1.4×10^{-9}
Gallium									
Ga-65	0.253 h	0.010	4.3×10^{-10}	0.001	2.4×10^{-10}	1.2×10^{-10}	6.9×10^{-11}	4.7×10^{-11}	3.7×10^{-11}
Ga-66	9.40 h	0.010	1.2×10^{-8}	0.001	7.9×10^{-9}	4.0×10^{-9}	2.5×10^{-9}	1.5×10^{-9}	1.2×10^{-9}
Ga-67	3.26 d	0.010	1.8×10^{-9}	0.001	1.2×10^{-9}	6.4×10^{-10}	4.0×10^{-10}	2.4×10^{-10}	1.9×10^{-10}
Ga-68	1.13 h	0.010	1.2×10^{-9}	0.001	6.7×10^{-10}	3.4×10^{-10}	2.0×10^{-10}	1.3×10^{-10}	1.0×10^{-10}
Ga-70	0.353 h	0.010	3.9×10^{-10}	0.001	2.2×10^{-10}	1.0×10^{-10}	5.9×10^{-11}	4.0×10^{-11}	3.1×10^{-11}

Ga-72	14.1 h	0.010	1.0×10^{-8}	0.001	6.8×10^{-9}	3.6×10^{-9}	2.2×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Ga-73	4.91 h	0.010	3.0×10^{-9}	0.001	1.9×10^{-9}	9.3×10^{-10}	5.5×10^{-10}	3.3×10^{-10}	2.6×10^{-10}
Germanium									
Ge-66	2.27 h	1.000	8.3×10^{-10}	1.000	5.3×10^{-10}	2.9×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	1.0×10^{-10}
Ge-67	0.312 h	1.000	7.7×10^{-10}	1.000	4.2×10^{-10}	2.1×10^{-10}	1.2×10^{-10}	8.2×10^{-11}	6.5×10^{-11}
Ge-68	288 d	1.000	1.2×10^{-8}	1.000	8.0×10^{-9}	4.2×10^{-9}	2.6×10^{-9}	1.6×10^{-9}	1.3×10^{-9}
Ge-69	1.63 d	1.000	2.0×10^{-9}	1.000	1.3×10^{-9}	7.1×10^{-10}	4.6×10^{-10}	3.0×10^{-10}	2.4×10^{-10}
Ge-71	11.8 d	1.000	1.2×10^{-10}	1.000	7.8×10^{-11}	4.0×10^{-11}	2.4×10^{-11}	1.5×10^{-11}	1.2×10^{-11}
Ge-75	1.38 h	1.000	5.5×10^{-10}	1.000	3.1×10^{-10}	1.5×10^{-10}	8.7×10^{-11}	5.9×10^{-11}	4.6×10^{-11}
Ge-77	11.3 h	1.000	3.0×10^{-9}	1.000	1.8×10^{-9}	9.9×10^{-10}	6.2×10^{-10}	4.1×10^{-10}	3.3×10^{-10}
Ge-78	1.45 h	1.000	1.2×10^{-9}	1.000	7.0×10^{-10}	3.6×10^{-10}	2.2×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Arsenic									
As-69	0.253 h	1.000	6.6×10^{-10}	0.500	3.7×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	7.2×10^{-11}	5.7×10^{-11}
As-70	0.876 h	1.000	1.2×10^{-9}	0.500	7.8×10^{-10}	4.1×10^{-10}	2.5×10^{-10}	1.7×10^{-10}	1.3×10^{-10}
As-71	2.70 d	1.000	2.8×10^{-9}	0.500	2.8×10^{-9}	1.5×10^{-9}	9.3×10^{-10}	5.7×10^{-10}	4.6×10^{-10}
As-72	1.08 d	1.000	1.1×10^{-8}	0.500	1.2×10^{-8}	6.3×10^{-9}	3.8×10^{-9}	2.3×10^{-9}	1.8×10^{-9}
As-73	80.3 d	1.000	2.6×10^{-9}	0.500	1.9×10^{-9}	9.3×10^{-10}	5.6×10^{-10}	3.2×10^{-10}	2.6×10^{-10}
As-74	17.8 d	1.000	1.0×10^{-8}	0.500	8.2×10^{-9}	4.3×10^{-9}	2.6×10^{-9}	1.6×10^{-9}	1.3×10^{-9}
As-76	1.10 d	1.000	1.0×10^{-8}	0.500	1.1×10^{-8}	5.8×10^{-9}	3.4×10^{-9}	2.0×10^{-9}	1.6×10^{-9}
As-77	1.62 d	1.000	2.7×10^{-9}	0.500	2.9×10^{-9}	1.5×10^{-9}	8.7×10^{-10}	5.0×10^{-10}	4.0×10^{-10}
As-78	1.51 h	1.000	2.0×10^{-9}	0.500	1.4×10^{-9}	7.0×10^{-10}	4.1×10^{-10}	2.7×10^{-10}	2.1×10^{-10}
Selenium									
Se-70	0.683 h	1.000	1.0×10^{-9}	0.800	7.1×10^{-10}	3.6×10^{-10}	2.2×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Se-73	7.15 h	1.000	1.6×10^{-9}	0.800	1.4×10^{-9}	7.4×10^{-10}	4.8×10^{-10}	2.5×10^{-10}	2.1×10^{-10}
Se-73m	0.650 h	1.000	2.6×10^{-10}	0.800	1.8×10^{-10}	9.5×10^{-11}	5.9×10^{-11}	3.5×10^{-11}	2.8×10^{-11}
Se-75	120 d	1.000	2.0×10^{-8}	0.800	1.3×10^{-8}	8.3×10^{-9}	6.0×10^{-9}	3.1×10^{-9}	2.6×10^{-9}
Se-79	6.50×10^{4} a	1.000	4.1×10^{-8}	0.800	2.8×10^{-8}	1.9×10^{-8}	1.4×10^{-8}	4.1×10^{-9}	2.9×10^{-9}

TABLE II-VI. (cont.)

Nuclide	Physical half-life	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
		f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Se-81	0.308 h	1.000	3.4×10^{-10}	0.800	1.9×10^{-10}	9.0×10^{-11}	5.1×10^{-11}	3.4×10^{-11}	2.7×10^{-11}
Se-81m	0.954 h	1.000	6.0×10^{-10}	0.800	3.7×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	6.7×10^{-11}	5.3×10^{-11}
Se-83	0.375 h	1.000	4.6×10^{-10}	0.800	2.9×10^{-10}	1.5×10^{-10}	8.7×10^{-11}	5.9×10^{-11}	4.7×10^{-11}
Bromine									
Br-74	0.422 h	1.000	9.0×10^{-10}	1.000	5.2×10^{-10}	2.6×10^{-10}	1.5×10^{-10}	1.1×10^{-10}	8.4×10^{-11}
Br-74m	0.691 h	1.000	1.5×10^{-9}	1.000	8.5×10^{-10}	4.3×10^{-10}	2.5×10^{-10}	1.7×10^{-10}	1.4×10^{-10}
Br-75	1.63 h	1.000	8.5×10^{-10}	1.000	4.9×10^{-10}	2.5×10^{-10}	1.5×10^{-10}	9.9×10^{-11}	7.9×10^{-11}
Br-76	16.2 h	1.000	4.2×10^{-9}	1.000	2.7×10^{-9}	1.4×10^{-9}	8.7×10^{-10}	5.6×10^{-10}	4.6×10^{-10}
Br-77	2.33 d	1.000	6.3×10^{-10}	1.000	4.4×10^{-10}	2.5×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	9.6×10^{-11}
Br-80	0.290 h	1.000	3.9×10^{-10}	1.000	2.1×10^{-10}	1.0×10^{-10}	5.8×10^{-11}	3.9×10^{-11}	3.1×10^{-11}
Br-80m	4.42 h	1.000	1.4×10^{-9}	1.000	8.0×10^{-10}	3.9×10^{-10}	2.3×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
Br-82	1.47 d	1.000	3.7×10^{-9}	1.000	2.6×10^{-9}	1.5×10^{-9}	9.5×10^{-10}	6.4×10^{-10}	5.4×10^{-10}
Br-83	2.39 h	1.000	5.3×10^{-10}	1.000	3.0×10^{-10}	1.4×10^{-10}	8.3×10^{-11}	5.5×10^{-11}	4.3×10^{-11}
Br-84	0.530 h	1.000	1.0×10^{-9}	1.000	5.8×10^{-10}	2.8×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	8.8×10^{-11}
Rubidium									
Rb-79	0.382 h	1.000	5.7×10^{-10}	1.000	3.2×10^{-10}	1.6×10^{-10}	9.2×10^{-11}	6.3×10^{-11}	5.0×10^{-11}
Rb-81	4.58 h	1.000	5.4×10^{-10}	1.000	3.2×10^{-10}	1.6×10^{-10}	1.0×10^{-10}	6.7×10^{-11}	5.4×10^{-11}
Rb-81m	0.533 h	1.000	1.1×10^{-10}	1.000	6.2×10^{-11}	3.1×10^{-11}	1.8×10^{-11}	1.2×10^{-11}	9.7×10^{-12}
Rb-82m	6.20 h	1.000	8.7×10^{-10}	1.000	5.9×10^{-10}	3.4×10^{-10}	2.2×10^{-10}	1.5×10^{-10}	1.3×10^{-10}
Rb-83	86.2 d	1.000	1.1×10^{-8}	1.000	8.4×10^{-9}	4.9×10^{-9}	3.2×10^{-9}	2.2×10^{-9}	1.9×10^{-9}
Rb-84	32.8 d	1.000	2.0×10^{-8}	1.000	1.4×10^{-8}	7.9×10^{-9}	5.0×10^{-9}	3.3×10^{-9}	2.8×10^{-9}
Rb-86	18.7 d	1.000	3.1×10^{-8}	1.000	2.0×10^{-8}	9.9×10^{-9}	5.9×10^{-9}	3.5×10^{-9}	2.8×10^{-9}
Rb-87	4.70×10^{10} a	1.000	1.5×10^{-8}	1.000	1.0×10^{-8}	5.2×10^{-9}	3.1×10^{-9}	1.8×10^{-9}	1.5×10^{-9}

Rb-88	0.297 h	1.000	1.1×10^{-9}	1.000	6.2×10^{-10}	3.0×10^{-10}	1.7×10^{-10}	1.2×10^{-10}	9.0×10^{-11}
Rb-89	0.253 h	1.000	5.4×10^{-10}	1.000	3.0×10^{-10}	1.5×10^{-10}	8.6×10^{-11}	5.9×10^{-11}	4.7×10^{-11}
Strontium[a]									
Sr-80	1.67 h	0.600	3.7×10^{-9}	0.300	2.3×10^{-9}	1.1×10^{-9}	6.5×10^{-10}	4.2×10^{-10}	3.4×10^{-10}
Sr-81	0.425 h	0.600	8.4×10^{-10}	0.300	4.9×10^{-10}	2.4×10^{-10}	1.4×10^{-10}	9.6×10^{-11}	7.7×10^{-11}
Sr-82	25.0 d	0.600	7.2×10^{-8}	0.300	4.1×10^{-8}	2.1×10^{-8}	1.3×10^{-8}	8.7×10^{-9}	6.1×10^{-9}
Sr-83	1.35 d	0.600	3.4×10^{-9}	0.300	2.7×10^{-9}	1.4×10^{-9}	9.1×10^{-10}	5.7×10^{-10}	4.9×10^{-10}
Sr-85	64.8 d	0.600	7.7×10^{-9}	0.300	3.1×10^{-9}	1.7×10^{-9}	1.5×10^{-9}	1.3×10^{-9}	5.6×10^{-10}
Sr-85m	1.16 h	0.600	4.5×10^{-11}	0.300	3.0×10^{-11}	1.7×10^{-11}	1.1×10^{-11}	7.8×10^{-12}	6.1×10^{-12}
Sr-87m	2.80 h	0.600	2.4×10^{-10}	0.300	1.7×10^{-10}	9.0×10^{-11}	5.6×10^{-11}	3.6×10^{-11}	3.0×10^{-11}
Sr-89	50.5 d	0.600	3.6×10^{-8}	0.300	1.8×10^{-8}	8.9×10^{-9}	5.8×10^{-9}	4.0×10^{-9}	2.6×10^{-9}
Sr-90	29.1 a	0.600	2.3×10^{-7}	0.300	7.3×10^{-8}	4.7×10^{-8}	6.0×10^{-8}	8.0×10^{-8}	2.8×10^{-8}
Sr-91	9.50 h	0.600	5.2×10^{-9}	0.300	4.0×10^{-9}	2.1×10^{-9}	1.2×10^{-9}	7.4×10^{-10}	6.5×10^{-10}
Sr-92	2.71 h	0.600	3.4×10^{-9}	0.300	2.7×10^{-9}	1.4×10^{-9}	8.2×10^{-10}	4.8×10^{-10}	4.3×10^{-10}
Yttrium									
Y-86	14.7 h	0.001	7.6×10^{-9}	1.0×10^{-4}	5.2×10^{-9}	2.9×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	9.6×10^{-10}
Y-86m	0.800 h	0.001	4.5×10^{-10}	1.0×10^{-4}	3.1×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	7.1×10^{-11}	5.6×10^{-11}
Y-87	3.35 d	0.001	4.6×10^{-9}	1.0×10^{-4}	3.2×10^{-9}	1.8×10^{-9}	1.1×10^{-9}	7.0×10^{-10}	5.5×10^{-10}
Y-88	107 d	0.001	8.1×10^{-9}	1.0×10^{-4}	6.0×10^{-9}	3.5×10^{-9}	2.4×10^{-9}	1.6×10^{-9}	1.3×10^{-9}
Y-90	2.67 d	0.001	3.1×10^{-8}	1.0×10^{-4}	2.0×10^{-8}	1.0×10^{-8}	5.9×10^{-9}	3.3×10^{-9}	2.7×10^{-9}
Y-90m	3.19 h	0.001	1.8×10^{-9}	1.0×10^{-4}	1.2×10^{-9}	6.1×10^{-10}	3.7×10^{-10}	2.2×10^{-10}	1.7×10^{-10}
Y-91	58.5 d	0.001	2.8×10^{-8}	1.0×10^{-4}	1.8×10^{-8}	8.8×10^{-9}	5.2×10^{-9}	2.9×10^{-9}	2.4×10^{-9}
Y-91m	0.828 h	0.001	9.2×10^{-11}	1.0×10^{-4}	6.0×10^{-11}	3.3×10^{-11}	2.1×10^{-11}	1.4×10^{-11}	1.1×10^{-11}
Y-92	3.54 h	0.001	5.9×10^{-9}	1.0×10^{-4}	3.6×10^{-9}	1.8×10^{-9}	1.0×10^{-9}	6.2×10^{-10}	4.9×10^{-10}
Y-93	10.1 h	0.001	1.4×10^{-8}	1.0×10^{-4}	8.5×10^{-9}	4.3×10^{-9}	2.5×10^{-9}	1.4×10^{-9}	1.2×10^{-9}

[a] The f_1 value for strontium for 1 to 15 year olds is 0.4.

TABLE II-VI. (cont.)

Nuclide	Physical half-life	Age g ≤ 1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
		f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Y-94	0.318 h	0.001	9.9×10^{-10}	1.0×10^{-4}	5.5×10^{-10}	2.7×10^{-10}	1.5×10^{-10}	1.0×10^{-10}	8.1×10^{-11}
Y-95	0.178 h	0.001	5.7×10^{-10}	1.0×10^{-4}	3.1×10^{-10}	1.5×10^{-10}	8.7×10^{-11}	5.9×10^{-11}	4.6×10^{-11}
Zirconium									
Zr-86	16.5 h	0.020	6.9×10^{-9}	0.010	4.8×10^{-9}	2.7×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	8.6×10^{-10}
Zr-88	83.4 d	0.020	2.8×10^{-9}	0.010	2.0×10^{-9}	1.2×10^{-9}	8.0×10^{-10}	5.4×10^{-10}	4.5×10^{-10}
Zr-89	3.27 d	0.020	6.5×10^{-9}	0.010	4.5×10^{-9}	2.5×10^{-9}	1.6×10^{-9}	9.9×10^{-10}	7.9×10^{-10}
Zr-93	1.53×10^{6} a	0.020	1.2×10^{-9}	0.010	7.6×10^{-10}	5.1×10^{-10}	5.8×10^{-10}	8.6×10^{-10}	1.1×10^{-9}
Zr-95	64.0 d	0.020	8.5×10^{-9}	0.010	5.6×10^{-9}	3.0×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	9.5×10^{-10}
Zr-97	16.9 h	0.020	2.2×10^{-8}	0.010	1.4×10^{-8}	7.3×10^{-9}	4.4×10^{-9}	2.6×10^{-9}	2.1×10^{-9}
Niobium									
Nb-88	0.238 h	0.020	6.7×10^{-10}	0.010	3.8×10^{-10}	1.9×10^{-10}	1.1×10^{-10}	7.9×10^{-11}	6.3×10^{-11}
Nb-89	2.03 h	0.020	3.0×10^{-9}	0.010	2.0×10^{-9}	1.0×10^{-9}	6.0×10^{-10}	3.4×10^{-10}	2.7×10^{-10}
Nb-89	1.10 h	0.020	1.5×10^{-9}	0.010	8.7×10^{-10}	4.4×10^{-10}	2.7×10^{-10}	1.8×10^{-10}	1.4×10^{-10}
Nb-90	14.6 h	0.020	1.1×10^{-8}	0.010	7.2×10^{-9}	3.9×10^{-9}	2.5×10^{-9}	1.6×10^{-9}	1.2×10^{-9}
Nb-93m	13.6 a	0.020	1.5×10^{-9}	0.010	9.1×10^{-10}	4.6×10^{-10}	2.7×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Nb-94	2.03×10^{4} a	0.020	1.5×10^{-8}	0.010	9.7×10^{-9}	5.3×10^{-9}	3.4×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
Nb-95	35.1 d	0.020	4.6×10^{-9}	0.010	3.2×10^{-9}	1.8×10^{-9}	1.1×10^{-9}	7.4×10^{-10}	5.8×10^{-10}
Nb-95m	3.61 d	0.020	6.4×10^{-9}	0.010	4.1×10^{-9}	2.1×10^{-9}	1.2×10^{-9}	7.1×10^{-10}	5.6×10^{-10}
Nb-96	23.3 h	0.020	9.2×10^{-9}	0.010	6.3×10^{-9}	3.4×10^{-9}	2.2×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Nb-97	1.20 h	0.020	7.7×10^{-10}	0.010	4.5×10^{-10}	2.3×10^{-10}	1.3×10^{-10}	8.7×10^{-11}	6.8×10^{-11}
Nb-98	0.858 h	0.020	1.2×10^{-9}	0.010	7.1×10^{-10}	3.6×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	1.1×10^{-10}

Molybdenum									
Mo-90	5.67 h	1.000	1.7×10^{-9}	1.000	1.2×10^{-9}	6.3×10^{-10}	4.0×10^{-10}	2.7×10^{-10}	2.2×10^{-10}
Mo-93	3.50×10^{3} a	1.000	7.9×10^{-9}	1.000	6.9×10^{-9}	5.0×10^{-9}	4.0×10^{-9}	3.4×10^{-9}	3.1×10^{-9}
Mo-93m	6.85 h	1.000	8.0×10^{-10}	1.000	5.4×10^{-10}	3.1×10^{-10}	2.0×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
Mo-99	2.75 d	1.000	5.5×10^{-9}	1.000	3.5×10^{-9}	1.8×10^{-9}	1.1×10^{-9}	7.6×10^{-10}	6.0×10^{-10}
Mo-101	0.244 h	1.000	4.8×10^{-10}	1.000	2.7×10^{-10}	1.3×10^{-10}	7.6×10^{-11}	5.2×10^{-11}	4.1×10^{-11}
Technetium									
Tc-93	2.75 h	1.000	2.7×10^{-10}	0.500	2.5×10^{-10}	1.5×10^{-10}	9.8×10^{-11}	6.8×10^{-11}	5.5×10^{-11}
Tc-93m	0.725 h	1.000	2.0×10^{-10}	0.500	1.3×10^{-10}	7.3×10^{-11}	4.6×10^{-11}	3.2×10^{-11}	2.5×10^{-11}
Tc-94	4.88 h	1.000	1.2×10^{-9}	0.500	1.0×10^{-9}	5.8×10^{-10}	3.7×10^{-10}	2.5×10^{-10}	2.0×10^{-10}
Tc-94m	0.867 h	1.000	1.3×10^{-9}	0.500	6.5×10^{-10}	3.3×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	1.0×10^{-10}
Tc-95	20.0 h	1.000	9.9×10^{-10}	0.500	8.7×10^{-10}	5.0×10^{-10}	3.3×10^{-10}	2.3×10^{-10}	1.8×10^{-10}
Tc-95m	61.0 d	1.000	4.7×10^{-9}	0.500	2.8×10^{-9}	1.6×10^{-9}	1.0×10^{-9}	7.0×10^{-10}	5.6×10^{-10}
Tc-96	4.28 d	1.000	6.7×10^{-9}	0.500	5.1×10^{-9}	3.0×10^{-9}	2.0×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Tc-96m	0.858 h	1.000	1.0×10^{-10}	0.500	6.5×10^{-11}	3.6×10^{-11}	2.3×10^{-11}	1.6×10^{-11}	1.2×10^{-11}
Tc-97	2.60×10^{6} a	1.000	9.9×10^{-10}	0.500	4.9×10^{-10}	2.4×10^{-10}	1.4×10^{-10}	8.8×10^{-11}	6.8×10^{-11}
Tc-97m	87.0 d	1.000	8.7×10^{-9}	0.500	4.1×10^{-9}	2.0×10^{-9}	1.1×10^{-9}	7.0×10^{-10}	5.5×10^{-10}
Tc-98	4.20×10^{6} a	1.000	2.3×10^{-8}	0.500	1.2×10^{-8}	6.1×10^{-9}	3.7×10^{-9}	2.5×10^{-9}	2.0×10^{-9}
Tc-99	2.13×10^{5} a	1.000	1.0×10^{-8}	0.500	4.8×10^{-9}	2.3×10^{-9}	1.3×10^{-9}	8.2×10^{-10}	6.4×10^{-10}
Tc-99m	6.02 h	1.000	2.0×10^{-10}	0.500	1.3×10^{-10}	7.2×10^{-11}	4.3×10^{-11}	2.8×10^{-11}	2.2×10^{-11}
Tc-101	0.237 h	1.000	2.4×10^{-10}	0.500	1.3×10^{-10}	6.1×10^{-11}	3.5×10^{-11}	2.4×10^{-11}	1.9×10^{-11}
Tc-104	0.303 h	1.000	1.0×10^{-9}	0.500	5.3×10^{-10}	2.6×10^{-10}	1.5×10^{-10}	1.0×10^{-10}	8.0×10^{-11}
Ruthenium									
Ru-94	0.863 h	0.100	9.3×10^{-10}	0.050	5.9×10^{-10}	3.1×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	9.4×10^{-11}
Ru-97	2.90 d	0.100	1.2×10^{-9}	0.050	8.5×10^{-10}	4.7×10^{-10}	3.0×10^{-10}	1.9×10^{-10}	1.5×10^{-10}
Ru-103	39.3 d	0.100	7.1×10^{-9}	0.050	4.6×10^{-9}	2.4×10^{-9}	1.5×10^{-9}	9.2×10^{-10}	7.3×10^{-10}
Ru-105	4.44 h	0.100	2.7×10^{-9}	0.050	1.8×10^{-9}	9.1×10^{-10}	5.5×10^{-10}	3.3×10^{-10}	2.6×10^{-10}
Ru-106	1.01 a	0.100	8.4×10^{-8}	0.050	4.9×10^{-8}	2.5×10^{-8}	1.5×10^{-8}	8.6×10^{-9}	7.0×10^{-9}

TABLE II-VI. (cont.)

Nuclide	Physical half-life	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
		f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Rhodium									
Rh-99	16.0 d	0.100	4.2×10^{-9}	0.050	2.9×10^{-9}	1.6×10^{-9}	1.0×10^{-9}	6.5×10^{-10}	5.1×10^{-10}
Rh-99m	4.70 h	0.100	4.9×10^{-10}	0.050	3.5×10^{-10}	2.0×10^{-10}	1.3×10^{-10}	8.3×10^{-11}	6.6×10^{-11}
Rh-100	20.8 h	0.100	4.9×10^{-9}	0.050	3.6×10^{-9}	2.0×10^{-9}	1.4×10^{-9}	8.8×10^{-10}	7.1×10^{-10}
Rh-101	3.20 a	0.100	4.9×10^{-9}	0.050	2.8×10^{-9}	1.6×10^{-9}	1.0×10^{-9}	6.7×10^{-10}	5.5×10^{-10}
Rh-101m	4.34 d	0.100	1.7×10^{-9}	0.050	1.2×10^{-9}	6.8×10^{-10}	4.4×10^{-10}	2.8×10^{-10}	2.2×10^{-10}
Rh-102	2.90 a	0.100	1.9×10^{-8}	0.050	1.0×10^{-8}	6.4×10^{-9}	4.3×10^{-9}	3.0×10^{-9}	2.6×10^{-9}
Rh-102m	207 d	0.100	1.2×10^{-8}	0.050	7.4×10^{-9}	3.9×10^{-9}	2.4×10^{-9}	1.4×10^{-9}	1.2×10^{-9}
Rh-103m	0.935 h	0.100	4.7×10^{-11}	0.050	2.7×10^{-11}	1.3×10^{-11}	7.4×10^{-12}	4.8×10^{-12}	3.8×10^{-12}
Rh-105	1.47 d	0.100	4.0×10^{-9}	0.050	2.7×10^{-9}	1.3×10^{-9}	8.0×10^{-10}	4.6×10^{-10}	3.7×10^{-10}
Rh-106m	2.20 h	0.100	1.4×10^{-9}	0.050	9.7×10^{-10}	5.3×10^{-10}	3.3×10^{-10}	2.0×10^{-10}	1.6×10^{-10}
Rh-107	0.362 h	0.100	2.9×10^{-10}	0.050	1.6×10^{-10}	7.9×10^{-11}	4.5×10^{-11}	3.1×10^{-11}	2.4×10^{-11}
Palladium									
Pd-100	3.63 d	0.050	7.4×10^{-9}	0.005	5.2×10^{-9}	2.9×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	9.4×10^{-10}
Pd-101	8.27 h	0.050	8.2×10^{-10}	0.005	5.7×10^{-10}	3.1×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	9.4×10^{-11}
Pd-103	17.0 d	0.050	2.2×10^{-9}	0.005	1.4×10^{-9}	7.2×10^{-10}	4.3×10^{-10}	2.4×10^{-10}	1.9×10^{-10}
Pd-107	6.50×10^{6} a	0.050	4.4×10^{-10}	0.005	2.8×10^{-10}	1.4×10^{-10}	8.1×10^{-11}	4.6×10^{-11}	3.7×10^{-11}
Pd-109	13.4 h	0.050	6.3×10^{-9}	0.005	4.1×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	6.8×10^{-10}	5.5×10^{-10}
Silver									
Ag-102	0.215 h	0.100	4.2×10^{-10}	0.050	2.4×10^{-10}	1.2×10^{-10}	7.3×10^{-11}	5.0×10^{-11}	4.0×10^{-11}
Ag-103	1.09 h	0.100	4.5×10^{-10}	0.050	2.7×10^{-10}	1.4×10^{-10}	8.3×10^{-11}	5.5×10^{-11}	4.3×10^{-11}
Ag-104	1.15 h	0.100	4.3×10^{-10}	0.050	2.9×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	7.5×10^{-11}	6.0×10^{-11}
Ag-104m	0.558 h	0.100	5.6×10^{-10}	0.050	3.3×10^{-10}	1.7×10^{-10}	1.0×10^{-10}	6.8×10^{-11}	5.4×10^{-11}

Ag-105	41.0 d	0.100	3.9×10^{-9}	0.050	2.5×10^{-9}	1.4×10^{-9}	9.1×10^{-10}	5.9×10^{-10}	4.7×10^{-10}
Ag-106	0.399 h	0.100	3.7×10^{-10}	0.050	2.1×10^{-10}	1.0×10^{-10}	6.0×10^{-11}	4.1×10^{-11}	3.2×10^{-11}
Ag-106m	8.41 d	0.100	9.7×10^{-9}	0.050	6.9×10^{-9}	4.1×10^{-9}	2.8×10^{-9}	1.8×10^{-9}	1.5×10^{-9}
Ag-108m	1.27×10^{2} a	0.100	2.1×10^{-8}	0.050	1.1×10^{-8}	6.5×10^{-9}	4.3×10^{-9}	2.8×10^{-9}	2.3×10^{-9}
Ag-110m	250 d	0.100	2.4×10^{-8}	0.050	1.4×10^{-8}	7.8×10^{-9}	5.2×10^{-9}	3.4×10^{-9}	2.8×10^{-9}
Ag-111	7.45 d	0.100	1.4×10^{-8}	0.050	9.3×10^{-9}	4.6×10^{-9}	2.7×10^{-9}	1.6×10^{-9}	1.3×10^{-9}
Ag-112	3.12 h	0.100	4.9×10^{-9}	0.050	3.0×10^{-9}	1.5×10^{-9}	8.9×10^{-10}	5.4×10^{-10}	4.3×10^{-10}
Ag-115	0.333 h	0.100	7.2×10^{-10}	0.050	4.1×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	7.7×10^{-11}	6.0×10^{-11}
Cadmium									
Cd-104	0.961 h	0.100	4.2×10^{-10}	0.050	2.9×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	7.2×10^{-11}	5.4×10^{-11}
Cd-107	6.49 h	0.100	7.1×10^{-10}	0.050	4.6×10^{-10}	2.3×10^{-10}	1.3×10^{-10}	7.8×10^{-11}	6.2×10^{-11}
Cd-109	1.27 a	0.100	2.1×10^{-8}	0.050	9.5×10^{-9}	5.5×10^{-9}	3.5×10^{-9}	2.4×10^{-9}	2.0×10^{-9}
Cd-113	9.30×10^{15} a	0.100	1.0×10^{-7}	0.050	4.8×10^{-8}	3.7×10^{-8}	3.0×10^{-8}	2.6×10^{-8}	2.5×10^{-8}
Cd-113m	13.6 a	0.100	1.2×10^{-7}	0.050	5.6×10^{-8}	3.9×10^{-8}	2.9×10^{-8}	2.4×10^{-8}	2.3×10^{-8}
Cd-115	2.23 d	0.100	1.4×10^{-8}	0.050	9.7×10^{-9}	4.9×10^{-9}	2.9×10^{-9}	1.7×10^{-9}	1.4×10^{-9}
Cd-115m	44.6 d	0.100	4.1×10^{-8}	0.050	1.9×10^{-8}	9.7×10^{-9}	6.9×10^{-9}	4.1×10^{-9}	3.3×10^{-9}
Cd-117	2.49 h	0.100	2.9×10^{-9}	0.050	1.9×10^{-9}	9.5×10^{-10}	5.7×10^{-10}	3.5×10^{-10}	2.8×10^{-10}
Cd-117m	3.36 h	0.100	2.6×10^{-9}	0.050	1.7×10^{-9}	9.0×10^{-10}	5.6×10^{-10}	3.5×10^{-10}	2.8×10^{-10}
Indium									
In-109	4.20 h	0.040	5.2×10^{-10}	0.020	3.6×10^{-10}	2.0×10^{-10}	1.3×10^{-10}	8.2×10^{-11}	6.6×10^{-11}
In-110	4.90 h	0.040	1.5×10^{-9}	0.020	1.1×10^{-9}	6.5×10^{-10}	4.4×10^{-10}	3.0×10^{-10}	2.4×10^{-10}
In-110	1.15 h	0.040	1.1×10^{-9}	0.020	6.4×10^{-10}	3.2×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	1.0×10^{-10}
In-111	2.83 d	0.040	2.4×10^{-9}	0.020	1.7×10^{-9}	9.1×10^{-10}	5.9×10^{-10}	3.7×10^{-10}	2.9×10^{-10}
In-112	0.240 h	0.040	1.2×10^{-10}	0.020	6.7×10^{-11}	3.3×10^{-11}	1.9×10^{-11}	1.3×10^{-11}	1.0×10^{-11}
In-113m	1.66 h	0.040	3.0×10^{-10}	0.020	1.8×10^{-10}	9.3×10^{-11}	6.2×10^{-11}	3.6×10^{-11}	2.8×10^{-11}
In-114m	49.5 d	0.040	5.6×10^{-8}	0.020	3.1×10^{-8}	1.5×10^{-8}	9.0×10^{-9}	5.2×10^{-9}	4.1×10^{-9}
In-115	5.10×10^{15} a	0.040	1.3×10^{-7}	0.020	6.4×10^{-8}	4.8×10^{-8}	4.3×10^{-8}	3.6×10^{-8}	3.2×10^{-8}

TABLE II-VI. (cont.)

Nuclide	Physical half-life	Age $g \leq 1$ a		f_1 for	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
		f_1	e(g)	$g > 1$ a	e(g)	e(g)	e(g)	e(g)	e(g)
In-115m	4.49 h	0.040	9.6×10^{-10}	0.020	6.0×10^{-10}	3.0×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	8.6×10^{-11}
In-116m	0.902 h	0.040	5.8×10^{-10}	0.020	3.6×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	8.0×10^{-11}	6.4×10^{-11}
In-117	0.730 h	0.040	3.3×10^{-10}	0.020	1.9×10^{-10}	9.7×10^{-11}	5.8×10^{-11}	3.9×10^{-11}	3.1×10^{-11}
In-117m	1.94 h	0.040	1.4×10^{-9}	0.020	8.6×10^{-10}	4.3×10^{-10}	2.5×10^{-10}	1.6×10^{-10}	1.2×10^{-10}
In-119m	0.300 h	0.040	5.9×10^{-10}	0.020	3.2×10^{-10}	1.6×10^{-10}	8.8×10^{-11}	6.0×10^{-11}	4.7×10^{-11}
Tin									
Sn-110	4.00 h	0.040	3.5×10^{-9}	0.020	2.3×10^{-9}	1.2×10^{-9}	7.4×10^{-10}	4.4×10^{-10}	3.5×10^{-10}
Sn-111	0.588 h	0.040	2.5×10^{-10}	0.020	1.5×10^{-10}	7.4×10^{-11}	4.4×10^{-11}	3.0×10^{-11}	2.3×10^{-11}
Sn-113	115 d	0.040	7.8×10^{-9}	0.020	5.0×10^{-9}	2.6×10^{-9}	1.6×10^{-9}	9.2×10^{-10}	7.3×10^{-10}
Sn-117m	13.6 d	0.040	7.7×10^{-9}	0.020	5.0×10^{-9}	2.5×10^{-9}	1.5×10^{-9}	8.8×10^{-10}	7.1×10^{-10}
Sn-119m	293 d	0.040	4.1×10^{-9}	0.020	2.5×10^{-9}	1.3×10^{-9}	7.5×10^{-10}	4.3×10^{-10}	3.4×10^{-10}
Sn-121	1.13 d	0.040	2.6×10^{-9}	0.020	1.7×10^{-9}	8.4×10^{-10}	5.0×10^{-10}	2.8×10^{-10}	2.3×10^{-10}
Sn-121m	55.0 a	0.040	4.6×10^{-9}	0.020	2.7×10^{-9}	1.4×10^{-9}	8.2×10^{-10}	4.7×10^{-10}	3.8×10^{-10}
Sn-123	129 d	0.040	2.5×10^{-8}	0.020	1.6×10^{-8}	7.8×10^{-9}	4.6×10^{-9}	2.6×10^{-9}	2.1×10^{-9}
Sn-123m	0.668 h	0.040	4.7×10^{-10}	0.020	2.6×10^{-10}	1.3×10^{-10}	7.3×10^{-11}	4.9×10^{-11}	3.8×10^{-11}
Sn-125	9.64 d	0.040	3.5×10^{-8}	0.020	2.2×10^{-8}	1.1×10^{-8}	6.7×10^{-9}	3.8×10^{-9}	3.1×10^{-9}
Sn-126	1.00×10^{5} a	0.040	5.0×10^{-8}	0.020	3.0×10^{-8}	1.6×10^{-8}	9.8×10^{-9}	5.9×10^{-9}	4.7×10^{-9}
Sn-127	2.10 h	0.040	2.0×10^{-9}	0.020	1.3×10^{-9}	6.6×10^{-10}	4.0×10^{-10}	2.5×10^{-10}	2.0×10^{-10}
Sn-128	0.985 h	0.040	1.6×10^{-9}	0.020	9.7×10^{-10}	4.9×10^{-10}	3.0×10^{-10}	1.9×10^{-10}	1.5×10^{-10}
Antimony									
Sb-115	0.530 h	0.200	2.5×10^{-10}	0.100	1.5×10^{-10}	7.5×10^{-11}	4.5×10^{-11}	3.1×10^{-11}	2.4×10^{-11}
Sb-116	0.263 h	0.200	2.7×10^{-10}	0.100	1.6×10^{-10}	8.0×10^{-11}	4.8×10^{-11}	3.3×10^{-11}	2.6×10^{-11}
Sb-116m	1.00 h	0.200	5.0×10^{-10}	0.100	3.3×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	8.3×10^{-11}	6.7×10^{-11}

Sb-117	2.80 h	0.200	1.6×10^{-10}	0.100	1.0×10^{-10}	5.6×10^{-11}	3.5×10^{-11}	2.2×10^{-11}	1.8×10^{-11}
Sb-118m	5.00 h	0.200	1.3×10^{-9}	0.100	1.0×10^{-9}	5.8×10^{-10}	3.9×10^{-10}	2.6×10^{-10}	2.1×10^{-10}
Sb-119	1.59 d	0.200	8.4×10^{-10}	0.100	5.8×10^{-10}	3.0×10^{-10}	1.8×10^{-10}	1.0×10^{-10}	8.0×10^{-11}
Sb-120	5.76 d	0.200	8.1×10^{-9}	0.100	6.0×10^{-9}	3.5×10^{-9}	2.3×10^{-9}	1.6×10^{-9}	1.2×10^{-9}
Sb-120	0.265 h	0.200	1.7×10^{-10}	0.100	9.4×10^{-11}	4.6×10^{-11}	2.7×10^{-11}	1.8×10^{-11}	1.4×10^{-11}
Sb-122	2.70 d	0.200	1.8×10^{-8}	0.100	1.2×10^{-8}	6.1×10^{-9}	3.7×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
Sb-124	60.2 d	0.200	2.5×10^{-8}	0.100	1.6×10^{-8}	8.4×10^{-9}	5.2×10^{-9}	3.2×10^{-9}	2.5×10^{-9}
Sb-124m	0.337 h	0.200	8.5×10^{-11}	0.100	4.9×10^{-11}	2.5×10^{-11}	1.5×10^{-11}	1.0×10^{-11}	8.0×10^{-12}
Sb-125	2.77 a	0.200	1.1×10^{-8}	0.100	6.1×10^{-9}	3.4×10^{-9}	2.1×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Sb-126	12.4 d	0.200	2.0×10^{-8}	0.100	1.4×10^{-8}	7.6×10^{-9}	4.9×10^{-9}	3.1×10^{-9}	2.4×10^{-9}
Sb-126m	0.317 h	0.200	3.9×10^{-10}	0.100	2.2×10^{-10}	1.1×10^{-10}	6.6×10^{-11}	4.5×10^{-11}	3.6×10^{-11}
Sb-127	3.85 d	0.200	1.7×10^{-8}	0.100	1.2×10^{-8}	5.9×10^{-9}	3.6×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
Sb-128	9.01 h	0.200	6.3×10^{-9}	0.100	4.5×10^{-9}	2.4×10^{-9}	1.5×10^{-9}	9.5×10^{-10}	7.6×10^{-10}
Sb-128	0.173 h	0.200	3.7×10^{-10}	0.100	2.1×10^{-10}	1.0×10^{-10}	6.0×10^{-11}	4.1×10^{-11}	3.3×10^{-11}
Sb-129	4.32 h	0.200	4.3×10^{-9}	0.100	2.8×10^{-9}	1.5×10^{-9}	8.8×10^{-10}	5.3×10^{-10}	4.2×10^{-10}
Sb-130	0.667 h	0.200	9.1×10^{-10}	0.100	5.4×10^{-10}	2.8×10^{-10}	1.7×10^{-10}	1.2×10^{-10}	9.1×10^{-11}
Sb-131	0.383 h	0.200	1.1×10^{-9}	0.100	7.3×10^{-10}	3.9×10^{-10}	2.1×10^{-10}	1.4×10^{-10}	1.0×10^{-10}
Tellurium									
Te-116	2.49 h	0.600	1.4×10^{-9}	0.300	1.0×10^{-9}	5.5×10^{-10}	3.4×10^{-10}	2.1×10^{-10}	1.7×10^{-10}
Te-121	17.0 d	0.600	3.1×10^{-9}	0.300	2.0×10^{-9}	1.2×10^{-9}	8.0×10^{-10}	5.4×10^{-10}	4.3×10^{-10}
Te-121m	154 d	0.600	2.7×10^{-8}	0.300	1.2×10^{-8}	6.9×10^{-9}	4.2×10^{-9}	2.8×10^{-9}	2.3×10^{-9}
Te-123	1.00×10^{13} a	0.600	2.0×10^{-8}	0.300	9.3×10^{-9}	6.9×10^{-9}	5.4×10^{-9}	4.7×10^{-9}	4.4×10^{-9}
Te-123m	120 d	0.600	1.9×10^{-8}	0.300	8.8×10^{-9}	4.9×10^{-9}	2.8×10^{-9}	1.7×10^{-9}	1.4×10^{-9}
Te-125m	58.0 d	0.600	1.3×10^{-8}	0.300	6.3×10^{-9}	3.3×10^{-9}	1.9×10^{-9}	1.1×10^{-9}	8.7×10^{-10}
Te-127	9.35 h	0.600	1.5×10^{-9}	0.300	1.2×10^{-9}	6.2×10^{-10}	3.6×10^{-10}	2.1×10^{-10}	1.7×10^{-10}
Te-127m	109 d	0.600	4.1×10^{-8}	0.300	1.8×10^{-8}	9.5×10^{-9}	5.2×10^{-9}	3.0×10^{-9}	2.3×10^{-9}
Te-129	1.16 h	0.600	7.5×10^{-10}	0.300	4.4×10^{-10}	2.1×10^{-10}	1.2×10^{-10}	8.0×10^{-11}	6.3×10^{-11}

TABLE II-VI. (cont.)

Nuclide	Physical half-life	Age g ≤1 a		f_1 for g > 1 a	Age 1-2 a	Age 2-7 a	Age 7-12 a	Age 12-17 a	Age > 17 a
		f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Te-129m	33.6 d	0.600	4.4×10^{-8}	0.300	2.4×10^{-8}	1.2×10^{-8}	6.6×10^{-9}	3.9×10^{-9}	3.0×10^{-9}
Te-131	0.417 h	0.600	9.0×10^{-10}	0.300	6.6×10^{-10}	3.5×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	8.7×10^{-11}
Te-131m	1.25 d	0.600	2.0×10^{-8}	0.300	1.4×10^{-8}	7.8×10^{-9}	4.3×10^{-9}	2.7×10^{-9}	1.9×10^{-9}
Te-132	3.26 d	0.600	4.8×10^{-8}	0.300	3.0×10^{-8}	1.6×10^{-8}	8.3×10^{-9}	5.3×10^{-9}	3.8×10^{-9}
Te-133	0.207 h	0.600	8.4×10^{-10}	0.300	6.3×10^{-10}	3.3×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	7.2×10^{-11}
Te-133m	0.923 h	0.600	3.1×10^{-9}	0.300	2.4×10^{-9}	1.3×10^{-9}	6.3×10^{-10}	4.1×10^{-10}	2.8×10^{-10}
Te-134	0.696 h	0.600	1.1×10^{-9}	0.300	7.5×10^{-10}	3.9×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
Iodine									
I-120	1.35 h	1.000	3.9×10^{-9}	1.000	2.8×10^{-9}	1.4×10^{-9}	7.2×10^{-10}	4.8×10^{-10}	3.4×10^{-10}
I-120m	0.883 h	1.000	2.3×10^{-9}	1.000	1.5×10^{-9}	7.8×10^{-10}	4.2×10^{-10}	2.9×10^{-10}	2.1×10^{-10}
I-121	2.12 h	1.000	6.2×10^{-10}	1.000	5.3×10^{-10}	3.1×10^{-10}	1.7×10^{-10}	1.2×10^{-10}	8.2×10^{-11}
I-123	13.2 h	1.000	2.2×10^{-9}	1.000	1.9×10^{-9}	1.1×10^{-9}	4.9×10^{-10}	3.3×10^{-10}	2.1×10^{-10}
I-124	4.18 d	1.000	1.2×10^{-7}	1.000	1.1×10^{-7}	6.3×10^{-8}	3.1×10^{-8}	2.0×10^{-8}	1.3×10^{-8}
I-125	60.1 d	1.000	5.2×10^{-8}	1.000	5.7×10^{-8}	4.1×10^{-8}	3.1×10^{-8}	2.2×10^{-8}	1.5×10^{-8}
I-126	13.0 d	1.000	2.1×10^{-7}	1.000	2.1×10^{-7}	1.3×10^{-7}	6.8×10^{-8}	4.5×10^{-8}	2.9×10^{-8}
I-128	0.416 h	1.000	5.7×10^{-10}	1.000	3.3×10^{-10}	1.6×10^{-10}	8.9×10^{-11}	6.0×10^{-11}	4.6×10^{-11}
I-129	1.57×10^{7} a	1.000	1.8×10^{-7}	1.000	2.2×10^{-7}	1.7×10^{-7}	1.9×10^{-7}	1.4×10^{-7}	1.1×10^{-7}
I-130	12.4 h	1.000	2.1×10^{-8}	1.000	1.8×10^{-8}	9.8×10^{-9}	4.6×10^{-9}	3.0×10^{-9}	2.0×10^{-9}
I-131	8.04 d	1.000	1.8×10^{-7}	1.000	1.8×10^{-7}	1.0×10^{-7}	5.2×10^{-8}	3.4×10^{-8}	2.2×10^{-8}
I-132	2.30 h	1.000	3.0×10^{-9}	1.000	2.4×10^{-9}	1.3×10^{-9}	6.2×10^{-10}	4.1×10^{-10}	2.9×10^{-10}
I-132m	1.39 h	1.000	2.4×10^{-9}	1.000	2.0×10^{-9}	1.1×10^{-9}	5.0×10^{-10}	3.3×10^{-10}	2.2×10^{-10}
I-133	20.8 h	1.000	4.9×10^{-8}	1.000	4.4×10^{-8}	2.3×10^{-8}	1.0×10^{-8}	6.8×10^{-9}	4.3×10^{-9}
I-134	0.876 h	1.000	1.1×10^{-9}	1.000	7.5×10^{-10}	3.9×10^{-10}	2.1×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
I-135	6.61 h	1.000	1.0×10^{-8}	1.000	8.9×10^{-9}	4.7×10^{-9}	2.2×10^{-9}	1.4×10^{-9}	9.3×10^{-10}

Caesium									
Cs-125	0.750 h	1.000	3.9×10^{-10}	1.000	2.2×10^{-10}	1.1×10^{-10}	6.5×10^{-11}	4.4×10^{-11}	3.5×10^{-11}
Cs-127	6.25 h	1.000	1.8×10^{-10}	1.000	1.2×10^{-10}	6.6×10^{-11}	4.2×10^{-11}	2.9×10^{-11}	2.4×10^{-11}
Cs-129	1.34 d	1.000	4.4×10^{-10}	1.000	3.0×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	7.2×10^{-11}	6.0×10^{-11}
Cs-130	0.498 h	1.000	3.3×10^{-10}	1.000	1.8×10^{-10}	9.0×10^{-11}	5.2×10^{-11}	3.6×10^{-11}	2.8×10^{-11}
Cs-131	9.69 d	1.000	4.6×10^{-10}	1.000	2.9×10^{-10}	1.6×10^{-10}	1.0×10^{-10}	6.9×10^{-11}	5.8×10^{-11}
Cs-132	6.48 d	1.000	2.7×10^{-9}	1.000	1.8×10^{-9}	1.1×10^{-9}	7.7×10^{-10}	5.7×10^{-10}	5.0×10^{-10}
Cs-134	2.06 a	1.000	2.6×10^{-8}	1.000	1.6×10^{-8}	1.3×10^{-8}	1.4×10^{-8}	1.9×10^{-8}	1.9×10^{-8}
Cs-134m	2.90 h	1.000	2.1×10^{-10}	1.000	1.2×10^{-10}	5.9×10^{-11}	3.5×10^{-11}	2.5×10^{-11}	2.0×10^{-11}
Cs-135	2.30×10^{6} a	1.000	4.1×10^{-9}	1.000	2.3×10^{-9}	1.7×10^{-9}	1.7×10^{-9}	2.0×10^{-9}	2.0×10^{-9}
Cs-135m	0.883 h	1.000	1.3×10^{-10}	1.000	8.6×10^{-11}	4.9×10^{-11}	3.2×10^{-11}	2.3×10^{-11}	1.9×10^{-11}
Cs-136	13.1 d	1.000	1.5×10^{-8}	1.000	9.5×10^{-9}	6.1×10^{-9}	4.4×10^{-9}	3.4×10^{-9}	3.0×10^{-9}
Cs-137	30.0 a	1.000	2.1×10^{-8}	1.000	1.2×10^{-8}	9.6×10^{-9}	1.0×10^{-8}	1.3×10^{-8}	1.3×10^{-8}
Cs-138	0.536 h	1.000	1.1×10^{-9}	1.000	5.9×10^{-10}	2.9×10^{-10}	1.7×10^{-10}	1.2×10^{-10}	9.2×10^{-11}
Barium[a]									
Ba-126	1.61 h	0.600	2.7×10^{-9}	0.200	1.7×10^{-9}	8.5×10^{-10}	5.0×10^{-10}	3.1×10^{-10}	2.6×10^{-10}
Ba-128	2.43 d	0.600	2.0×10^{-8}	0.200	1.7×10^{-8}	9.0×10^{-9}	5.2×10^{-9}	3.0×10^{-9}	2.7×10^{-9}
Ba-131	11.8 d	0.600	4.2×10^{-9}	0.200	2.6×10^{-9}	1.4×10^{-9}	9.4×10^{-10}	6.2×10^{-10}	4.5×10^{-10}
Ba-131m	0.243 h	0.600	5.8×10^{-11}	0.200	3.2×10^{-11}	1.6×10^{-11}	9.3×10^{-12}	6.3×10^{-12}	4.9×10^{-12}
Ba-133	10.7 a	0.600	2.2×10^{-8}	0.200	6.2×10^{-9}	3.9×10^{-9}	4.6×10^{-9}	7.3×10^{-9}	1.5×10^{-9}
Ba-133m	1.62 d	0.600	4.2×10^{-9}	0.200	3.6×10^{-9}	1.8×10^{-9}	1.1×10^{-9}	5.9×10^{-10}	5.4×10^{-10}
Ba-135m	1.20 d	0.600	3.3×10^{-9}	0.200	2.9×10^{-9}	1.5×10^{-9}	8.5×10^{-10}	4.7×10^{-10}	4.3×10^{-10}
Ba-139	1.38 h	0.600	1.4×10^{-9}	0.200	8.4×10^{-10}	4.1×10^{-10}	2.4×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Ba-140	12.7 d	0.600	3.2×10^{-8}	0.200	1.8×10^{-8}	9.2×10^{-9}	5.8×10^{-9}	3.7×10^{-9}	2.6×10^{-9}
Ba-141	0.305 h	0.600	7.6×10^{-10}	0.200	4.7×10^{-10}	2.3×10^{-10}	1.3×10^{-10}	8.6×10^{-11}	7.0×10^{-11}
Ba-142	0.177 h	0.600	3.6×10^{-10}	0.200	2.2×10^{-10}	1.1×10^{-10}	6.6×10^{-11}	4.3×10^{-11}	3.5×10^{-11}

[a] The f_1 value for barium for 1 to 15 year olds is 0.3.

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤ 1 a f_1	Age g ≤ 1 a e(g)	f_1 for g > 1 a	Age 1–2 a e(g)	Age 2–7 a e(g)	Age 7–12 a e(g)	Age 12–17 a e(g)	Age > 17 a e(g)
Te-123	1.00×10^{13} a	F	0.600	1.1×10^{-8}	0.300	9.1×10^{-9}	6.2×10^{-9}	4.8×10^{-9}	4.0×10^{-9}	3.9×10^{-9}
		M	0.200	5.6×10^{-9}	0.100	4.4×10^{-9}	3.0×10^{-9}	2.3×10^{-9}	2.0×10^{-9}	1.9×10^{-9}
		S	0.020	5.3×10^{-9}	0.010	5.0×10^{-9}	3.5×10^{-9}	2.4×10^{-9}	2.1×10^{-9}	2.0×10^{-9}
Te-123m	120 d	F	0.600	9.8×10^{-9}	0.300	6.8×10^{-9}	3.4×10^{-9}	1.9×10^{-9}	1.1×10^{-9}	9.5×10^{-10}
		M	0.200	1.8×10^{-8}	0.100	1.3×10^{-8}	8.0×10^{-9}	5.7×10^{-9}	5.0×10^{-9}	4.0×10^{-9}
		S	0.020	2.0×10^{-8}	0.010	1.6×10^{-8}	9.8×10^{-9}	7.1×10^{-9}	6.3×10^{-9}	5.1×10^{-9}
Te-125m	58.0 d	F	0.600	6.2×10^{-9}	0.300	4.2×10^{-9}	2.0×10^{-9}	1.1×10^{-9}	6.1×10^{-10}	5.1×10^{-10}
		M	0.200	1.5×10^{-8}	0.100	1.1×10^{-8}	6.6×10^{-9}	4.8×10^{-9}	4.3×10^{-9}	3.4×10^{-9}
		S	0.020	1.7×10^{-8}	0.010	1.3×10^{-8}	7.8×10^{-9}	5.8×10^{-9}	5.3×10^{-9}	4.2×10^{-9}
Te-127	9.35 h	F	0.600	4.3×10^{-10}	0.300	3.2×10^{-10}	1.4×10^{-10}	8.5×10^{-11}	4.5×10^{-11}	3.9×10^{-11}
		M	0.200	1.0×10^{-9}	0.100	7.3×10^{-10}	3.6×10^{-10}	2.4×10^{-10}	1.6×10^{-10}	1.3×10^{-10}
		S	0.020	1.2×10^{-9}	0.010	7.9×10^{-10}	3.9×10^{-10}	2.6×10^{-10}	1.7×10^{-10}	1.4×10^{-10}
Te-127m	109 d	F	0.600	2.1×10^{-8}	0.300	1.4×10^{-8}	6.5×10^{-9}	3.5×10^{-9}	2.0×10^{-9}	1.5×10^{-9}
		M	0.200	3.5×10^{-8}	0.100	2.6×10^{-8}	1.5×10^{-8}	1.1×10^{-8}	9.2×10^{-9}	7.4×10^{-9}
		S	0.020	4.1×10^{-8}	0.010	3.3×10^{-8}	2.0×10^{-8}	1.4×10^{-8}	1.2×10^{-8}	9.8×10^{-9}
Te-129	1.16 h	F	0.600	1.8×10^{-10}	0.300	1.2×10^{-10}	5.1×10^{-11}	3.2×10^{-11}	1.9×10^{-11}	1.6×10^{-11}
		M	0.200	3.3×10^{-10}	0.100	2.2×10^{-10}	9.9×10^{-11}	6.5×10^{-11}	4.4×10^{-11}	3.7×10^{-11}
		S	0.020	3.5×10^{-10}	0.010	2.3×10^{-10}	1.0×10^{-10}	6.9×10^{-11}	4.7×10^{-11}	3.9×10^{-11}
Te-129m	33.6 d	F	0.600	2.0×10^{-8}	0.300	1.3×10^{-8}	5.8×10^{-9}	3.1×10^{-9}	1.7×10^{-9}	1.3×10^{-9}
		M	0.200	3.5×10^{-8}	0.100	2.6×10^{-8}	1.4×10^{-8}	9.8×10^{-9}	8.0×10^{-9}	6.6×10^{-9}
		S	0.020	3.8×10^{-8}	0.010	2.9×10^{-8}	1.7×10^{-8}	1.2×10^{-8}	9.6×10^{-9}	7.9×10^{-9}
Te-131	0.417 h	F	0.600	2.3×10^{-10}	0.300	2.0×10^{-10}	9.9×10^{-11}	5.3×10^{-11}	3.3×10^{-11}	2.3×10^{-11}
		M	0.200	2.6×10^{-10}	0.100	1.7×10^{-10}	8.1×10^{-11}	5.2×10^{-11}	3.5×10^{-11}	2.8×10^{-11}
		S	0.020	2.4×10^{-10}	0.010	1.6×10^{-10}	7.4×10^{-11}	4.9×10^{-11}	3.3×10^{-11}	2.8×10^{-11}

Te-131m	1.25 d	F	0.600	8.7×10^{-9}	0.300	7.6×10^{-9}	3.9×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	8.6×10^{-10}
		M	0.200	7.9×10^{-9}	0.100	5.8×10^{-9}	3.0×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	9.4×10^{-10}
		S	0.020	7.0×10^{-9}	0.010	5.1×10^{-9}	2.6×10^{-9}	1.8×10^{-9}	1.1×10^{-9}	9.1×10^{-10}
Te-132	3.26 d	F	0.600	2.2×10^{-8}	0.300	1.8×10^{-8}	8.5×10^{-9}	4.2×10^{-9}	2.6×10^{-9}	1.8×10^{-9}
		M	0.200	1.6×10^{-8}	0.100	1.3×10^{-8}	6.4×10^{-9}	4.0×10^{-9}	2.6×10^{-9}	2.0×10^{-9}
		S	0.020	1.5×10^{-8}	0.010	1.1×10^{-8}	5.8×10^{-9}	3.8×10^{-9}	2.5×10^{-9}	2.0×10^{-9}
Te-133	0.207 h	F	0.600	2.4×10^{-10}	0.300	2.1×10^{-10}	9.6×10^{-11}	4.6×10^{-11}	2.8×10^{-11}	1.9×10^{-11}
		M	0.200	2.0×10^{-10}	0.100	1.3×10^{-10}	6.1×10^{-11}	3.8×10^{-11}	2.4×10^{-11}	2.0×10^{-11}
		S	0.020	1.7×10^{-10}	0.010	1.2×10^{-10}	5.4×10^{-11}	3.5×10^{-11}	2.2×10^{-11}	1.9×10^{-11}
Te-133m	0.923 h	F	0.600	1.0×10^{-9}	0.300	8.9×10^{-10}	4.1×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	8.1×10^{-11}
		M	0.200	8.5×10^{-10}	0.100	5.8×10^{-10}	2.8×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	8.7×10^{-11}
		S	0.020	7.4×10^{-10}	0.010	5.1×10^{-10}	2.5×10^{-10}	1.6×10^{-10}	1.0×10^{-10}	8.4×10^{-11}
Te-134	0.696 h	F	0.600	4.7×10^{-10}	0.300	3.7×10^{-10}	1.8×10^{-10}	1.0×10^{-10}	6.0×10^{-11}	4.7×10^{-11}
		M	0.200	5.5×10^{-10}	0.100	3.9×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	8.1×10^{-11}	6.6×10^{-11}
		S	0.020	5.6×10^{-10}	0.010	4.0×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	8.4×10^{-11}	6.8×10^{-11}
Iodine										
I-120	1.35 h	F	1.000	1.3×10^{-9}	1.000	1.0×10^{-9}	4.8×10^{-10}	2.3×10^{-10}	1.4×10^{-10}	1.0×10^{-10}
		M	0.200	1.1×10^{-9}	0.100	7.3×10^{-10}	3.4×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	1.0×10^{-10}
		S	0.020	1.0×10^{-9}	0.010	6.9×10^{-10}	3.2×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	1.0×10^{-10}
I-120m	0.883 h	F	1.000	8.6×10^{-10}	1.000	6.9×10^{-10}	3.3×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	8.2×10^{-11}
		M	0.200	8.2×10^{-10}	0.100	5.9×10^{-10}	2.9×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	8.7×10^{-11}
		S	0.020	8.2×10^{-10}	0.010	5.8×10^{-10}	2.8×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	8.8×10^{-11}
I-121	2.12 h	F	1.000	2.3×10^{-10}	1.000	2.1×10^{-10}	1.1×10^{-10}	6.0×10^{-11}	3.8×10^{-11}	2.7×10^{-11}
		M	0.200	2.1×10^{-10}	0.100	1.5×10^{-10}	7.8×10^{-11}	4.9×10^{-11}	3.2×10^{-11}	2.5×10^{-11}
		S	0.020	1.9×10^{-10}	0.010	1.4×10^{-10}	7.0×10^{-11}	4.5×10^{-11}	3.0×10^{-11}	2.4×10^{-11}
I-123	13.2 h	F	1.000	8.7×10^{-10}	1.000	7.9×10^{-10}	3.8×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	7.4×10^{-11}
		M	0.200	5.3×10^{-10}	0.100	3.9×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	8.2×10^{-11}	6.4×10^{-11}
		S	0.020	4.3×10^{-10}	0.010	3.2×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	7.6×10^{-11}	6.0×10^{-11}
I-124	4.18 d	F	1.000	4.7×10^{-8}	1.000	4.5×10^{-8}	2.2×10^{-8}	1.1×10^{-8}	6.7×10^{-9}	4.4×10^{-9}
		M	0.200	1.4×10^{-8}	0.100	9.3×10^{-9}	4.6×10^{-9}	2.5×10^{-9}	1.6×10^{-9}	1.2×10^{-9}
		S	0.020	6.2×10^{-9}	0.010	4.4×10^{-9}	2.2×10^{-9}	1.4×10^{-9}	9.4×10^{-10}	7.7×10^{-10}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)	g > 1 a	e(g)	e(g)	e(g)	e(g)	e(g)
I-125	60.1 d	F	1.000	2.0×10^{-8}	1.000	2.3×10^{-8}	1.5×10^{-8}	1.1×10^{-8}	7.2×10^{-9}	5.1×10^{-9}
		M	0.200	6.9×10^{-9}	0.100	5.6×10^{-9}	3.6×10^{-9}	2.6×10^{-9}	1.8×10^{-9}	1.4×10^{-9}
		S	0.020	2.4×10^{-9}	0.010	1.8×10^{-9}	1.0×10^{-9}	6.7×10^{-10}	4.8×10^{-10}	3.8×10^{-10}
I-126	13.0 d	F	1.000	8.1×10^{-8}	1.000	8.3×10^{-8}	4.5×10^{-8}	2.4×10^{-8}	1.5×10^{-8}	9.8×10^{-9}
		M	0.200	2.4×10^{-8}	0.100	1.7×10^{-8}	9.5×10^{-9}	5.5×10^{-9}	3.8×10^{-9}	2.7×10^{-9}
		S	0.020	8.3×10^{-9}	0.010	5.9×10^{-9}	3.3×10^{-9}	2.2×10^{-9}	1.8×10^{-9}	1.4×10^{-9}
I-128	0.416 h	F	1.000	1.5×10^{-10}	1.000	1.1×10^{-10}	4.7×10^{-11}	2.7×10^{-11}	1.6×10^{-11}	1.3×10^{-11}
		M	0.200	1.9×10^{-10}	0.100	1.2×10^{-10}	5.3×10^{-11}	3.4×10^{-11}	2.2×10^{-11}	1.9×10^{-11}
		S	0.020	1.9×10^{-10}	0.010	1.2×10^{-10}	5.4×10^{-11}	3.5×10^{-11}	2.3×10^{-11}	2.0×10^{-11}
I-129	1.57×10^{7} a	F	1.000	7.2×10^{-8}	1.000	8.6×10^{-8}	6.1×10^{-8}	6.7×10^{-8}	4.6×10^{-8}	3.6×10^{-8}
		M	0.200	3.6×10^{-8}	0.100	3.3×10^{-8}	2.4×10^{-8}	2.4×10^{-8}	1.9×10^{-8}	1.5×10^{-8}
		S	0.020	2.9×10^{-8}	0.010	2.6×10^{-8}	1.8×10^{-8}	1.3×10^{-8}	1.1×10^{-8}	9.8×10^{-9}
I-130	12.4 h	F	1.000	8.2×10^{-9}	1.000	7.4×10^{-9}	3.5×10^{-9}	1.6×10^{-9}	1.0×10^{-9}	6.7×10^{-10}
		M	0.200	4.3×10^{-9}	0.100	3.1×10^{-9}	1.5×10^{-9}	9.2×10^{-10}	5.8×10^{-10}	4.5×10^{-10}
		S	0.020	3.3×10^{-9}	0.010	2.4×10^{-9}	1.2×10^{-9}	7.9×10^{-10}	5.1×10^{-10}	4.1×10^{-10}
I-131	8.04 d	F	1.000	7.2×10^{-8}	1.000	7.2×10^{-8}	3.7×10^{-8}	1.9×10^{-8}	1.1×10^{-8}	7.4×10^{-9}
		M	0.200	2.2×10^{-8}	0.100	1.5×10^{-8}	8.2×10^{-9}	4.7×10^{-9}	3.4×10^{-9}	2.4×10^{-9}
		S	0.020	8.8×10^{-9}	0.010	6.2×10^{-9}	3.5×10^{-9}	2.4×10^{-9}	2.0×10^{-9}	1.6×10^{-9}
I-132	2.30 h	F	1.000	1.1×10^{-9}	1.000	9.6×10^{-10}	4.5×10^{-10}	2.2×10^{-10}	1.3×10^{-10}	9.4×10^{-11}
		M	0.200	9.9×10^{-10}	0.100	7.3×10^{-10}	3.6×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
		S	0.020	9.3×10^{-10}	0.010	6.8×10^{-10}	3.4×10^{-10}	2.1×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
I-132m	1.39 h	F	1.000	9.6×10^{-10}	1.000	8.4×10^{-10}	4.0×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	7.9×10^{-11}
		M	0.200	7.2×10^{-10}	0.100	5.3×10^{-10}	2.6×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	8.7×10^{-11}
		S	0.020	6.6×10^{-10}	0.010	4.8×10^{-10}	2.4×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	8.5×10^{-11}

I-133	20.8 h	F	1.000	1.9×10^{-8}	1.000	1.8×10^{-8}	8.3×10^{-9}	3.8×10^{-9}	2.2×10^{-9}	1.5×10^{-9}
		M	0.200	6.6×10^{-9}	0.100	4.4×10^{-9}	2.1×10^{-9}	1.2×10^{-9}	7.4×10^{-10}	5.5×10^{-10}
		S	0.020	3.8×10^{-9}	0.010	2.9×10^{-9}	1.4×10^{-9}	9.0×10^{-10}	5.3×10^{-10}	4.3×10^{-10}
I-134	0.876 h	F	1.000	4.6×10^{-10}	1.000	3.7×10^{-10}	1.8×10^{-10}	9.7×10^{-11}	5.9×10^{-11}	4.5×10^{-11}
		M	0.200	4.8×10^{-10}	0.100	3.4×10^{-10}	1.7×10^{-10}	1.0×10^{-10}	6.7×10^{-11}	5.4×10^{-11}
		S	0.020	4.8×10^{-10}	0.010	3.4×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	6.8×10^{-11}	5.5×10^{-11}
I-135	6.61 h	F	1.000	4.1×10^{-9}	1.000	3.7×10^{-9}	1.7×10^{-9}	7.9×10^{-10}	4.8×10^{-10}	3.2×10^{-10}
		M	0.200	2.2×10^{-9}	0.100	1.6×10^{-9}	7.8×10^{-10}	4.7×10^{-10}	3.0×10^{-10}	2.4×10^{-10}
		S	0.020	1.8×10^{-9}	0.010	1.3×10^{-9}	6.5×10^{-10}	4.2×10^{-10}	2.7×10^{-10}	2.2×10^{-10}
Caesium										
Cs-125	0.750 h	F	1.000	1.2×10^{-10}	1.000	8.3×10^{-11}	3.9×10^{-11}	2.4×10^{-11}	1.4×10^{-11}	1.2×10^{-11}
		M	0.200	2.0×10^{-10}	0.100	1.4×10^{-10}	6.5×10^{-11}	4.2×10^{-11}	2.7×10^{-11}	2.2×10^{-11}
		S	0.020	2.1×10^{-10}	0.010	1.4×10^{-10}	6.8×10^{-11}	4.4×10^{-11}	2.8×10^{-11}	2.3×10^{-11}
Cs-127	6.25 h	F	1.000	1.6×10^{-10}	1.000	1.3×10^{-10}	6.9×10^{-11}	4.2×10^{-11}	2.5×10^{-11}	2.0×10^{-11}
		M	0.200	2.8×10^{-10}	0.100	2.2×10^{-10}	1.1×10^{-10}	7.3×10^{-11}	4.6×10^{-11}	3.6×10^{-11}
		S	0.020	3.0×10^{-10}	0.010	2.3×10^{-10}	1.2×10^{-10}	7.6×10^{-11}	4.8×10^{-11}	3.8×10^{-11}
Cs-129	1.34 d	F	1.000	3.4×10^{-10}	1.000	2.8×10^{-10}	1.4×10^{-10}	8.7×10^{-11}	5.2×10^{-11}	4.2×10^{-11}
		M	0.200	5.7×10^{-10}	0.100	4.6×10^{-10}	2.4×10^{-10}	1.5×10^{-10}	9.1×10^{-11}	7.3×10^{-11}
		S	0.020	6.3×10^{-10}	0.010	4.9×10^{-10}	2.5×10^{-10}	1.6×10^{-10}	9.7×10^{-11}	7.7×10^{-11}
Cs-130	0.498 h	F	1.000	8.3×10^{-11}	1.000	5.6×10^{-11}	2.5×10^{-11}	1.6×10^{-11}	9.4×10^{-12}	7.8×10^{-12}
		M	0.200	1.3×10^{-10}	0.100	8.7×10^{-11}	4.0×10^{-11}	2.5×10^{-11}	1.6×10^{-11}	1.4×10^{-11}
		S	0.020	1.4×10^{-10}	0.010	9.0×10^{-11}	4.1×10^{-11}	2.6×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
Cs-131	9.69 d	F	1.000	2.4×10^{-10}	1.000	1.7×10^{-10}	8.4×10^{-11}	5.3×10^{-11}	3.2×10^{-11}	2.7×10^{-11}
		M	0.200	3.5×10^{-10}	0.100	2.6×10^{-10}	1.4×10^{-10}	8.5×10^{-11}	5.5×10^{-11}	4.4×10^{-11}
		S	0.020	3.8×10^{-10}	0.010	2.8×10^{-10}	1.4×10^{-10}	9.1×10^{-11}	5.9×10^{-11}	4.7×10^{-11}
Cs-132	6.48 d	F	1.000	1.5×10^{-9}	1.000	1.2×10^{-9}	6.4×10^{-10}	4.1×10^{-10}	2.7×10^{-10}	2.3×10^{-10}
		M	0.200	1.9×10^{-9}	0.100	1.5×10^{-9}	8.4×10^{-10}	5.4×10^{-10}	3.7×10^{-10}	2.9×10^{-10}
		S	0.020	2.0×10^{-9}	0.010	1.6×10^{-9}	8.7×10^{-10}	5.6×10^{-10}	3.8×10^{-10}	3.0×10^{-10}
Cs-134	2.06 a	F	1.000	1.1×10^{-8}	1.000	7.3×10^{-9}	5.2×10^{-9}	5.3×10^{-9}	6.3×10^{-9}	6.6×10^{-9}
		M	0.200	3.2×10^{-8}	0.100	2.6×10^{-8}	1.6×10^{-8}	1.2×10^{-8}	1.1×10^{-8}	9.1×10^{-9}
		S	0.020	7.0×10^{-8}	0.010	6.3×10^{-8}	4.1×10^{-8}	2.8×10^{-8}	2.3×10^{-8}	2.0×10^{-8}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for g > 1 a	Age 1-2 a e(g)	Age 2-7 a e(g)	Age 7-12 a e(g)	Age 12-17 a e(g)	Age > 17 a e(g)
			f_1	e(g)						
Cs-134m	2.90 h	F	1.000	1.3×10^{-10}	1.000	8.6×10^{-11}	3.8×10^{-11}	2.5×10^{-11}	1.6×10^{-11}	1.4×10^{-11}
		M	0.200	3.3×10^{-10}	0.100	2.3×10^{-10}	1.2×10^{-10}	8.3×10^{-11}	6.6×10^{-11}	5.4×10^{-11}
		S	0.020	3.6×10^{-10}	0.010	2.5×10^{-10}	1.3×10^{-10}	9.2×10^{-11}	7.4×10^{-11}	6.0×10^{-11}
Cs-135	2.30×10^6 a	F	1.000	1.7×10^{-9}	1.000	9.9×10^{-10}	6.2×10^{-10}	6.1×10^{-10}	6.8×10^{-10}	6.9×10^{-10}
		M	0.200	1.2×10^{-8}	0.100	9.3×10^{-9}	5.7×10^{-9}	4.1×10^{-9}	3.8×10^{-9}	3.1×10^{-9}
		S	0.020	2.7×10^{-8}	0.010	2.4×10^{-8}	1.6×10^{-8}	1.1×10^{-8}	9.5×10^{-9}	8.6×10^{-9}
Cs-135m	0.883 h	F	1.000	9.2×10^{-11}	1.000	7.8×10^{-11}	4.1×10^{-11}	2.4×10^{-11}	1.5×10^{-11}	1.2×10^{-11}
		M	0.200	1.2×10^{-10}	0.100	9.9×10^{-11}	5.2×10^{-11}	3.2×10^{-11}	1.9×10^{-11}	1.5×10^{-11}
		S	0.020	1.2×10^{-10}	0.010	1.0×10^{-10}	5.3×10^{-11}	3.3×10^{-11}	2.0×10^{-11}	1.6×10^{-11}
Cs-136	13.1 d	F	1.000	7.3×10^{-9}	1.000	5.2×10^{-9}	2.9×10^{-9}	2.0×10^{-9}	1.4×10^{-9}	1.2×10^{-9}
		M	0.200	1.3×10^{-8}	0.100	1.0×10^{-8}	6.0×10^{-9}	3.7×10^{-9}	3.1×10^{-9}	2.5×10^{-9}
		S	0.020	1.5×10^{-8}	0.010	1.1×10^{-8}	5.7×10^{-9}	4.1×10^{-9}	3.5×10^{-9}	2.8×10^{-9}
Cs-137	30.0 a	F	1.000	8.8×10^{-9}	1.000	5.4×10^{-9}	3.6×10^{-9}	3.7×10^{-9}	4.4×10^{-9}	4.6×10^{-9}
		M	0.200	3.6×10^{-8}	0.100	2.9×10^{-8}	1.8×10^{-8}	1.3×10^{-8}	1.1×10^{-8}	9.7×10^{-9}
		S	0.020	1.1×10^{-7}	0.010	1.0×10^{-7}	7.0×10^{-8}	4.8×10^{-8}	4.2×10^{-8}	3.9×10^{-8}
Cs-138	0.536 h	F	1.000	2.6×10^{-10}	1.000	1.8×10^{-10}	8.1×10^{-11}	5.0×10^{-11}	2.9×10^{-11}	2.4×10^{-11}
		M	0.200	4.0×10^{-10}	0.100	2.7×10^{-10}	1.3×10^{-10}	7.8×10^{-11}	4.9×10^{-11}	4.1×10^{-11}
		S	0.020	4.2×10^{-10}	0.010	2.8×10^{-10}	1.3×10^{-10}	8.2×10^{-11}	5.1×10^{-11}	4.3×10^{-11}
Barium[a]										
Ba-126	1.61 h	F	0.600	6.7×10^{-10}	0.200	5.2×10^{-10}	2.4×10^{-10}	1.4×10^{-10}	6.9×10^{-11}	7.4×10^{-11}
		M	0.200	1.0×10^{-9}	0.100	7.0×10^{-10}	3.2×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	1.0×10^{-10}
		S	0.020	1.1×10^{-9}	0.010	7.2×10^{-10}	3.3×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	1.1×10^{-10}

[a] The f_1 value for barium for 1 to 15 year olds for Type F is 0.3.

Ba-128	2.43 d	F	0.600	5.9×10^{-9}	0.200	5.4×10^{-9}	2.5×10^{-9}	1.4×10^{-9}	7.4×10^{-10}	7.6×10^{-10}
		M	0.200	1.1×10^{-8}	0.100	7.8×10^{-9}	3.7×10^{-9}	2.4×10^{-9}	1.5×10^{-9}	1.3×10^{-9}
		S	0.020	1.2×10^{-8}	0.010	8.3×10^{-9}	4.0×10^{-9}	2.6×10^{-9}	1.6×10^{-9}	1.4×10^{-9}
Ba-131	11.8 d	F	0.600	2.1×10^{-9}	0.200	1.4×10^{-9}	7.1×10^{-10}	4.7×10^{-10}	3.1×10^{-10}	2.2×10^{-10}
		M	0.200	3.7×10^{-9}	0.100	3.1×10^{-9}	1.6×10^{-9}	1.1×10^{-9}	9.7×10^{-10}	7.6×10^{-10}
		S	0.020	4.0×10^{-9}	0.010	3.0×10^{-9}	1.8×10^{-9}	1.3×10^{-9}	1.1×10^{-9}	8.7×10^{-10}
Ba-131m	0.243 h	F	0.600	2.7×10^{-11}	0.200	2.1×10^{-11}	1.0×10^{-11}	6.7×10^{-12}	4.7×10^{-12}	4.0×10^{-12}
		M	0.200	4.8×10^{-11}	0.100	3.3×10^{-11}	1.7×10^{-11}	1.2×10^{-11}	9.0×10^{-12}	7.4×10^{-12}
		S	0.020	5.0×10^{-11}	0.010	3.5×10^{-11}	1.8×10^{-11}	1.2×10^{-11}	9.5×10^{-12}	7.8×10^{-12}
Ba-133	10.7 a	F	0.600	1.1×10^{-8}	0.200	4.5×10^{-9}	2.6×10^{-9}	3.7×10^{-9}	6.0×10^{-9}	1.5×10^{-9}
		M	0.200	1.5×10^{-8}	0.100	1.0×10^{-8}	6.4×10^{-9}	5.1×10^{-9}	5.5×10^{-9}	3.1×10^{-9}
		S	0.020	3.2×10^{-8}	0.010	2.9×10^{-8}	2.0×10^{-8}	1.3×10^{-8}	1.1×10^{-8}	1.0×10^{-8}
Ba-133m	1.62 d	F	0.600	1.4×10^{-9}	0.200	1.1×10^{-9}	4.9×10^{-10}	3.1×10^{-10}	1.5×10^{-10}	1.8×10^{-10}
		M	0.200	3.0×10^{-9}	0.100	2.2×10^{-9}	1.0×10^{-9}	6.9×10^{-10}	5.2×10^{-10}	4.2×10^{-10}
		S	0.020	3.1×10^{-9}	0.010	2.4×10^{-9}	1.1×10^{-9}	7.6×10^{-10}	5.8×10^{-10}	4.6×10^{-10}
Ba-135m	1.20 d	F	0.600	1.1×10^{-9}	0.200	1.0×10^{-9}	4.6×10^{-10}	2.5×10^{-10}	1.2×10^{-10}	1.4×10^{-10}
		M	0.200	2.4×10^{-9}	0.100	1.8×10^{-9}	8.9×10^{-10}	5.4×10^{-10}	4.1×10^{-10}	3.3×10^{-10}
		S	0.020	2.7×10^{-9}	0.010	1.9×10^{-9}	8.6×10^{-10}	5.9×10^{-10}	4.5×10^{-10}	3.6×10^{-10}
Ba-139	1.38 h	F	0.600	3.3×10^{-10}	0.200	2.4×10^{-10}	1.1×10^{-10}	6.0×10^{-11}	3.1×10^{-11}	3.4×10^{-11}
		M	0.200	5.4×10^{-10}	0.100	3.5×10^{-10}	1.6×10^{-10}	1.0×10^{-10}	6.6×10^{-11}	5.6×10^{-11}
		S	0.020	5.7×10^{-10}	0.010	3.6×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	7.0×10^{-11}	5.9×10^{-11}
Ba-140	12.7 d	F	0.600	1.4×10^{-8}	0.200	7.8×10^{-9}	3.6×10^{-9}	2.4×10^{-9}	1.6×10^{-9}	1.0×10^{-9}
		M	0.200	2.7×10^{-8}	0.100	2.0×10^{-8}	1.1×10^{-8}	7.6×10^{-9}	6.2×10^{-9}	5.1×10^{-9}
		S	0.020	2.9×10^{-8}	0.010	2.2×10^{-8}	1.2×10^{-8}	8.6×10^{-9}	7.1×10^{-9}	5.8×10^{-9}
Ba-141	0.305 h	F	0.600	1.9×10^{-10}	0.200	1.4×10^{-10}	6.4×10^{-11}	3.8×10^{-11}	2.1×10^{-11}	2.1×10^{-11}
		M	0.200	3.0×10^{-10}	0.100	2.0×10^{-10}	9.3×10^{-11}	5.9×10^{-11}	3.8×10^{-11}	3.2×10^{-11}
		S	0.020	3.2×10^{-10}	0.010	2.1×10^{-10}	9.7×10^{-11}	6.2×10^{-11}	4.0×10^{-11}	3.4×10^{-11}
Ba-142	0.177 h	F	0.600	1.3×10^{-10}	0.200	9.6×10^{-11}	4.5×10^{-11}	2.7×10^{-11}	1.6×10^{-11}	1.5×10^{-11}
		M	0.200	1.8×10^{-10}	0.100	1.3×10^{-10}	6.1×10^{-11}	3.9×10^{-11}	2.5×10^{-11}	2.1×10^{-11}
		S	0.020	1.9×10^{-10}	0.010	1.3×10^{-10}	6.2×10^{-11}	4.0×10^{-11}	2.6×10^{-11}	2.2×10^{-11}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤ 1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Lanthanum										
La-131	0.983 h	F	0.005	1.2×10^{-10}	5.0×10^{-4}	8.7×10^{-11}	4.2×10^{-11}	2.6×10^{-11}	1.5×10^{-11}	1.3×10^{-11}
		M	0.005	1.8×10^{-10}	5.0×10^{-4}	1.3×10^{-10}	6.4×10^{-11}	4.1×10^{-11}	2.8×10^{-11}	2.3×10^{-11}
La-132	4.80 h	F	0.005	1.0×10^{-9}	5.0×10^{-4}	7.7×10^{-10}	3.7×10^{-10}	2.2×10^{-10}	1.2×10^{-10}	1.0×10^{-10}
		M	0.005	1.5×10^{-9}	5.0×10^{-4}	1.1×10^{-9}	5.4×10^{-10}	3.4×10^{-10}	2.0×10^{-10}	1.6×10^{-10}
La-135	19.5 h	F	0.005	1.0×10^{-10}	5.0×10^{-4}	7.7×10^{-11}	3.8×10^{-11}	2.3×10^{-11}	1.3×10^{-11}	1.0×10^{-11}
		M	0.005	1.3×10^{-10}	5.0×10^{-4}	1.0×10^{-10}	4.9×10^{-11}	3.0×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
La-137	6.00×10^{4} a	F	0.005	2.5×10^{-8}	5.0×10^{-4}	2.3×10^{-8}	1.5×10^{-8}	1.1×10^{-8}	8.9×10^{-9}	8.7×10^{-9}
		M	0.005	8.6×10^{-9}	5.0×10^{-4}	8.1×10^{-9}	5.6×10^{-9}	4.0×10^{-9}	3.6×10^{-9}	3.6×10^{-9}
La-138	1.35×10^{11} a	F	0.005	3.7×10^{-7}	5.0×10^{-4}	3.5×10^{-7}	2.4×10^{-7}	1.8×10^{-7}	1.6×10^{-7}	1.5×10^{-7}
		M	0.005	1.3×10^{-7}	5.0×10^{-4}	1.2×10^{-7}	9.1×10^{-8}	6.8×10^{-8}	6.4×10^{-8}	6.4×10^{-8}
La-140	1.68 d	F	0.005	5.8×10^{-9}	5.0×10^{-4}	4.2×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	6.9×10^{-10}	5.7×10^{-10}
		M	0.005	8.8×10^{-9}	5.0×10^{-4}	6.3×10^{-9}	3.1×10^{-9}	2.0×10^{-9}	1.3×10^{-9}	1.1×10^{-9}
La-141	3.93 h	F	0.005	8.6×10^{-10}	5.0×10^{-4}	5.5×10^{-10}	2.3×10^{-10}	1.4×10^{-10}	7.5×10^{-11}	6.3×10^{-11}
		M	0.005	1.4×10^{-9}	5.0×10^{-4}	9.3×10^{-10}	4.3×10^{-10}	2.8×10^{-10}	1.8×10^{-10}	1.5×10^{-10}
La-142	1.54 h	F	0.005	5.3×10^{-10}	5.0×10^{-4}	3.8×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	6.3×10^{-11}	5.2×10^{-11}
		M	0.005	8.1×10^{-10}	5.0×10^{-4}	5.7×10^{-10}	2.7×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	8.9×10^{-11}
La-143	0.237 h	F	0.005	1.4×10^{-10}	5.0×10^{-4}	8.6×10^{-11}	3.7×10^{-11}	2.3×10^{-11}	1.4×10^{-11}	1.2×10^{-11}
		M	0.005	2.1×10^{-10}	5.0×10^{-4}	1.3×10^{-10}	6.0×10^{-11}	3.9×10^{-11}	2.5×10^{-11}	2.1×10^{-11}
Cerium										
Ce-134	3.00 d	F	0.005	7.6×10^{-9}	5.0×10^{-4}	5.3×10^{-9}	2.3×10^{-9}	1.4×10^{-9}	7.7×10^{-10}	5.7×10^{-10}
		M	0.005	1.1×10^{-8}	5.0×10^{-4}	7.6×10^{-9}	3.7×10^{-9}	2.4×10^{-9}	1.5×10^{-9}	1.3×10^{-9}
		S	0.005	1.2×10^{-8}	5.0×10^{-4}	8.0×10^{-9}	3.8×10^{-9}	2.5×10^{-9}	1.6×10^{-9}	1.3×10^{-9}

Ce-135	17.6 h	F	0.005	2.3×10^{-9}	5.0×10^{-4}	1.7×10^{-9}	8.5×10^{-10}	5.3×10^{-10}	3.0×10^{-10}	2.4×10^{-10}
		M	0.005	3.6×10^{-9}	5.0×10^{-4}	2.7×10^{-9}	1.4×10^{-9}	8.9×10^{-10}	5.9×10^{-10}	4.8×10^{-10}
		S	0.005	3.7×10^{-9}	5.0×10^{-4}	2.8×10^{-9}	1.4×10^{-9}	9.4×10^{-10}	6.3×10^{-10}	5.0×10^{-10}
Ce-137	9.00 h	F	0.005	7.5×10^{-11}	5.0×10^{-4}	5.6×10^{-11}	2.7×10^{-11}	1.6×10^{-11}	8.7×10^{-12}	7.0×10^{-12}
		M	0.005	1.1×10^{-10}	5.0×10^{-4}	7.6×10^{-11}	3.6×10^{-11}	2.2×10^{-11}	1.2×10^{-11}	9.8×10^{-12}
		S	0.005	1.1×10^{-10}	5.0×10^{-4}	7.8×10^{-11}	3.7×10^{-11}	2.3×10^{-11}	1.3×10^{-11}	1.0×10^{-11}
Ce-137m	1.43 d	F	0.005	1.6×10^{-9}	5.0×10^{-4}	1.1×10^{-9}	4.6×10^{-10}	2.8×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
		M	0.005	3.1×10^{-9}	5.0×10^{-4}	2.2×10^{-9}	1.1×10^{-9}	6.7×10^{-10}	5.1×10^{-10}	4.1×10^{-10}
		S	0.005	3.3×10^{-9}	5.0×10^{-4}	2.3×10^{-9}	1.0×10^{-9}	7.3×10^{-10}	5.6×10^{-10}	4.4×10^{-10}
Ce-139	138 d	F	0.005	1.1×10^{-8}	5.0×10^{-4}	8.5×10^{-9}	4.5×10^{-9}	2.8×10^{-9}	1.8×10^{-9}	1.5×10^{-9}
		M	0.005	7.5×10^{-9}	5.0×10^{-4}	6.1×10^{-9}	3.6×10^{-9}	2.5×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
		S	0.005	7.8×10^{-9}	5.0×10^{-4}	6.3×10^{-9}	3.9×10^{-9}	2.7×10^{-9}	2.4×10^{-9}	1.9×10^{-9}
Ce-141	32.5 d	F	0.005	1.1×10^{-8}	5.0×10^{-4}	7.3×10^{-9}	3.5×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	9.3×10^{-10}
		M	0.005	1.4×10^{-8}	5.0×10^{-4}	1.1×10^{-8}	6.3×10^{-9}	4.6×10^{-9}	4.1×10^{-9}	3.2×10^{-9}
		S	0.005	1.6×10^{-8}	5.0×10^{-4}	1.2×10^{-8}	7.1×10^{-9}	5.3×10^{-9}	4.8×10^{-9}	3.8×10^{-9}
Ce-143	1.38 d	F	0.005	3.6×10^{-9}	5.0×10^{-4}	2.3×10^{-9}	1.0×10^{-9}	6.2×10^{-10}	3.3×10^{-10}	2.7×10^{-10}
		M	0.005	5.6×10^{-9}	5.0×10^{-4}	3.9×10^{-9}	1.9×10^{-9}	1.3×10^{-9}	9.3×10^{-10}	7.5×10^{-10}
		S	0.005	5.9×10^{-9}	5.0×10^{-4}	4.1×10^{-9}	2.1×10^{-9}	1.4×10^{-9}	1.0×10^{-9}	8.3×10^{-10}
Ce-144	284 d	F	0.005	3.6×10^{-7}	5.0×10^{-4}	2.7×10^{-7}	1.4×10^{-7}	7.8×10^{-8}	4.8×10^{-8}	4.0×10^{-8}
		M	0.005	1.9×10^{-7}	5.0×10^{-4}	1.6×10^{-7}	8.8×10^{-8}	5.5×10^{-8}	4.1×10^{-8}	3.6×10^{-8}
		S	0.005	2.1×10^{-7}	5.0×10^{-4}	1.8×10^{-7}	1.1×10^{-7}	7.3×10^{-8}	5.8×10^{-8}	5.3×10^{-8}
Praseodymium										
Pr-136	0.218 h	M	0.005	1.3×10^{-10}	5.0×10^{-4}	8.8×10^{-11}	4.2×10^{-11}	2.6×10^{-11}	1.6×10^{-11}	1.3×10^{-11}
		S	0.005	1.3×10^{-10}	5.0×10^{-4}	9.0×10^{-11}	4.3×10^{-11}	2.7×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
Pr-137	1.28 h	M	0.005	1.8×10^{-10}	5.0×10^{-4}	1.3×10^{-10}	6.1×10^{-11}	3.9×10^{-11}	2.4×10^{-11}	2.0×10^{-11}
		S	0.005	1.9×10^{-10}	5.0×10^{-4}	1.3×10^{-10}	6.4×10^{-11}	4.0×10^{-11}	2.5×10^{-11}	2.1×10^{-11}
Pr-138m	2.10 h	M	0.005	5.9×10^{-10}	5.0×10^{-4}	4.5×10^{-10}	2.3×10^{-10}	1.4×10^{-10}	9.0×10^{-11}	7.2×10^{-11}
		S	0.005	6.0×10^{-10}	5.0×10^{-4}	4.7×10^{-10}	2.4×10^{-10}	1.5×10^{-10}	9.3×10^{-11}	7.4×10^{-11}
Pr-139	4.51 h	M	0.005	1.5×10^{-10}	5.0×10^{-4}	1.1×10^{-10}	5.5×10^{-11}	3.5×10^{-11}	2.3×10^{-11}	1.8×10^{-11}
		S	0.005	1.6×10^{-10}	5.0×10^{-4}	1.2×10^{-10}	5.7×10^{-11}	3.7×10^{-11}	2.4×10^{-11}	2.0×10^{-11}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤ 1 a		f_1 for	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)	g > 1 a	e(g)	e(g)	e(g)	e(g)	e(g)
Pr-142	19.1 h	M	0.005	5.3×10^{-9}	5.0×10^{-4}	3.5×10^{-9}	1.6×10^{-9}	1.0×10^{-9}	6.2×10^{-10}	5.2×10^{-10}
		S	0.005	5.5×10^{-9}	5.0×10^{-4}	3.7×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	6.6×10^{-10}	5.5×10^{-10}
Pr-142m	0.243 h	M	0.005	6.7×10^{-11}	5.0×10^{-4}	4.5×10^{-11}	2.0×10^{-11}	1.3×10^{-11}	7.9×10^{-12}	6.6×10^{-12}
		S	0.005	7.0×10^{-11}	5.0×10^{-4}	4.7×10^{-11}	2.2×10^{-11}	1.4×10^{-11}	8.4×10^{-12}	7.0×10^{-12}
Pr-143	13.6 d	M	0.005	1.2×10^{-8}	5.0×10^{-4}	8.4×10^{-9}	4.6×10^{-9}	3.2×10^{-9}	2.7×10^{-9}	2.2×10^{-9}
		S	0.005	1.3×10^{-8}	5.0×10^{-4}	9.2×10^{-9}	5.1×10^{-9}	3.6×10^{-9}	3.0×10^{-9}	2.4×10^{-9}
Pr-144	0.288 h	M	0.005	1.9×10^{-10}	5.0×10^{-4}	1.2×10^{-10}	5.0×10^{-11}	3.2×10^{-11}	2.1×10^{-11}	1.8×10^{-11}
		S	0.005	1.9×10^{-10}	5.0×10^{-4}	1.2×10^{-10}	5.2×10^{-11}	3.4×10^{-11}	2.1×10^{-11}	1.8×10^{-11}
Pr-145	5.98 h	M	0.005	1.6×10^{-9}	5.0×10^{-4}	1.0×10^{-9}	4.7×10^{-10}	3.0×10^{-10}	1.9×10^{-10}	1.6×10^{-10}
		S	0.005	1.6×10^{-9}	5.0×10^{-4}	1.1×10^{-9}	4.9×10^{-10}	3.2×10^{-10}	2.0×10^{-10}	1.7×10^{-10}
Pr-147	0.227 h	M	0.005	1.5×10^{-10}	5.0×10^{-4}	1.0×10^{-10}	4.8×10^{-11}	3.1×10^{-11}	2.1×10^{-11}	1.8×10^{-11}
		S	0.005	1.6×10^{-10}	5.0×10^{-4}	1.1×10^{-10}	5.0×10^{-11}	3.3×10^{-11}	2.2×10^{-11}	1.8×10^{-11}
Neodymium										
Nd-136	0.844 h	M	0.005	4.6×10^{-10}	5.0×10^{-4}	3.2×10^{-10}	1.6×10^{-10}	9.8×10^{-11}	6.3×10^{-11}	5.1×10^{-11}
		S	0.005	4.8×10^{-10}	5.0×10^{-4}	3.3×10^{-10}	1.6×10^{-10}	1.0×10^{-10}	6.6×10^{-11}	5.4×10^{-11}
Nd-138	5.04 h	M	0.005	2.3×10^{-9}	5.0×10^{-4}	1.7×10^{-9}	7.7×10^{-10}	4.8×10^{-10}	2.8×10^{-10}	2.3×10^{-10}
		S	0.005	2.4×10^{-9}	5.0×10^{-4}	1.8×10^{-9}	8.0×10^{-10}	5.0×10^{-10}	3.0×10^{-10}	2.5×10^{-10}
Nd-139	0.495 h	M	0.005	9.0×10^{-11}	5.0×10^{-4}	6.2×10^{-11}	3.0×10^{-11}	1.9×10^{-11}	1.2×10^{-11}	9.9×10^{-12}
		S	0.005	9.4×10^{-11}	5.0×10^{-4}	6.4×10^{-11}	3.1×10^{-11}	2.0×10^{-11}	1.3×10^{-11}	1.0×10^{-11}
Nd-139m	5.50 h	M	0.005	1.1×10^{-9}	5.0×10^{-4}	8.8×10^{-10}	4.5×10^{-10}	2.9×10^{-10}	1.8×10^{-10}	1.5×10^{-10}
		S	0.005	1.2×10^{-9}	5.0×10^{-4}	9.1×10^{-10}	4.6×10^{-10}	3.0×10^{-10}	1.9×10^{-10}	1.5×10^{-10}
Nd-141	2.49 h	M	0.005	4.1×10^{-11}	5.0×10^{-4}	3.1×10^{-11}	1.5×10^{-11}	9.6×10^{-12}	6.0×10^{-12}	4.8×10^{-12}
		S	0.005	4.3×10^{-11}	5.0×10^{-4}	3.2×10^{-11}	1.6×10^{-11}	1.0×10^{-11}	6.2×10^{-12}	5.0×10^{-12}
Nd-147	11.0 d	M	0.005	1.1×10^{-8}	5.0×10^{-4}	8.0×10^{-9}	4.5×10^{-9}	3.2×10^{-9}	2.6×10^{-9}	2.1×10^{-9}
		S	0.005	1.2×10^{-8}	5.0×10^{-4}	8.6×10^{-9}	4.9×10^{-9}	3.5×10^{-9}	3.0×10^{-9}	2.4×10^{-9}

Nd-149	1.73 h	M	0.005	6.8×10^{-10}	5.0×10^{-4}	4.6×10^{-10}	2.2×10^{-10}	1.5×10^{-10}	1.0×10^{-10}	8.4×10^{-11}
		S	0.005	7.1×10^{-10}	5.0×10^{-4}	4.8×10^{-10}	2.3×10^{-10}	1.5×10^{-10}	1.1×10^{-10}	8.9×10^{-11}
Nd-151	0.207 h	M	0.005	1.5×10^{-10}	5.0×10^{-4}	9.9×10^{-11}	4.6×10^{-11}	3.0×10^{-11}	2.0×10^{-11}	1.7×10^{-11}
		S	0.005	1.5×10^{-10}	5.0×10^{-4}	1.0×10^{-10}	4.8×10^{-11}	3.1×10^{-11}	2.1×10^{-11}	1.7×10^{-11}
Promethium										
Pm-141	0.348 h	M	0.005	1.4×10^{-10}	5.0×10^{-4}	9.4×10^{-11}	4.3×10^{-11}	2.7×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
		S	0.005	1.5×10^{-10}	5.0×10^{-4}	9.7×10^{-11}	4.4×10^{-11}	2.8×10^{-11}	1.8×10^{-11}	1.5×10^{-11}
Pm-143	265 d	M	0.005	6.2×10^{-9}	5.0×10^{-4}	5.4×10^{-9}	3.3×10^{-9}	2.2×10^{-9}	1.7×10^{-9}	1.5×10^{-9}
		S	0.005	5.5×10^{-9}	5.0×10^{-4}	4.8×10^{-9}	3.1×10^{-9}	2.1×10^{-9}	1.7×10^{-9}	1.4×10^{-9}
Pm-144	363 d	M	0.005	3.1×10^{-8}	5.0×10^{-4}	2.8×10^{-8}	1.8×10^{-8}	1.2×10^{-8}	9.3×10^{-9}	8.2×10^{-9}
		S	0.005	2.6×10^{-8}	5.0×10^{-4}	2.4×10^{-8}	1.6×10^{-8}	1.1×10^{-8}	8.9×10^{-9}	7.5×10^{-9}
Pm-145	17.7 a	M	0.005	1.1×10^{-8}	5.0×10^{-4}	9.8×10^{-9}	6.4×10^{-9}	4.3×10^{-9}	3.7×10^{-9}	3.6×10^{-9}
		S	0.005	7.1×10^{-9}	5.0×10^{-4}	6.5×10^{-9}	4.3×10^{-9}	2.9×10^{-9}	2.4×10^{-9}	2.3×10^{-9}
Pm-146	5.53 a	M	0.005	6.4×10^{-8}	5.0×10^{-4}	5.9×10^{-8}	3.9×10^{-8}	2.6×10^{-8}	2.2×10^{-8}	2.1×10^{-8}
		S	0.005	5.3×10^{-8}	5.0×10^{-4}	4.9×10^{-8}	3.3×10^{-8}	2.2×10^{-8}	1.9×10^{-8}	1.7×10^{-8}
Pm-147	2.62 a	M	0.005	2.1×10^{-8}	5.0×10^{-4}	1.8×10^{-8}	1.1×10^{-8}	7.0×10^{-9}	5.7×10^{-9}	5.0×10^{-9}
		S	0.005	1.9×10^{-8}	5.0×10^{-4}	1.6×10^{-8}	1.0×10^{-8}	6.8×10^{-9}	5.8×10^{-9}	4.9×10^{-9}
Pm-148	5.37 d	M	0.005	1.5×10^{-8}	5.0×10^{-4}	1.0×10^{-8}	5.2×10^{-9}	3.4×10^{-9}	2.4×10^{-9}	2.0×10^{-9}
		S	0.005	1.5×10^{-8}	5.0×10^{-4}	1.1×10^{-8}	5.5×10^{-9}	3.7×10^{-9}	2.6×10^{-9}	2.2×10^{-9}
Pm-148m	41.3 d	M	0.005	2.4×10^{-8}	5.0×10^{-4}	1.9×10^{-8}	1.1×10^{-8}	7.7×10^{-9}	6.3×10^{-9}	5.1×10^{-9}
		S	0.005	2.5×10^{-8}	5.0×10^{-4}	2.0×10^{-8}	1.2×10^{-8}	8.3×10^{-9}	7.1×10^{-9}	5.7×10^{-9}
Pm-149	2.21 d	M	0.005	5.0×10^{-9}	5.0×10^{-4}	3.5×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	8.3×10^{-10}	6.7×10^{-10}
		S	0.005	5.3×10^{-9}	5.0×10^{-4}	3.6×10^{-9}	1.8×10^{-9}	1.2×10^{-9}	9.0×10^{-10}	7.3×10^{-10}
Pm-150	2.68 h	M	0.005	1.2×10^{-9}	5.0×10^{-4}	7.9×10^{-10}	3.8×10^{-10}	2.4×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
		S	0.005	1.2×10^{-9}	5.0×10^{-4}	8.2×10^{-10}	3.9×10^{-10}	2.5×10^{-10}	1.6×10^{-10}	1.3×10^{-10}
Pm-151	1.18 d	M	0.005	3.3×10^{-9}	5.0×10^{-4}	2.5×10^{-9}	1.2×10^{-9}	8.3×10^{-10}	5.3×10^{-10}	4.3×10^{-10}
		S	0.005	3.4×10^{-9}	5.0×10^{-4}	2.6×10^{-9}	1.3×10^{-9}	7.9×10^{-10}	5.7×10^{-10}	4.6×10^{-10}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Samarium										
Sm-141	0.170 h	M	0.005	1.5×10^{-10}	5.0×10^{-4}	1.0×10^{-10}	4.7×10^{-11}	2.9×10^{-11}	1.8×10^{-11}	1.5×10^{-11}
Sm-141m	0.377 h	M	0.005	3.0×10^{-10}	5.0×10^{-4}	2.1×10^{-10}	9.7×10^{-11}	6.1×10^{-11}	3.9×10^{-11}	3.2×10^{-11}
Sm-142	1.21 h	M	0.005	7.5×10^{-10}	5.0×10^{-4}	4.8×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	8.5×10^{-11}	7.1×10^{-11}
Sm-145	340 d	M	0.005	8.1×10^{-9}	5.0×10^{-4}	6.8×10^{-9}	4.0×10^{-9}	2.5×10^{-9}	1.9×10^{-9}	1.6×10^{-9}
Sm-146	1.03×10^{8} a	M	0.005	2.7×10^{-5}	5.0×10^{-4}	2.6×10^{-5}	1.7×10^{-5}	1.2×10^{-5}	1.1×10^{-5}	1.1×10^{-5}
Sm-147	1.06×10^{11} a	M	0.005	2.5×10^{-5}	5.0×10^{-4}	2.3×10^{-5}	1.6×10^{-5}	1.1×10^{-5}	9.6×10^{-6}	9.6×10^{-6}
Sm-151	90.0 a	M	0.005	1.1×10^{-8}	5.0×10^{-4}	1.0×10^{-8}	6.7×10^{-9}	4.5×10^{-9}	4.0×10^{-9}	4.0×10^{-9}
Sm-153	1.95 d	M	0.005	4.2×10^{-9}	5.0×10^{-4}	2.9×10^{-9}	1.5×10^{-9}	1.0×10^{-9}	7.9×10^{-10}	6.3×10^{-10}
Sm-155	0.368 h	M	0.005	1.5×10^{-10}	5.0×10^{-4}	9.9×10^{-11}	4.4×10^{-11}	2.9×10^{-11}	2.0×10^{-11}	1.7×10^{-11}
Sm-156	9.40 h	M	0.005	1.6×10^{-9}	5.0×10^{-4}	1.1×10^{-9}	5.8×10^{-10}	3.5×10^{-10}	2.7×10^{-10}	2.2×10^{-10}
Europium										
Eu-145	5.94 d	M	0.005	3.6×10^{-9}	5.0×10^{-4}	2.9×10^{-9}	1.6×10^{-9}	1.0×10^{-9}	6.8×10^{-10}	5.5×10^{-10}
Eu-146	4.61 d	M	0.005	5.5×10^{-9}	5.0×10^{-4}	4.4×10^{-9}	2.4×10^{-9}	1.5×10^{-9}	1.0×10^{-9}	8.0×10^{-10}
Eu-147	24.0 d	M	0.005	4.9×10^{-9}	5.0×10^{-4}	3.7×10^{-9}	2.2×10^{-9}	1.6×10^{-9}	1.3×10^{-9}	1.1×10^{-9}
Eu-148	54.5 d	M	0.005	1.4×10^{-8}	5.0×10^{-4}	1.2×10^{-8}	6.8×10^{-9}	4.6×10^{-9}	3.2×10^{-9}	2.6×10^{-9}
Eu-149	93.1 d	M	0.005	1.6×10^{-9}	5.0×10^{-4}	1.3×10^{-9}	7.3×10^{-10}	4.7×10^{-10}	3.5×10^{-10}	2.9×10^{-10}
Eu-150	34.2 a	M	0.005	1.1×10^{-7}	5.0×10^{-4}	1.1×10^{-7}	7.8×10^{-8}	5.7×10^{-8}	5.3×10^{-8}	5.3×10^{-8}
Eu-150	12.6 h	M	0.005	1.6×10^{-9}	5.0×10^{-4}	1.1×10^{-9}	5.2×10^{-10}	3.4×10^{-10}	2.3×10^{-10}	1.9×10^{-10}
Eu-152	13.3 a	M	0.005	1.1×10^{-7}	5.0×10^{-4}	1.0×10^{-7}	7.0×10^{-8}	4.9×10^{-8}	4.3×10^{-8}	4.2×10^{-8}
Eu-152m	9.32 h	M	0.005	1.9×10^{-9}	5.0×10^{-4}	1.3×10^{-9}	6.6×10^{-10}	4.2×10^{-10}	2.4×10^{-10}	2.2×10^{-10}

Eu-154	8.80 a	M	0.005	1.6×10^{-7}	5.0×10^{-4}	1.5×10^{-7}	9.7×10^{-8}	6.5×10^{-8}	5.6×10^{-8}	5.3×10^{-8}
Eu-155	4.96 a	M	0.005	2.6×10^{-8}	5.0×10^{-4}	2.3×10^{-8}	1.4×10^{-8}	9.2×10^{-9}	7.6×10^{-9}	6.9×10^{-9}
Eu-156	15.2 d	M	0.005	1.9×10^{-8}	5.0×10^{-4}	1.4×10^{-8}	7.7×10^{-9}	5.3×10^{-9}	4.2×10^{-9}	3.4×10^{-9}
Eu-157	15.1 h	M	0.005	2.5×10^{-9}	5.0×10^{-4}	1.9×10^{-9}	8.9×10^{-10}	5.9×10^{-10}	3.5×10^{-10}	2.8×10^{-10}
Eu-158	0.765 h	M	0.005	4.3×10^{-10}	5.0×10^{-4}	2.9×10^{-10}	1.3×10^{-10}	8.5×10^{-11}	5.6×10^{-11}	4.7×10^{-11}
Gadolinium										
Gd-145	0.382 h	F	0.005	1.3×10^{-10}	5.0×10^{-4}	9.6×10^{-11}	4.7×10^{-11}	2.9×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
		M	0.005	1.8×10^{-10}	5.0×10^{-4}	1.3×10^{-10}	6.2×10^{-11}	3.9×10^{-11}	2.4×10^{-11}	2.0×10^{-11}
Gd-146	48.3 d	F	0.005	2.9×10^{-8}	5.0×10^{-4}	2.3×10^{-8}	1.2×10^{-8}	7.8×10^{-9}	5.1×10^{-9}	4.4×10^{-9}
		M	0.005	2.8×10^{-8}	5.0×10^{-4}	2.2×10^{-8}	1.3×10^{-8}	9.3×10^{-9}	7.9×10^{-9}	6.4×10^{-9}
Gd-147	1.59 d	F	0.005	2.1×10^{-9}	5.0×10^{-4}	1.7×10^{-9}	8.4×10^{-10}	5.3×10^{-10}	3.1×10^{-10}	2.6×10^{-10}
		M	0.005	2.8×10^{-9}	5.0×10^{-4}	2.2×10^{-9}	1.1×10^{-9}	7.5×10^{-10}	5.1×10^{-10}	4.0×10^{-10}
Gd-148	93.0 a	F	0.005	8.3×10^{-5}	5.0×10^{-4}	7.6×10^{-5}	4.7×10^{-5}	3.2×10^{-5}	2.6×10^{-5}	2.6×10^{-5}
		M	0.005	3.2×10^{-5}	5.0×10^{-4}	2.9×10^{-5}	1.9×10^{-5}	1.3×10^{-5}	1.2×10^{-5}	1.1×10^{-5}
Gd-149	9.40 d	F	0.005	2.6×10^{-9}	5.0×10^{-4}	2.0×10^{-9}	8.0×10^{-10}	5.1×10^{-10}	3.1×10^{-10}	2.6×10^{-10}
		M	0.005	3.6×10^{-9}	5.0×10^{-4}	3.0×10^{-9}	1.5×10^{-9}	1.1×10^{-9}	9.2×10^{-10}	7.3×10^{-10}
Gd-151	120 d	F	0.005	6.3×10^{-9}	5.0×10^{-4}	4.9×10^{-9}	2.5×10^{-9}	1.5×10^{-9}	9.2×10^{-10}	7.8×10^{-10}
		M	0.005	4.5×10^{-9}	5.0×10^{-4}	3.5×10^{-9}	2.0×10^{-9}	1.3×10^{-9}	1.0×10^{-9}	8.6×10^{-10}
Gd-152	1.08×10^{14} a	F	0.005	5.9×10^{-5}	5.0×10^{-4}	5.4×10^{-5}	3.4×10^{-5}	2.4×10^{-5}	1.9×10^{-5}	1.9×10^{-5}
		M	0.005	2.1×10^{-5}	5.0×10^{-4}	1.9×10^{-5}	1.3×10^{-5}	8.9×10^{-6}	7.9×10^{-6}	8.0×10^{-6}
Gd-153	242 d	F	0.005	1.5×10^{-8}	5.0×10^{-4}	1.2×10^{-8}	6.5×10^{-9}	3.9×10^{-9}	2.4×10^{-9}	2.1×10^{-9}
		M	0.005	9.9×10^{-9}	5.0×10^{-4}	7.9×10^{-9}	4.8×10^{-9}	3.1×10^{-9}	2.5×10^{-9}	2.1×10^{-9}
Gd-159	18.6 h	F	0.005	1.2×10^{-9}	5.0×10^{-4}	8.9×10^{-10}	3.8×10^{-10}	2.3×10^{-10}	1.2×10^{-10}	1.0×10^{-10}
		M	0.005	2.2×10^{-9}	5.0×10^{-4}	1.5×10^{-9}	7.3×10^{-10}	4.9×10^{-10}	3.4×10^{-10}	2.7×10^{-10}
Terbium										
Tb-147	1.65 h	M	0.005	6.7×10^{-10}	5.0×10^{-4}	4.8×10^{-10}	2.3×10^{-10}	1.5×10^{-10}	9.3×10^{-11}	7.6×10^{-11}
Tb-149	4.15 h	M	0.005	2.1×10^{-8}	5.0×10^{-4}	1.5×10^{-8}	9.6×10^{-9}	6.6×10^{-9}	5.8×10^{-9}	4.9×10^{-9}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)	g > 1 a	e(g)	e(g)	e(g)	e(g)	e(g)
Tb-150	3.27 h	M	0.005	1.0×10^{-9}	5.0×10^{-4}	7.4×10^{-10}	3.5×10^{-10}	2.2×10^{-10}	1.3×10^{-10}	1.1×10^{-10}
Tb-151	17.6 h	M	0.005	1.6×10^{-9}	5.0×10^{-4}	1.2×10^{-9}	6.3×10^{-10}	4.2×10^{-10}	2.8×10^{-10}	2.3×10^{-10}
Tb-153	2.34 d	M	0.005	1.4×10^{-9}	5.0×10^{-4}	1.0×10^{-9}	5.4×10^{-10}	3.6×10^{-10}	2.3×10^{-10}	1.9×10^{-10}
Tb-154	21.4 h	M	0.005	2.7×10^{-9}	5.0×10^{-4}	2.1×10^{-9}	1.1×10^{-9}	7.1×10^{-10}	4.5×10^{-10}	3.6×10^{-10}
Tb-155	5.32 d	M	0.005	1.4×10^{-9}	5.0×10^{-4}	1.0×10^{-9}	5.6×10^{-10}	3.4×10^{-10}	2.7×10^{-10}	2.2×10^{-10}
Tb-156	5.34 d	M	0.005	7.0×10^{-9}	5.0×10^{-4}	5.4×10^{-9}	3.0×10^{-9}	2.0×10^{-9}	1.5×10^{-9}	1.2×10^{-9}
Tb-156m	*1.02 d*	*M*	*0.005*	1.1×10^{-9}	5.0×10^{-4}	9.4×10^{-10}	4.7×10^{-10}	3.3×10^{-10}	2.7×10^{-10}	2.1×10^{-10}
Tb-156m	5.00 h	M	0.005	6.2×10^{-10}	5.0×10^{-4}	4.5×10^{-10}	2.4×10^{-10}	1.7×10^{-10}	1.2×10^{-10}	9.6×10^{-11}
Tb-157	1.50×10^2 a	M	0.005	3.2×10^{-9}	5.0×10^{-4}	3.0×10^{-9}	2.0×10^{-9}	1.4×10^{-9}	1.2×10^{-9}	1.2×10^{-9}
Tb-158	1.50×10^2 a	M	0.005	1.1×10^{-7}	5.0×10^{-4}	1.0×10^{-7}	7.0×10^{-8}	5.1×10^{-8}	4.7×10^{-8}	4.6×10^{-8}
Tb-160	72.3 d	M	0.005	3.2×10^{-8}	5.0×10^{-4}	2.5×10^{-8}	1.5×10^{-8}	1.0×10^{-8}	8.6×10^{-9}	7.0×10^{-9}
Tb-161	6.91 d	M	0.005	6.6×10^{-9}	5.0×10^{-4}	4.7×10^{-9}	2.6×10^{-9}	1.9×10^{-9}	1.6×10^{-9}	1.3×10^{-9}
Dysprosium										
Dy-155	10.0 h	M	0.005	5.6×10^{-10}	5.0×10^{-4}	4.4×10^{-10}	2.3×10^{-10}	1.5×10^{-10}	9.6×10^{-11}	7.7×10^{-11}
Dy-157	8.10 h	M	0.005	2.4×10^{-10}	5.0×10^{-4}	1.9×10^{-10}	9.9×10^{-11}	6.2×10^{-11}	3.8×10^{-11}	3.0×10^{-11}
Dy-159	144 d	M	0.005	2.1×10^{-9}	5.0×10^{-4}	1.7×10^{-9}	9.6×10^{-10}	6.0×10^{-10}	4.4×10^{-10}	3.7×10^{-10}
Dy-165	2.33 h	M	0.005	5.2×10^{-10}	5.0×10^{-4}	3.4×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	7.2×10^{-11}	6.0×10^{-11}
Dy-166	3.40 d	M	0.005	1.2×10^{-8}	5.0×10^{-4}	8.3×10^{-9}	4.4×10^{-9}	3.0×10^{-9}	2.3×10^{-9}	1.9×10^{-9}
Holmium										
Ho-155	0.800 h	M	0.005	1.7×10^{-10}	5.0×10^{-4}	1.2×10^{-10}	5.8×10^{-11}	3.7×10^{-11}	2.4×10^{-11}	2.0×10^{-11}
Ho-157	0.210 h	M	0.005	3.4×10^{-11}	5.0×10^{-4}	2.5×10^{-11}	1.3×10^{-11}	8.0×10^{-12}	5.1×10^{-12}	4.2×10^{-12}

Ho-159	0.550 h	M	0.005	4.6×10^{-11}	5.0×10^{-4}	3.3×10^{-11}	1.7×10^{-11}	1.1×10^{-11}	7.5×10^{-12}	6.1×10^{-12}
Ho-161	2.50 h	M	0.005	5.7×10^{-11}	5.0×10^{-4}	4.0×10^{-11}	2.0×10^{-11}	1.2×10^{-11}	7.5×10^{-12}	6.0×10^{-12}
Ho-162	0.250 h	M	0.005	2.1×10^{-11}	5.0×10^{-4}	1.5×10^{-11}	7.2×10^{-12}	4.8×10^{-12}	3.4×10^{-12}	2.8×10^{-12}
Ho-162m	1.13 h	M	0.005	1.5×10^{-10}	5.0×10^{-4}	1.1×10^{-10}	5.8×10^{-11}	3.8×10^{-11}	2.6×10^{-11}	2.1×10^{-11}
Ho-164	0.483 h	M	0.005	6.8×10^{-11}	5.0×10^{-4}	4.5×10^{-11}	2.1×10^{-11}	1.4×10^{-11}	9.9×10^{-12}	8.4×10^{-12}
Ho-164m	0.625 h	M	0.005	9.1×10^{-11}	5.0×10^{-4}	5.9×10^{-11}	3.0×10^{-11}	2.0×10^{-11}	1.3×10^{-11}	1.2×10^{-11}
Ho-166	1.12 d	M	0.005	6.0×10^{-9}	5.0×10^{-4}	4.0×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	7.9×10^{-10}	6.5×10^{-10}
Ho-166m	1.20×10^{3} a	M	0.005	2.6×10^{-7}	5.0×10^{-4}	2.5×10^{-7}	1.8×10^{-7}	1.3×10^{-7}	1.2×10^{-7}	1.2×10^{-7}
Ho-167	3.10 h	M	0.005	5.2×10^{-10}	5.0×10^{-4}	3.6×10^{-10}	1.8×10^{-10}	1.2×10^{-10}	8.7×10^{-11}	7.1×10^{-11}
Erbium										
Er-161	3.24 h	M	0.005	3.8×10^{-10}	5.0×10^{-4}	2.9×10^{-10}	1.5×10^{-10}	9.5×10^{-11}	6.0×10^{-11}	4.8×10^{-11}
Er-165	10.4 h	M	0.005	7.2×10^{-11}	5.0×10^{-4}	5.3×10^{-11}	2.6×10^{-11}	1.6×10^{-11}	9.6×10^{-12}	7.9×10^{-12}
Er-169	9.30 d	M	0.005	4.7×10^{-9}	5.0×10^{-4}	3.5×10^{-9}	2.0×10^{-9}	1.5×10^{-9}	1.3×10^{-9}	1.0×10^{-9}
Er-171	7.52 h	M	0.005	1.8×10^{-9}	5.0×10^{-4}	1.2×10^{-9}	5.9×10^{-10}	3.9×10^{-10}	2.7×10^{-10}	2.2×10^{-10}
Er-172	2.05 d	M	0.005	6.6×10^{-9}	5.0×10^{-4}	4.7×10^{-9}	2.5×10^{-9}	1.7×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Thulium										
Tm-162	0.362 h	M	0.005	1.3×10^{-10}	5.0×10^{-4}	9.6×10^{-11}	4.7×10^{-11}	3.0×10^{-11}	1.9×10^{-11}	1.6×10^{-11}
Tm-166	7.70 h	M	0.005	1.3×10^{-9}	5.0×10^{-4}	9.9×10^{-10}	5.2×10^{-10}	3.3×10^{-10}	2.2×10^{-10}	1.7×10^{-10}
Tm-167	9.24 d	M	0.005	5.6×10^{-9}	5.0×10^{-4}	4.1×10^{-9}	2.3×10^{-9}	1.7×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Tm-170	129 d	M	0.005	3.6×10^{-8}	5.0×10^{-4}	2.8×10^{-8}	1.6×10^{-8}	1.1×10^{-8}	8.5×10^{-9}	7.0×10^{-9}
Tm-171	1.92 a	M	0.005	6.8×10^{-9}	5.0×10^{-4}	5.7×10^{-9}	3.4×10^{-9}	2.0×10^{-9}	1.6×10^{-9}	1.4×10^{-9}
Tm-172	2.65 d	M	0.005	8.4×10^{-9}	5.0×10^{-4}	5.8×10^{-9}	2.9×10^{-9}	1.9×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Tm-173	8.24 h	M	0.005	1.5×10^{-9}	5.0×10^{-4}	1.0×10^{-9}	5.0×10^{-10}	3.3×10^{-10}	2.2×10^{-10}	1.8×10^{-10}
Tm-175	0.253 h	M	0.005	1.6×10^{-10}	5.0×10^{-4}	1.1×10^{-10}	5.0×10^{-11}	3.3×10^{-11}	2.2×10^{-11}	1.8×10^{-11}
Ytterbium										
Yb-162	0.315 h	M	0.005	1.1×10^{-10}	5.0×10^{-4}	7.9×10^{-11}	3.9×10^{-11}	2.5×10^{-11}	1.6×10^{-11}	1.3×10^{-11}
		S	0.005	1.2×10^{-10}	5.0×10^{-4}	8.2×10^{-11}	4.0×10^{-11}	2.6×10^{-11}	1.7×10^{-11}	1.4×10^{-11}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Yb-166	2.36 d	M	0.005	4.7×10^{-9}	5.0×10^{-4}	3.5×10^{-9}	1.9×10^{-9}	1.3×10^{-9}	9.0×10^{-10}	7.2×10^{-10}
		S	0.005	4.9×10^{-9}	5.0×10^{-4}	3.7×10^{-9}	2.0×10^{-9}	1.3×10^{-9}	9.6×10^{-10}	7.7×10^{-10}
Yb-167	0.292 h	M	0.005	4.4×10^{-11}	5.0×10^{-4}	3.1×10^{-11}	1.6×10^{-11}	1.1×10^{-11}	7.9×10^{-12}	6.5×10^{-12}
		S	0.005	4.6×10^{-11}	5.0×10^{-4}	3.2×10^{-11}	1.7×10^{-11}	1.1×10^{-11}	8.4×10^{-12}	6.9×10^{-12}
Yb-169	32.0 d	M	0.005	1.2×10^{-8}	5.0×10^{-4}	8.7×10^{-9}	5.1×10^{-9}	3.7×10^{-9}	3.2×10^{-9}	2.5×10^{-9}
		S	0.005	1.3×10^{-8}	5.0×10^{-4}	9.8×10^{-9}	5.9×10^{-9}	4.2×10^{-9}	3.7×10^{-9}	3.0×10^{-9}
Yb-175	4.19 d	M	0.005	3.5×10^{-9}	5.0×10^{-4}	2.5×10^{-9}	1.4×10^{-9}	9.8×10^{-10}	8.3×10^{-10}	6.5×10^{-10}
		S	0.005	3.7×10^{-9}	5.0×10^{-4}	2.7×10^{-9}	1.5×10^{-9}	1.1×10^{-9}	9.2×10^{-10}	7.3×10^{-10}
Yb-177	1.90 h	M	0.005	5.0×10^{-10}	5.0×10^{-4}	3.3×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	7.8×10^{-11}	6.4×10^{-11}
		S	0.005	5.3×10^{-10}	5.0×10^{-4}	3.5×10^{-10}	1.7×10^{-10}	1.2×10^{-10}	8.4×10^{-11}	6.9×10^{-11}
Yb-178	1.23 h	M	0.005	5.9×10^{-10}	5.0×10^{-4}	3.9×10^{-10}	1.8×10^{-10}	1.2×10^{-10}	8.5×10^{-11}	7.0×10^{-11}
		S	0.005	6.2×10^{-10}	5.0×10^{-4}	4.1×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	9.1×10^{-11}	7.5×10^{-11}
Lutetium										
Lu-169	1.42 d	M	0.005	2.3×10^{-9}	5.0×10^{-4}	1.8×10^{-9}	9.5×10^{-10}	6.3×10^{-10}	4.4×10^{-10}	3.5×10^{-10}
		S	0.005	2.4×10^{-9}	5.0×10^{-4}	1.9×10^{-9}	1.0×10^{-9}	6.7×10^{-10}	4.8×10^{-10}	3.8×10^{-10}
Lu-170	2.00 d	M	0.005	4.3×10^{-9}	5.0×10^{-4}	3.4×10^{-9}	1.8×10^{-9}	1.2×10^{-9}	7.8×10^{-10}	6.3×10^{-10}
		S	0.005	4.5×10^{-9}	5.0×10^{-4}	3.5×10^{-9}	1.8×10^{-9}	1.2×10^{-9}	8.2×10^{-10}	6.6×10^{-10}
Lu-171	8.22 d	M	0.005	5.0×10^{-9}	5.0×10^{-4}	3.7×10^{-9}	2.1×10^{-9}	1.2×10^{-9}	9.8×10^{-10}	8.0×10^{-10}
		S	0.005	4.7×10^{-9}	5.0×10^{-4}	3.9×10^{-9}	2.0×10^{-9}	1.4×10^{-9}	1.1×10^{-9}	8.8×10^{-10}
Lu-172	6.70 d	M	0.005	8.7×10^{-9}	5.0×10^{-4}	6.7×10^{-9}	3.8×10^{-9}	2.6×10^{-9}	1.8×10^{-9}	1.4×10^{-9}
		S	0.005	9.3×10^{-9}	5.0×10^{-4}	7.1×10^{-9}	4.0×10^{-9}	2.8×10^{-9}	2.0×10^{-9}	1.6×10^{-9}
Lu-173	1.37 a	M	0.005	1.0×10^{-8}	5.0×10^{-4}	8.5×10^{-9}	5.1×10^{-9}	3.2×10^{-9}	2.5×10^{-9}	2.2×10^{-9}
		S	0.005	1.0×10^{-8}	5.0×10^{-4}	8.7×10^{-9}	5.4×10^{-9}	3.6×10^{-9}	2.9×10^{-9}	2.4×10^{-9}

Lu-174	3.31 a	M	0.005	1.7×10^{-8}	5.0×10^{-4}	1.5×10^{-8}	9.1×10^{-9}	5.8×10^{-9}	4.7×10^{-9}	4.2×10^{-9}
		S	0.005	1.6×10^{-8}	5.0×10^{-4}	1.4×10^{-8}	8.9×10^{-9}	5.9×10^{-9}	4.9×10^{-9}	4.2×10^{-9}
Lu-174m	142 d	M	0.005	1.9×10^{-8}	5.0×10^{-4}	1.4×10^{-8}	8.6×10^{-9}	5.4×10^{-9}	4.3×10^{-9}	3.7×10^{-9}
		S	0.005	2.0×10^{-8}	5.0×10^{-4}	1.5×10^{-8}	9.2×10^{-9}	6.1×10^{-9}	5.0×10^{-9}	4.2×10^{-9}
Lu-176	3.60×10^{10} a	M	0.005	1.8×10^{-7}	5.0×10^{-4}	1.7×10^{-7}	1.1×10^{-7}	7.8×10^{-8}	7.1×10^{-8}	7.0×10^{-8}
		S	0.005	1.5×10^{-7}	5.0×10^{-4}	1.4×10^{-7}	9.4×10^{-8}	6.5×10^{-8}	5.9×10^{-8}	5.6×10^{-8}
Lu-176m	3.68 h	M	0.005	8.9×10^{-10}	5.0×10^{-4}	5.9×10^{-10}	2.8×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	1.1×10^{-10}
		S	0.005	9.3×10^{-10}	5.0×10^{-4}	6.2×10^{-10}	3.0×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	1.2×10^{-10}
Lu-177	6.71 d	M	0.005	5.3×10^{-9}	5.0×10^{-4}	3.8×10^{-9}	2.2×10^{-9}	1.6×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
		S	0.005	5.7×10^{-9}	5.0×10^{-4}	4.1×10^{-9}	2.4×10^{-9}	1.7×10^{-9}	1.5×10^{-9}	1.2×10^{-9}
Lu-177m	161 d	M	0.005	5.8×10^{-8}	5.0×10^{-4}	4.6×10^{-8}	2.8×10^{-8}	1.9×10^{-8}	1.6×10^{-8}	1.3×10^{-8}
		S	0.005	6.5×10^{-8}	5.0×10^{-4}	5.3×10^{-8}	3.2×10^{-8}	2.3×10^{-8}	2.0×10^{-8}	1.6×10^{-8}
Lu-178	0.473 h	M	0.005	2.3×10^{-10}	5.0×10^{-4}	1.5×10^{-10}	6.6×10^{-11}	4.3×10^{-11}	2.9×10^{-11}	2.4×10^{-11}
		S	0.005	2.4×10^{-10}	5.0×10^{-4}	1.5×10^{-10}	6.9×10^{-11}	4.5×10^{-11}	3.0×10^{-11}	2.6×10^{-11}
Lu-178m	0.378 h	M	0.005	2.6×10^{-10}	5.0×10^{-4}	1.8×10^{-10}	8.3×10^{-11}	5.6×10^{-11}	3.8×10^{-11}	3.2×10^{-11}
		S	0.005	2.7×10^{-10}	5.0×10^{-4}	1.9×10^{-10}	8.7×10^{-11}	5.8×10^{-11}	4.0×10^{-11}	3.3×10^{-11}
Lu-179	4.59 h	M	0.005	9.9×10^{-10}	5.0×10^{-4}	6.5×10^{-10}	3.0×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	1.1×10^{-10}
		S	0.005	1.0×10^{-9}	5.0×10^{-4}	6.8×10^{-10}	3.2×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	1.2×10^{-10}
Hafnium										
Hf-170	16.0 h	F	0.020	1.4×10^{-9}	0.002	1.1×10^{-9}	5.4×10^{-10}	3.4×10^{-10}	2.0×10^{-10}	1.6×10^{-10}
		M	0.020	2.2×10^{-9}	0.002	1.7×10^{-9}	8.7×10^{-10}	5.8×10^{-10}	3.9×10^{-10}	3.2×10^{-10}
Hf-172	1.87 a	F	0.020	1.5×10^{-7}	0.002	1.3×10^{-7}	7.8×10^{-8}	4.9×10^{-8}	3.5×10^{-8}	3.2×10^{-8}
		M	0.020	8.1×10^{-8}	0.002	6.9×10^{-8}	4.3×10^{-8}	2.8×10^{-8}	2.3×10^{-8}	2.0×10^{-8}
Hf-173	24.0 h	F	0.020	6.6×10^{-10}	0.002	5.0×10^{-10}	2.5×10^{-10}	1.5×10^{-10}	8.9×10^{-11}	7.4×10^{-11}
		M	0.020	1.1×10^{-9}	0.002	8.2×10^{-10}	4.3×10^{-10}	2.9×10^{-10}	2.0×10^{-10}	1.6×10^{-10}
Hf-175	70.0 d	F	0.020	5.4×10^{-9}	0.002	4.0×10^{-9}	2.1×10^{-9}	1.3×10^{-9}	8.5×10^{-10}	7.2×10^{-10}
		M	0.020	5.8×10^{-9}	0.002	4.5×10^{-9}	2.6×10^{-9}	1.8×10^{-9}	1.4×10^{-9}	1.2×10^{-9}
Hf-177m	0.856 h	F	0.020	3.9×10^{-10}	0.002	2.8×10^{-10}	1.3×10^{-10}	8.5×10^{-11}	5.2×10^{-11}	4.4×10^{-11}
		M	0.020	6.5×10^{-10}	0.002	4.7×10^{-10}	2.3×10^{-10}	1.5×10^{-10}	1.1×10^{-10}	9.0×10^{-11}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g $\leq$1 a		f_1 for	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)	g > 1 a	e(g)	e(g)	e(g)	e(g)	e(g)
Hf-178m	31.0 a	F	0.020	6.2×10^{-7}	0.002	5.8×10^{-7}	4.0×10^{-7}	3.1×10^{-7}	2.7×10^{-7}	2.6×10^{-7}
		M	0.020	2.6×10^{-7}	0.002	2.4×10^{-7}	1.7×10^{-7}	1.3×10^{-7}	1.2×10^{-7}	1.2×10^{-7}
Hf-179m	25.1 d	F	0.020	9.7×10^{-9}	0.002	6.8×10^{-9}	3.4×10^{-9}	2.1×10^{-9}	1.2×10^{-9}	1.1×10^{-9}
		M	0.020	1.7×10^{-8}	0.002	1.3×10^{-8}	7.6×10^{-9}	5.5×10^{-9}	4.8×10^{-9}	3.8×10^{-9}
Hf-180m	5.50 h	F	0.020	5.4×10^{-10}	0.002	4.1×10^{-10}	2.0×10^{-10}	1.3×10^{-10}	7.2×10^{-11}	5.9×10^{-11}
		M	0.020	9.1×10^{-10}	0.002	6.8×10^{-10}	3.6×10^{-10}	2.4×10^{-10}	1.7×10^{-10}	1.3×10^{-10}
Hf-181	42.4 d	F	0.020	1.3×10^{-8}	0.002	9.6×10^{-9}	4.8×10^{-9}	2.8×10^{-9}	1.7×10^{-9}	1.4×10^{-9}
		M	0.020	2.2×10^{-8}	0.002	1.7×10^{-8}	9.9×10^{-9}	7.1×10^{-9}	6.3×10^{-9}	5.0×10^{-9}
Hf-182	9.00×10^{6} a	F	0.020	6.5×10^{-7}	0.002	6.2×10^{-7}	4.4×10^{-7}	3.6×10^{-7}	3.1×10^{-7}	3.1×10^{-7}
		M	0.020	2.4×10^{-7}	0.002	2.3×10^{-7}	1.7×10^{-7}	1.3×10^{-7}	1.3×10^{-7}	1.3×10^{-7}
Hf-182m	1.02 h	F	0.020	1.9×10^{-10}	0.002	1.4×10^{-10}	6.6×10^{-11}	4.2×10^{-11}	2.6×10^{-11}	2.1×10^{-11}
		M	0.020	3.2×10^{-10}	0.002	2.3×10^{-10}	1.2×10^{-10}	7.8×10^{-11}	5.6×10^{-11}	4.6×10^{-11}
Hf-183	1.07 h	F	0.020	2.5×10^{-10}	0.002	1.7×10^{-10}	7.9×10^{-11}	4.9×10^{-11}	2.8×10^{-11}	2.4×10^{-11}
		M	0.020	4.4×10^{-10}	0.002	3.0×10^{-10}	1.5×10^{-10}	9.8×10^{-11}	7.0×10^{-11}	5.7×10^{-11}
Hf-184	4.12 h	F	0.020	1.4×10^{-9}	0.002	9.6×10^{-10}	4.3×10^{-10}	2.7×10^{-10}	1.4×10^{-10}	1.2×10^{-10}
		M	0.020	2.6×10^{-9}	0.002	1.8×10^{-9}	8.9×10^{-10}	5.9×10^{-10}	4.0×10^{-10}	3.3×10^{-10}
Tantalum										
Ta-172	0.613 h	M	0.010	2.8×10^{-10}	0.001	1.9×10^{-10}	9.3×10^{-11}	6.0×10^{-11}	4.0×10^{-11}	3.3×10^{-11}
		S	0.010	2.9×10^{-10}	0.001	2.0×10^{-10}	9.8×10^{-11}	6.3×10^{-11}	4.2×10^{-11}	3.5×10^{-11}
Ta-173	3.65 h	M	0.010	8.8×10^{-10}	0.001	6.2×10^{-10}	3.0×10^{-10}	2.0×10^{-10}	1.3×10^{-10}	1.1×10^{-10}
		S	0.010	9.2×10^{-10}	0.001	6.5×10^{-10}	3.2×10^{-10}	2.1×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
Ta-174	1.20 h	M	0.010	3.2×10^{-10}	0.001	2.2×10^{-10}	1.1×10^{-10}	7.1×10^{-11}	5.0×10^{-11}	4.1×10^{-11}
		S	0.010	3.4×10^{-10}	0.001	2.3×10^{-10}	1.1×10^{-10}	7.5×10^{-11}	5.3×10^{-11}	4.3×10^{-11}
Ta-175	10.5 h	M	0.010	9.1×10^{-10}	0.001	7.0×10^{-10}	3.7×10^{-10}	2.4×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
		S	0.010	9.5×10^{-10}	0.001	7.3×10^{-10}	3.8×10^{-10}	2.5×10^{-10}	1.6×10^{-10}	1.3×10^{-10}

Ta-176	8.08 h	M	0.010	1.4×10^{-9}	0.001	1.1×10^{-9}	5.7×10^{-10}	3.7×10^{-10}	2.4×10^{-10}	1.9×10^{-10}
		S	0.010	1.4×10^{-9}	0.001	1.1×10^{-9}	5.9×10^{-10}	3.8×10^{-10}	2.5×10^{-10}	2.0×10^{-10}
Ta-177	2.36 d	M	0.010	6.5×10^{-10}	0.001	4.7×10^{-10}	2.5×10^{-10}	1.5×10^{-10}	1.2×10^{-10}	9.6×10^{-11}
		S	0.010	6.9×10^{-10}	0.001	5.0×10^{-10}	2.7×10^{-10}	1.7×10^{-10}	1.3×10^{-10}	1.1×10^{-10}
Ta-178	2.20 h	M	0.010	4.4×10^{-10}	0.001	3.3×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	8.0×10^{-11}	6.5×10^{-11}
		S	0.010	4.6×10^{-10}	0.001	3.4×10^{-10}	1.8×10^{-10}	1.2×10^{-10}	8.5×10^{-11}	6.8×10^{-11}
Ta-179	1.82 a	M	0.010	1.2×10^{-9}	0.001	9.6×10^{-10}	5.5×10^{-10}	3.5×10^{-10}	2.6×10^{-10}	2.2×10^{-10}
		S	0.010	2.4×10^{-9}	0.001	2.1×10^{-9}	1.3×10^{-9}	8.3×10^{-10}	6.4×10^{-10}	5.6×10^{-10}
Ta-180	1.00×10^{13} a	M	0.010	2.7×10^{-8}	0.001	2.2×10^{-8}	1.3×10^{-8}	9.2×10^{-9}	7.9×10^{-9}	6.4×10^{-9}
		S	0.010	7.0×10^{-8}	0.001	6.5×10^{-8}	4.5×10^{-8}	3.1×10^{-8}	2.8×10^{-8}	2.6×10^{-8}
Ta-180m	8.10 h	M	0.010	3.1×10^{-10}	0.001	2.2×10^{-10}	1.1×10^{-10}	7.4×10^{-11}	4.8×10^{-11}	4.4×10^{-11}
		S	0.010	3.3×10^{-10}	0.001	2.3×10^{-10}	1.2×10^{-10}	7.9×10^{-11}	5.2×10^{-11}	4.2×10^{-11}
Ta-182	115 d	M	0.010	3.2×10^{-8}	0.001	2.6×10^{-8}	1.5×10^{-8}	1.1×10^{-8}	9.5×10^{-9}	7.6×10^{-9}
		S	0.010	4.2×10^{-8}	0.001	3.4×10^{-8}	2.1×10^{-8}	1.5×10^{-8}	1.3×10^{-8}	1.0×10^{-8}
Ta-182m	0.264 h	M	0.010	1.6×10^{-10}	0.001	1.1×10^{-10}	4.9×10^{-11}	3.4×10^{-11}	2.4×10^{-11}	2.0×10^{-11}
		S	0.010	1.6×10^{-10}	0.001	1.1×10^{-10}	5.2×10^{-11}	3.6×10^{-11}	2.5×10^{-11}	2.1×10^{-11}
Ta-183	5.10 d	M	0.010	1.0×10^{-8}	0.001	7.4×10^{-9}	4.1×10^{-9}	2.9×10^{-9}	2.4×10^{-9}	1.9×10^{-9}
		S	0.010	1.1×10^{-8}	0.001	8.0×10^{-9}	4.5×10^{-9}	3.2×10^{-9}	2.7×10^{-9}	2.1×10^{-9}
Ta-184	8.70 h	M	0.010	3.2×10^{-9}	0.001	2.3×10^{-9}	1.1×10^{-9}	7.5×10^{-10}	5.0×10^{-10}	4.1×10^{-10}
		S	0.010	3.4×10^{-9}	0.001	2.4×10^{-9}	1.2×10^{-9}	7.9×10^{-10}	5.4×10^{-10}	4.3×10^{-10}
Ta-185	0.816 h	M	0.010	3.8×10^{-10}	0.001	2.5×10^{-10}	1.2×10^{-10}	7.7×10^{-11}	5.4×10^{-11}	4.5×10^{-11}
		S	0.010	4.0×10^{-10}	0.001	2.6×10^{-10}	1.2×10^{-10}	8.2×10^{-11}	5.7×10^{-11}	4.8×10^{-11}
Ta-186	0.175 h	M	0.010	1.6×10^{-10}	0.001	1.1×10^{-10}	4.8×10^{-11}	3.1×10^{-11}	2.0×10^{-11}	1.7×10^{-11}
		S	0.010	1.6×10^{-10}	0.001	1.1×10^{-10}	5.0×10^{-11}	3.2×10^{-11}	2.1×10^{-11}	1.8×10^{-11}
Tungsten										
W-176	2.30 h	F	0.600	3.3×10^{-10}	0.300	2.7×10^{-10}	1.4×10^{-10}	8.6×10^{-11}	5.0×10^{-11}	4.1×10^{-11}
W-177	2.25 h	F	0.600	2.0×10^{-10}	0.300	1.6×10^{-10}	8.2×10^{-11}	5.1×10^{-11}	3.0×10^{-11}	2.4×10^{-11}
W-178	21.7 d	F	0.600	7.2×10^{-10}	0.300	5.4×10^{-10}	2.5×10^{-10}	1.6×10^{-10}	8.7×10^{-11}	7.2×10^{-11}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
W-179	0.625 h	F	0.600	9.3×10^{-12}	0.300	6.8×10^{-12}	3.3×10^{-12}	2.0×10^{-12}	1.2×10^{-12}	9.2×10^{-13}
W-181	121 d	F	0.600	2.5×10^{-10}	0.300	1.9×10^{-10}	9.2×10^{-11}	5.7×10^{-11}	3.2×10^{-11}	2.7×10^{-11}
W-185	75.1 d	F	0.600	1.4×10^{-9}	0.300	1.0×10^{-9}	4.4×10^{-10}	2.7×10^{-10}	1.4×10^{-10}	1.2×10^{-10}
W-187	23.9 h	F	0.600	2.0×10^{-9}	0.300	1.5×10^{-9}	7.0×10^{-10}	4.3×10^{-10}	2.3×10^{-10}	1.9×10^{-10}
W-188	69.4 d	F	0.600	7.1×10^{-9}	0.300	5.0×10^{-9}	2.2×10^{-9}	1.3×10^{-9}	6.8×10^{-10}	5.7×10^{-10}
Rhenium										
Re-177	0.233 h	F	1.000	9.4×10^{-11}	0.800	6.7×10^{-11}	3.2×10^{-11}	1.9×10^{-11}	1.2×10^{-11}	9.7×10^{-12}
		M	1.000	1.1×10^{-10}	0.800	7.9×10^{-11}	3.9×10^{-11}	2.5×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
Re-178	0.220 h	F	1.000	9.9×10^{-11}	0.800	6.8×10^{-11}	3.1×10^{-11}	1.9×10^{-11}	1.2×10^{-11}	1.0×10^{-11}
		M	1.000	1.3×10^{-10}	0.800	8.5×10^{-11}	3.9×10^{-11}	2.6×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
Re-181	20.0 h	F	1.000	2.0×10^{-9}	0.800	1.4×10^{-9}	6.7×10^{-10}	3.8×10^{-10}	2.3×10^{-10}	1.8×10^{-10}
		M	1.000	2.1×10^{-9}	0.800	1.5×10^{-9}	7.4×10^{-10}	4.6×10^{-10}	3.1×10^{-10}	2.5×10^{-10}
Re-182	2.67 d	F	1.000	6.5×10^{-9}	0.800	4.7×10^{-9}	2.2×10^{-9}	1.3×10^{-9}	8.0×10^{-10}	6.4×10^{-10}
		M	1.000	8.7×10^{-9}	0.800	6.3×10^{-9}	3.4×10^{-9}	2.2×10^{-9}	1.5×10^{-9}	1.2×10^{-9}
Re-182	12.7 h	F	1.000	1.3×10^{-9}	0.800	1.0×10^{-9}	4.9×10^{-10}	2.8×10^{-10}	1.7×10^{-10}	1.4×10^{-10}
		M	1.000	1.4×10^{-9}	0.800	1.1×10^{-9}	5.7×10^{-10}	3.6×10^{-10}	2.5×10^{-10}	2.0×10^{-10}
Re-184	38.0 d	F	1.000	4.1×10^{-9}	0.800	2.9×10^{-9}	1.4×10^{-9}	8.6×10^{-10}	5.4×10^{-10}	4.4×10^{-10}
		M	1.000	9.1×10^{-9}	0.800	6.8×10^{-9}	4.0×10^{-9}	2.8×10^{-9}	2.4×10^{-9}	1.9×10^{-9}
Re-184m	165 d	F	1.000	6.6×10^{-9}	0.800	4.6×10^{-9}	2.0×10^{-9}	1.2×10^{-9}	7.3×10^{-10}	5.9×10^{-10}
		M	1.000	2.9×10^{-8}	0.800	2.2×10^{-8}	1.3×10^{-8}	9.3×10^{-9}	8.1×10^{-9}	6.5×10^{-9}
Re-186	3.78 d	F	1.000	7.3×10^{-9}	0.800	4.7×10^{-9}	2.0×10^{-9}	1.1×10^{-9}	6.6×10^{-10}	5.2×10^{-10}
		M	1.000	8.7×10^{-9}	0.800	5.7×10^{-9}	2.8×10^{-9}	1.8×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
Re-186m	2.00×10^{5} a	F	1.000	1.2×10^{-8}	0.800	7.0×10^{-9}	2.9×10^{-9}	1.7×10^{-9}	1.0×10^{-9}	8.3×10^{-10}
		M	1.000	5.9×10^{-8}	0.800	4.6×10^{-8}	2.7×10^{-8}	1.8×10^{-8}	1.4×10^{-8}	1.2×10^{-8}

Re-187	5.00×10^{10} a	F	1.000	2.6×10^{-11}	0.800	1.6×10^{-11}	6.8×10^{-12}	3.8×10^{-12}	2.3×10^{-12}	1.8×10^{-12}
		M	1.000	5.7×10^{-11}	0.800	4.1×10^{-11}	2.0×10^{-11}	1.2×10^{-11}	7.5×10^{-12}	6.3×10^{-12}
Re-188	17.0 h	F	1.000	6.5×10^{-9}	0.800	4.4×10^{-9}	1.9×10^{-9}	1.0×10^{-9}	6.1×10^{-10}	4.6×10^{-10}
		M	1.000	6.0×10^{-9}	0.800	4.0×10^{-9}	1.8×10^{-9}	1.0×10^{-9}	6.8×10^{-10}	5.4×10^{-10}
Re-188m	0.310 h	F	1.000	1.4×10^{-10}	0.800	9.1×10^{-11}	4.0×10^{-11}	2.1×10^{-11}	1.3×10^{-11}	1.0×10^{-11}
		M	1.000	1.3×10^{-10}	0.800	8.6×10^{-11}	4.0×10^{-11}	2.7×10^{-11}	1.6×10^{-11}	1.3×10^{-11}
Re-189	1.01 d	F	1.000	3.7×10^{-9}	0.800	2.5×10^{-9}	1.1×10^{-9}	5.8×10^{-10}	3.5×10^{-10}	2.7×10^{-10}
		M	1.000	3.9×10^{-9}	0.800	2.6×10^{-9}	1.2×10^{-9}	7.6×10^{-10}	5.5×10^{-10}	4.3×10^{-10}
Osmium										
Os-180	0.366 h	F	0.020	7.1×10^{-11}	0.010	5.3×10^{-11}	2.6×10^{-11}	1.6×10^{-11}	1.0×10^{-11}	8.2×10^{-12}
		M	0.020	1.1×10^{-10}	0.010	7.9×10^{-11}	3.9×10^{-11}	2.5×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
		S	0.020	1.1×10^{-10}	0.010	8.2×10^{-11}	4.1×10^{-11}	2.6×10^{-11}	1.8×10^{-11}	1.5×10^{-11}
Os-181	1.75 h	F	0.020	3.0×10^{-10}	0.010	2.3×10^{-10}	1.1×10^{-10}	7.0×10^{-11}	4.1×10^{-11}	3.3×10^{-11}
		M	0.020	4.5×10^{-10}	0.010	3.4×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	7.6×10^{-11}	6.2×10^{-11}
		S	0.020	4.7×10^{-10}	0.010	3.6×10^{-10}	1.8×10^{-10}	1.2×10^{-10}	8.1×10^{-11}	6.5×10^{-11}
Os-182	22.0 h	F	0.020	1.6×10^{-9}	0.010	1.2×10^{-9}	6.0×10^{-10}	3.7×10^{-10}	2.1×10^{-10}	1.7×10^{-10}
		M	0.020	2.5×10^{-9}	0.010	1.9×10^{-9}	1.0×10^{-9}	6.6×10^{-10}	4.5×10^{-10}	3.6×10^{-10}
		S	0.020	2.6×10^{-9}	0.010	2.0×10^{-9}	1.0×10^{-9}	6.9×10^{-10}	4.8×10^{-10}	3.8×10^{-10}
Os-185	94.0 d	F	0.020	7.2×10^{-9}	0.010	5.8×10^{-9}	3.1×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	1.1×10^{-9}
		M	0.020	6.6×10^{-9}	0.010	5.4×10^{-9}	2.9×10^{-9}	2.0×10^{-9}	1.5×10^{-9}	1.3×10^{-9}
		S	0.020	7.0×10^{-9}	0.010	5.8×10^{-9}	3.6×10^{-9}	2.4×10^{-9}	1.9×10^{-9}	1.6×10^{-9}
Os-189m	6.00 h	F	0.020	3.8×10^{-11}	0.010	2.8×10^{-11}	1.2×10^{-11}	7.0×10^{-12}	3.5×10^{-12}	2.5×10^{-12}
		M	0.020	6.5×10^{-11}	0.010	4.1×10^{-11}	1.8×10^{-11}	1.1×10^{-11}	6.0×10^{-12}	5.0×10^{-12}
		S	0.020	6.8×10^{-11}	0.010	4.3×10^{-11}	1.9×10^{-11}	1.2×10^{-11}	6.3×10^{-12}	5.3×10^{-12}
Os-191	15.4 d	F	0.020	2.8×10^{-9}	0.010	1.9×10^{-9}	8.5×10^{-10}	5.3×10^{-10}	3.0×10^{-10}	2.5×10^{-10}
		M	0.020	8.0×10^{-9}	0.010	5.8×10^{-9}	3.4×10^{-9}	2.4×10^{-9}	2.0×10^{-9}	1.7×10^{-9}
		S	0.020	9.0×10^{-9}	0.010	6.5×10^{-9}	3.9×10^{-9}	2.7×10^{-9}	2.3×10^{-9}	1.9×10^{-9}
Os-191m	13.0 h	F	0.020	3.0×10^{-10}	0.010	2.0×10^{-10}	8.8×10^{-11}	5.4×10^{-11}	2.9×10^{-11}	2.4×10^{-11}
		M	0.020	7.8×10^{-10}	0.010	5.4×10^{-10}	3.1×10^{-10}	2.1×10^{-10}	1.7×10^{-10}	1.4×10^{-10}
		S	0.020	8.5×10^{-10}	0.010	6.0×10^{-10}	3.4×10^{-10}	2.4×10^{-10}	2.0×10^{-10}	1.6×10^{-10}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for g > 1 a	Age 1-2 a	Age 2-7 a	Age 7-12 a	Age 12-17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Os-193	1.25 d	F	0.020	1.9×10^{-9}	0.010	1.2×10^{-9}	5.2×10^{-10}	3.2×10^{-10}	1.8×10^{-10}	1.6×10^{-10}
		M	0.020	3.8×10^{-9}	0.010	2.6×10^{-9}	1.3×10^{-9}	8.4×10^{-10}	5.9×10^{-10}	4.8×10^{-10}
		S	0.020	4.0×10^{-9}	0.010	2.7×10^{-9}	1.3×10^{-9}	9.0×10^{-10}	6.4×10^{-10}	5.2×10^{-10}
Os-194	6.00 a	F	0.020	8.7×10^{-8}	0.010	6.8×10^{-8}	3.4×10^{-8}	2.1×10^{-8}	1.3×10^{-8}	1.1×10^{-8}
		M	0.020	9.9×10^{-8}	0.010	8.3×10^{-8}	4.8×10^{-8}	3.1×10^{-8}	2.4×10^{-8}	2.1×10^{-8}
		S	0.020	2.6×10^{-7}	0.010	2.4×10^{-7}	1.6×10^{-7}	1.1×10^{-7}	8.8×10^{-8}	8.5×10^{-8}
Iridium										
Ir-182	0.250 h	F	0.020	1.4×10^{-10}	0.010	9.8×10^{-11}	4.5×10^{-11}	2.8×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
		M	0.020	2.1×10^{-10}	0.010	1.4×10^{-10}	6.7×10^{-11}	4.3×10^{-11}	2.8×10^{-11}	2.3×10^{-11}
		S	0.020	2.2×10^{-10}	0.010	1.5×10^{-10}	6.9×10^{-11}	4.4×10^{-11}	2.9×10^{-11}	2.4×10^{-11}
Ir-184	3.02 h	F	0.020	5.7×10^{-10}	0.010	4.4×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	7.6×10^{-11}	6.2×10^{-11}
		M	0.020	8.6×10^{-10}	0.010	6.4×10^{-10}	3.2×10^{-10}	2.1×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
		S	0.020	8.9×10^{-10}	0.010	6.6×10^{-10}	3.4×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	1.2×10^{-10}
Ir-185	14.0 h	F	0.020	8.0×10^{-10}	0.010	6.1×10^{-10}	2.9×10^{-10}	1.8×10^{-10}	1.0×10^{-10}	8.2×10^{-11}
		M	0.020	1.3×10^{-9}	0.010	9.7×10^{-10}	4.9×10^{-10}	3.2×10^{-10}	2.2×10^{-10}	1.8×10^{-10}
		S	0.020	1.4×10^{-9}	0.010	1.0×10^{-9}	5.2×10^{-10}	3.4×10^{-10}	2.3×10^{-10}	1.9×10^{-10}
Ir-186	15.8 h	F	0.020	1.5×10^{-9}	0.010	1.2×10^{-9}	5.9×10^{-10}	3.6×10^{-10}	2.1×10^{-10}	1.7×10^{-10}
		M	0.020	2.2×10^{-9}	0.010	1.7×10^{-9}	8.8×10^{-10}	5.8×10^{-10}	3.8×10^{-10}	3.1×10^{-10}
		S	0.020	2.3×10^{-9}	0.010	1.8×10^{-9}	9.2×10^{-10}	6.0×10^{-10}	4.0×10^{-10}	3.2×10^{-10}
Ir-186	1.75 h	F	0.020	2.1×10^{-10}	0.010	1.6×10^{-10}	7.7×10^{-11}	4.8×10^{-11}	2.8×10^{-11}	2.3×10^{-11}
		M	0.020	3.3×10^{-10}	0.010	2.4×10^{-10}	1.2×10^{-10}	7.7×10^{-11}	5.1×10^{-11}	4.2×10^{-11}
		S	0.020	3.4×10^{-10}	0.010	2.5×10^{-10}	1.2×10^{-10}	8.1×10^{-11}	5.4×10^{-11}	4.4×10^{-11}
Ir-187	10.5 h	F	0.020	3.6×10^{-10}	0.010	2.8×10^{-10}	1.4×10^{-10}	8.2×10^{-11}	4.6×10^{-11}	3.7×10^{-11}
		M	0.020	5.8×10^{-10}	0.010	4.3×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	9.2×10^{-11}	7.4×10^{-11}
		S	0.020	6.0×10^{-10}	0.010	4.5×10^{-10}	2.3×10^{-10}	1.5×10^{-10}	9.7×10^{-11}	7.9×10^{-11}

Ir-188	1.73 d	F	0.020	2.0×10^{-9}	0.010	1.6×10^{-9}	8.0×10^{-10}	5.0×10^{-10}	2.9×10^{-10}	2.4×10^{-10}
		M	0.020	2.7×10^{-9}	0.010	2.1×10^{-9}	1.1×10^{-9}	7.5×10^{-10}	5.0×10^{-10}	4.0×10^{-10}
		S	0.020	2.8×10^{-9}	0.010	2.2×10^{-9}	1.2×10^{-9}	7.8×10^{-10}	5.2×10^{-10}	4.2×10^{-10}
Ir-189	13.3 d	F	0.020	1.2×10^{-9}	0.010	8.2×10^{-10}	3.8×10^{-10}	2.4×10^{-10}	1.3×10^{-10}	1.1×10^{-10}
		M	0.020	2.7×10^{-9}	0.010	1.9×10^{-9}	1.1×10^{-9}	7.7×10^{-10}	6.4×10^{-10}	5.2×10^{-10}
		S	0.020	3.0×10^{-9}	0.010	2.2×10^{-9}	1.3×10^{-9}	8.7×10^{-10}	7.3×10^{-10}	6.0×10^{-10}
Ir-190	12.1 d	F	0.020	6.2×10^{-9}	0.010	4.7×10^{-9}	2.4×10^{-9}	1.5×10^{-9}	9.1×10^{-10}	7.7×10^{-10}
		M	0.020	1.1×10^{-8}	0.010	8.6×10^{-9}	4.4×10^{-9}	3.1×10^{-9}	2.7×10^{-9}	2.1×10^{-9}
		S	0.020	1.1×10^{-8}	0.010	9.4×10^{-9}	4.8×10^{-9}	3.5×10^{-9}	3.0×10^{-9}	2.4×10^{-9}
Ir-190m	3.10 h	F	0.020	4.2×10^{-10}	0.010	3.4×10^{-10}	1.7×10^{-10}	1.0×10^{-10}	6.0×10^{-11}	4.9×10^{-11}
		M	0.020	6.0×10^{-10}	0.010	4.7×10^{-10}	2.4×10^{-10}	1.5×10^{-10}	9.9×10^{-11}	7.9×10^{-11}
		S	0.020	6.2×10^{-10}	0.010	4.8×10^{-10}	2.5×10^{-10}	1.6×10^{-10}	1.0×10^{-10}	8.3×10^{-11}
Ir-190m	1.20 h	F	0.020	3.2×10^{-11}	0.010	2.4×10^{-11}	1.2×10^{-11}	7.2×10^{-12}	4.3×10^{-12}	3.6×10^{-12}
		M	0.020	5.7×10^{-11}	0.010	4.2×10^{-11}	2.0×10^{-11}	1.4×10^{-11}	1.2×10^{-11}	9.3×10^{-12}
		S	0.020	5.5×10^{-11}	0.010	4.5×10^{-11}	2.2×10^{-11}	1.6×10^{-11}	1.3×10^{-11}	1.0×10^{-11}
Ir-192	74.0 d	F	0.020	1.5×10^{-8}	0.010	1.1×10^{-8}	5.7×10^{-9}	3.3×10^{-9}	2.1×10^{-9}	1.8×10^{-9}
		M	0.020	2.3×10^{-8}	0.010	1.8×10^{-8}	1.1×10^{-8}	7.6×10^{-9}	6.4×10^{-9}	5.2×10^{-9}
		S	0.020	2.8×10^{-8}	0.010	2.2×10^{-8}	1.3×10^{-8}	9.5×10^{-9}	8.1×10^{-9}	6.6×10^{-9}
Ir-192m	2.41×10^{2} a	F	0.020	2.7×10^{-8}	0.010	2.3×10^{-8}	1.4×10^{-8}	8.2×10^{-9}	5.4×10^{-9}	4.8×10^{-9}
		M	0.020	2.3×10^{-8}	0.010	2.1×10^{-8}	1.3×10^{-8}	8.4×10^{-9}	6.6×10^{-9}	5.8×10^{-9}
		S	0.020	9.2×10^{-8}	0.010	9.1×10^{-8}	6.5×10^{-8}	4.5×10^{-8}	4.0×10^{-8}	3.9×10^{-8}
Ir-193m	11.9 d	F	0.020	1.2×10^{-9}	0.010	8.4×10^{-10}	3.7×10^{-10}	2.2×10^{-10}	1.2×10^{-10}	1.0×10^{-10}
		M	0.020	4.8×10^{-9}	0.010	3.5×10^{-9}	2.1×10^{-9}	1.5×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
		S	0.020	5.4×10^{-9}	0.010	4.0×10^{-9}	2.4×10^{-9}	1.8×10^{-9}	1.6×10^{-9}	1.3×10^{-9}
Ir-194	19.1 h	F	0.020	2.9×10^{-9}	0.010	1.9×10^{-9}	8.1×10^{-10}	4.9×10^{-10}	2.5×10^{-10}	2.1×10^{-10}
		M	0.020	5.3×10^{-9}	0.010	3.5×10^{-9}	1.6×10^{-9}	1.0×10^{-9}	6.3×10^{-10}	5.2×10^{-10}
		S	0.020	5.5×10^{-9}	0.010	3.7×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	6.7×10^{-10}	5.6×10^{-10}
Ir-194m	171 d	F	0.020	3.4×10^{-8}	0.010	2.7×10^{-8}	1.4×10^{-8}	9.5×10^{-9}	6.2×10^{-9}	5.4×10^{-9}
		M	0.020	3.9×10^{-8}	0.010	3.2×10^{-8}	1.9×10^{-8}	1.3×10^{-8}	1.1×10^{-8}	9.0×10^{-9}
		S	0.020	5.0×10^{-8}	0.010	4.2×10^{-8}	2.6×10^{-8}	1.8×10^{-8}	1.5×10^{-8}	1.3×10^{-8}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤ 1 a: f_1	Age g ≤ 1 a: e(g)	f_1 for g > 1 a	Age 1–2 a e(g)	Age 2–7 a e(g)	Age 7–12 a e(g)	Age 12–17 a e(g)	Age > 17 a e(g)
Ir-195	2.50 h	F	0.020	2.9×10^{-10}	0.010	1.9×10^{-10}	8.1×10^{-11}	5.1×10^{-11}	2.9×10^{-11}	2.4×10^{-11}
		M	0.020	5.4×10^{-10}	0.010	3.6×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	8.1×10^{-11}	6.7×10^{-11}
		S	0.020	5.7×10^{-10}	0.010	3.8×10^{-10}	1.8×10^{-10}	1.2×10^{-10}	8.7×10^{-11}	7.1×10^{-11}
Ir-195m	3.80 h	F	0.020	6.9×10^{-10}	0.010	4.8×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	7.2×10^{-11}	6.0×10^{-11}
		M	0.020	1.2×10^{-9}	0.010	8.6×10^{-10}	4.2×10^{-10}	2.7×10^{-10}	1.9×10^{-10}	1.6×10^{-10}
		S	0.020	1.3×10^{-9}	0.010	9.0×10^{-10}	4.4×10^{-10}	2.9×10^{-10}	2.0×10^{-10}	1.7×10^{-10}
Platinum										
Pt-186	2.00 h	F	0.020	3.0×10^{-10}	0.010	2.4×10^{-10}	1.2×10^{-10}	7.2×10^{-11}	4.1×10^{-11}	3.3×10^{-11}
Pt-188	10.2 d	F	0.020	3.6×10^{-9}	0.010	2.7×10^{-9}	1.3×10^{-9}	8.4×10^{-10}	5.0×10^{-10}	4.2×10^{-10}
Pt-189	10.9 h	F	0.020	3.8×10^{-10}	0.010	2.9×10^{-10}	1.4×10^{-10}	8.4×10^{-11}	4.7×10^{-11}	3.8×10^{-11}
Pt-191	2.80 d	F	0.020	1.1×10^{-9}	0.010	7.9×10^{-10}	3.7×10^{-10}	2.3×10^{-10}	1.3×10^{-10}	1.1×10^{-10}
Pt-193	50.0 a	F	0.020	2.2×10^{-10}	0.010	1.6×10^{-10}	7.2×10^{-11}	4.3×10^{-11}	2.5×10^{-11}	2.1×10^{-11}
Pt-193m	4.33 d	F	0.020	1.6×10^{-9}	0.010	1.0×10^{-9}	4.5×10^{-10}	2.7×10^{-10}	1.4×10^{-10}	1.2×10^{-10}
Pt-195m	4.02 d	F	0.020	2.2×10^{-9}	0.010	1.5×10^{-9}	6.4×10^{-10}	3.9×10^{-10}	2.1×10^{-10}	1.8×10^{-10}
Pt-197	18.3 h	F	0.020	1.1×10^{-9}	0.010	7.3×10^{-10}	3.1×10^{-10}	1.9×10^{-10}	1.0×10^{-10}	8.5×10^{-11}
Pt-197m	1.57 h	F	0.020	2.8×10^{-10}	0.010	1.8×10^{-10}	7.9×10^{-11}	4.9×10^{-11}	2.8×10^{-11}	2.4×10^{-11}
Pt-199	0.513 h	F	0.020	1.3×10^{-10}	0.010	8.3×10^{-11}	3.6×10^{-11}	2.3×10^{-11}	1.4×10^{-11}	1.2×10^{-11}
Pt-200	12.5 h	F	0.020	2.6×10^{-9}	0.010	1.7×10^{-9}	7.2×10^{-10}	5.1×10^{-10}	2.6×10^{-10}	2.2×10^{-10}
Gold										
Au-193	17.6 h	F	0.200	3.7×10^{-10}	0.100	2.8×10^{-10}	1.3×10^{-10}	7.9×10^{-11}	4.3×10^{-11}	3.6×10^{-11}
		M	0.200	7.5×10^{-10}	0.100	5.6×10^{-10}	2.8×10^{-10}	1.9×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
		S	0.200	7.9×10^{-10}	0.100	5.9×10^{-10}	3.0×10^{-10}	2.0×10^{-10}	1.5×10^{-10}	1.2×10^{-10}

Au-194	1.65 d	F	0.200	1.2×10^{-9}	0.100	9.6×10^{-10}	4.9×10^{-10}	3.0×10^{-10}	1.8×10^{-10}	1.4×10^{-10}
		M	0.200	1.7×10^{-9}	0.100	1.4×10^{-9}	7.1×10^{-10}	4.6×10^{-10}	2.9×10^{-10}	2.3×10^{-10}
		S	0.200	1.7×10^{-9}	0.100	1.4×10^{-9}	7.3×10^{-10}	4.7×10^{-10}	3.0×10^{-10}	2.4×10^{-10}
Au-195	183 d	F	0.200	7.2×10^{-10}	0.100	5.3×10^{-10}	2.5×10^{-10}	1.5×10^{-10}	8.1×10^{-11}	6.6×10^{-11}
		M	0.200	5.2×10^{-9}	0.100	4.1×10^{-9}	2.4×10^{-9}	1.6×10^{-9}	1.4×10^{-9}	1.1×10^{-9}
		S	0.200	8.1×10^{-9}	0.100	6.6×10^{-9}	3.9×10^{-9}	2.6×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
Au-198	2.69 d	F	0.200	2.4×10^{-9}	0.100	1.7×10^{-9}	7.6×10^{-10}	4.7×10^{-10}	2.5×10^{-10}	2.1×10^{-10}
		M	0.200	5.0×10^{-9}	0.100	4.1×10^{-9}	1.9×10^{-9}	1.3×10^{-9}	9.7×10^{-10}	7.8×10^{-10}
		S	0.200	5.4×10^{-9}	0.100	4.4×10^{-9}	2.0×10^{-9}	1.4×10^{-9}	1.1×10^{-9}	8.6×10^{-10}
Au-198m	2.30 d	F	0.200	3.3×10^{-9}	0.100	2.4×10^{-9}	1.1×10^{-9}	6.9×10^{-10}	3.7×10^{-10}	3.2×10^{-10}
		M	0.200	8.7×10^{-9}	0.100	6.5×10^{-9}	3.6×10^{-9}	2.6×10^{-9}	2.2×10^{-9}	1.8×10^{-9}
		S	0.200	9.5×10^{-9}	0.100	7.1×10^{-9}	4.0×10^{-9}	2.9×10^{-9}	2.5×10^{-9}	2.0×10^{-9}
Au-199	3.14 d	F	0.200	1.1×10^{-9}	0.100	7.9×10^{-10}	3.5×10^{-10}	2.2×10^{-10}	1.1×10^{-10}	9.8×10^{-11}
		M	0.200	3.4×10^{-9}	0.100	2.5×10^{-9}	1.4×10^{-9}	1.0×10^{-9}	9.0×10^{-10}	7.1×10^{-10}
		S	0.200	3.8×10^{-9}	0.100	2.8×10^{-9}	1.6×10^{-9}	1.2×10^{-9}	1.0×10^{-9}	7.9×10^{-10}
Au-200	0.807 h	F	0.200	1.9×10^{-10}	0.100	1.2×10^{-10}	5.2×10^{-11}	3.2×10^{-11}	1.9×10^{-11}	1.6×10^{-11}
		M	0.200	3.2×10^{-10}	0.100	2.1×10^{-10}	9.3×10^{-11}	6.0×10^{-11}	4.0×10^{-11}	3.3×10^{-11}
		S	0.200	3.4×10^{-10}	0.100	2.1×10^{-10}	9.8×10^{-11}	6.3×10^{-11}	4.2×10^{-11}	3.5×10^{-11}
Au-200m	18.7 h	F	0.200	2.7×10^{-9}	0.100	2.1×10^{-9}	1.0×10^{-9}	6.4×10^{-10}	3.6×10^{-10}	2.9×10^{-10}
		M	0.200	4.8×10^{-9}	0.100	3.7×10^{-9}	1.9×10^{-9}	1.2×10^{-9}	8.4×10^{-10}	6.8×10^{-10}
		S	0.200	5.1×10^{-9}	0.100	3.9×10^{-9}	2.0×10^{-9}	1.3×10^{-9}	8.9×10^{-10}	7.2×10^{-10}
Au-201	0.440 h	F	0.200	9.0×10^{-11}	0.100	5.7×10^{-11}	2.5×10^{-11}	1.6×10^{-11}	1.0×10^{-11}	8.7×10^{-12}
		M	0.200	1.5×10^{-10}	0.100	9.6×10^{-11}	4.3×10^{-11}	2.9×10^{-11}	2.0×10^{-11}	1.7×10^{-11}
		S	0.200	1.5×10^{-10}	0.100	1.0×10^{-10}	4.5×10^{-11}	3.0×10^{-11}	2.1×10^{-11}	1.7×10^{-11}
Mercury										
Hg-193 (organic)	3.50 h	F	0.800	2.2×10^{-10}	0.400	1.8×10^{-10}	8.2×10^{-11}	5.0×10^{-11}	2.9×10^{-11}	2.4×10^{-11}
Hg-193 (inorganic)	3.50 h	F	0.040	2.7×10^{-10}	0.020	2.0×10^{-10}	8.9×10^{-11}	5.5×10^{-11}	3.1×10^{-11}	2.6×10^{-11}
		M	0.040	5.3×10^{-10}	0.020	3.8×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	9.2×10^{-11}	7.5×10^{-11}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤ 1 a		f_1 for g > 1 a	Age 1-2 a	Age 2-7 a	Age 7-12 a	Age 12-17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Hg-193m (organic)	11.1 h	F	0.800	8.4×10^{-10}	0.400	7.6×10^{-10}	3.7×10^{-10}	2.2×10^{-10}	1.3×10^{-10}	1.0×10^{-10}
Hg-193m (inorganic)	11.1 h	F	0.040	1.1×10^{-9}	0.020	8.5×10^{-10}	4.1×10^{-10}	2.5×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
		M	0.040	1.9×10^{-9}	0.020	1.4×10^{-9}	7.2×10^{-10}	4.7×10^{-10}	3.2×10^{-10}	2.6×10^{-10}
Hg-194 (organic)	2.60×10^2 a	F	0.800	4.9×10^{-8}	0.400	3.7×10^{-8}	2.4×10^{-8}	1.9×10^{-8}	1.5×10^{-8}	1.4×10^{-8}
Hg-194 (inorganic)	2.60×10^2 a	F	0.040	3.2×10^{-8}	0.020	2.9×10^{-8}	2.0×10^{-8}	1.6×10^{-8}	1.4×10^{-8}	1.3×10^{-8}
		M	0.040	2.1×10^{-8}	0.020	1.9×10^{-8}	1.3×10^{-8}	1.0×10^{-8}	8.9×10^{-9}	8.3×10^{-9}
Hg-195 (organic)	9.90 h	F	0.800	2.0×10^{-10}	0.400	1.8×10^{-10}	8.5×10^{-11}	5.1×10^{-11}	2.8×10^{-11}	2.3×10^{-11}
Hg-195 (inorganic)	9.90 h	F	0.040	2.7×10^{-10}	0.020	2.0×10^{-10}	9.5×10^{-11}	5.7×10^{-11}	3.1×10^{-11}	2.5×10^{-11}
		M	0.040	5.3×10^{-10}	0.020	3.9×10^{-10}	2.0×10^{-10}	1.3×10^{-10}	9.0×10^{-11}	7.3×10^{-11}
Hg-195m (organic)	1.73 d	F	0.800	1.1×10^{-9}	0.400	9.7×10^{-10}	4.4×10^{-10}	2.7×10^{-10}	1.4×10^{-10}	1.2×10^{-10}
Hg-195m (inorganic)	1.73 d	F	0.040	1.6×10^{-9}	0.020	1.1×10^{-9}	5.1×10^{-10}	3.1×10^{-10}	1.7×10^{-10}	1.4×10^{-10}
		M	0.040	3.7×10^{-9}	0.020	2.6×10^{-9}	1.4×10^{-9}	8.5×10^{-10}	6.7×10^{-10}	5.3×10^{-10}
Hg-197 (organic)	2.67 d	F	0.800	4.7×10^{-10}	0.400	4.0×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	5.8×10^{-11}	4.7×10^{-11}
Hg-197 (inorganic)	2.67 d	F	0.040	6.8×10^{-10}	0.020	4.7×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	6.8×10^{-11}	5.6×10^{-11}
		M	0.040	1.7×10^{-9}	0.020	1.2×10^{-9}	6.6×10^{-10}	4.6×10^{-10}	3.8×10^{-10}	3.0×10^{-10}
Hg-197m (organic)	23.8 h	F	0.800	9.3×10^{-10}	0.400	7.8×10^{-10}	3.4×10^{-10}	2.1×10^{-10}	1.1×10^{-10}	9.6×10^{-11}
Hg-197m (inorganic)	23.8 h	F	0.040	1.4×10^{-9}	0.020	9.3×10^{-10}	4.0×10^{-10}	2.5×10^{-10}	1.3×10^{-10}	1.1×10^{-10}
		M	0.040	3.5×10^{-9}	0.020	2.5×10^{-9}	1.1×10^{-9}	8.2×10^{-10}	6.7×10^{-10}	5.3×10^{-10}

Hg-199m (organic)	0.710 h	F	0.800	1.4×10^{-10}	0.400	9.6×10^{-11}	4.2×10^{-11}	2.7×10^{-11}	1.7×10^{-11}	1.5×10^{-11}
Hg-199m (inorganic)	0.710 h	F	0.040	1.4×10^{-10}	0.020	9.6×10^{-11}	4.2×10^{-11}	2.7×10^{-11}	1.7×10^{-11}	1.5×10^{-11}
		M	0.040	2.5×10^{-10}	0.020	1.7×10^{-10}	7.9×10^{-11}	5.4×10^{-11}	3.8×10^{-11}	3.2×10^{-11}
Hg-203 (organic)	46.6 d	F	0.800	5.7×10^{-9}	0.400	3.7×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	6.6×10^{-10}	5.6×10^{-10}
Hg-203 (inorganic)	46.6 d	F	0.040	4.2×10^{-9}	0.020	2.9×10^{-9}	1.4×10^{-9}	9.0×10^{-10}	5.5×10^{-10}	4.6×10^{-10}
		M	0.040	1.0×10^{-8}	0.020	7.9×10^{-9}	4.7×10^{-9}	3.4×10^{-9}	3.0×10^{-9}	2.4×10^{-9}
Thallium										
Tl-194	0.550 h	F	1.000	3.6×10^{-11}	1.000	3.0×10^{-11}	1.5×10^{-11}	9.2×10^{-12}	5.5×10^{-12}	4.4×10^{-12}
Tl-194m	0.546 h	F	1.000	1.7×10^{-10}	1.000	1.2×10^{-10}	6.1×10^{-11}	3.8×10^{-11}	2.3×10^{-11}	1.9×10^{-11}
Tl-195	1.16 h	F	1.000	1.3×10^{-10}	1.000	1.0×10^{-10}	5.3×10^{-11}	3.2×10^{-11}	1.9×10^{-11}	1.5×10^{-11}
Tl-197	2.84 h	F	1.000	1.3×10^{-10}	1.000	9.7×10^{-11}	4.7×10^{-11}	2.9×10^{-11}	1.7×10^{-11}	1.4×10^{-11}
Tl-198	5.30 h	F	1.000	4.7×10^{-10}	1.000	4.0×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	7.5×10^{-11}	6.0×10^{-11}
Tl-198m	1.87 h	F	1.000	3.2×10^{-10}	1.000	2.5×10^{-10}	1.2×10^{-10}	7.5×10^{-11}	4.5×10^{-11}	3.7×10^{-11}
Tl-199	7.42 h	F	1.000	1.7×10^{-10}	1.000	1.3×10^{-10}	6.4×10^{-11}	3.9×10^{-11}	2.3×10^{-11}	1.9×10^{-11}
Tl-200	1.09 d	F	1.000	1.0×10^{-9}	1.000	8.7×10^{-10}	4.6×10^{-10}	2.8×10^{-10}	1.6×10^{-10}	1.3×10^{-10}
Tl-201	3.04 d	F	1.000	4.5×10^{-10}	1.000	3.3×10^{-10}	1.5×10^{-10}	9.4×10^{-11}	5.4×10^{-11}	4.4×10^{-11}
Tl-202	12.2 d	F	1.000	1.5×10^{-9}	1.000	1.2×10^{-9}	5.9×10^{-10}	3.8×10^{-10}	2.3×10^{-10}	1.9×10^{-10}
Tl-204	3.78 a	F	1.000	5.0×10^{-9}	1.000	3.3×10^{-9}	1.5×10^{-9}	8.8×10^{-10}	4.7×10^{-10}	3.9×10^{-10}
Lead[a]										
Pb-195m	0.263 h	F	0.600	1.3×10^{-10}	0.200	1.0×10^{-10}	4.9×10^{-11}	3.1×10^{-11}	1.9×10^{-11}	1.6×10^{-11}
		M	0.200	2.0×10^{-10}	0.100	1.5×10^{-10}	7.1×10^{-11}	4.6×10^{-11}	3.1×10^{-11}	2.5×10^{-11}
		S	0.020	2.1×10^{-10}	0.010	1.5×10^{-10}	7.4×10^{-11}	4.8×10^{-11}	3.2×10^{-11}	2.7×10^{-11}

[a] The f_1 value for lead for 1 to 15 year olds for Type F is 0.4.

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤ 1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Pb-198	2.40 h	F	0.600	3.4×10^{-10}	0.200	2.9×10^{-10}	1.5×10^{-10}	8.9×10^{-11}	5.2×10^{-11}	4.3×10^{-11}
		M	0.200	5.0×10^{-10}	0.100	4.0×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	8.3×10^{-11}	6.6×10^{-11}
		S	0.020	5.4×10^{-10}	0.010	4.2×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	8.7×10^{-11}	7.0×10^{-11}
Pb-199	1.50 h	F	0.600	1.9×10^{-10}	0.200	1.6×10^{-10}	8.2×10^{-11}	4.9×10^{-11}	2.9×10^{-11}	2.3×10^{-11}
		M	0.200	2.8×10^{-10}	0.100	2.2×10^{-10}	1.1×10^{-10}	7.1×10^{-11}	4.5×10^{-11}	3.6×10^{-11}
		S	0.020	2.9×10^{-10}	0.010	2.3×10^{-10}	1.2×10^{-10}	7.4×10^{-11}	4.7×10^{-11}	3.7×10^{-11}
Pb-200	21.5 h	F	0.600	1.1×10^{-9}	0.200	9.3×10^{-10}	4.6×10^{-10}	2.8×10^{-10}	1.6×10^{-10}	1.4×10^{-10}
		M	0.200	2.2×10^{-9}	0.100	1.7×10^{-9}	8.6×10^{-10}	5.7×10^{-10}	4.1×10^{-10}	3.3×10^{-10}
		S	0.020	2.4×10^{-9}	0.010	1.8×10^{-9}	9.2×10^{-10}	6.2×10^{-10}	4.4×10^{-10}	3.5×10^{-10}
Pb-201	9.40 h	F	0.600	4.8×10^{-10}	0.200	4.1×10^{-10}	2.0×10^{-10}	1.2×10^{-10}	7.1×10^{-11}	6.0×10^{-11}
		M	0.200	8.0×10^{-10}	0.100	6.4×10^{-10}	3.3×10^{-10}	2.1×10^{-10}	1.4×10^{-10}	1.1×10^{-10}
		S	0.020	8.8×10^{-10}	0.010	6.7×10^{-10}	3.5×10^{-10}	2.2×10^{-10}	1.5×10^{-10}	1.2×10^{-10}
Pb-202	3.00×10^{5} a	F	0.600	1.9×10^{-8}	0.200	1.3×10^{-8}	8.9×10^{-9}	1.3×10^{-8}	1.8×10^{-8}	1.1×10^{-8}
		M	0.200	1.2×10^{-8}	0.100	8.9×10^{-9}	6.2×10^{-9}	6.7×10^{-9}	8.7×10^{-9}	6.3×10^{-9}
		S	0.020	2.8×10^{-8}	0.010	2.8×10^{-8}	2.0×10^{-8}	1.4×10^{-8}	1.3×10^{-8}	1.2×10^{-8}
Pb-202m	3.62 h	F	0.600	4.7×10^{-10}	0.200	4.0×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	7.5×10^{-11}	6.2×10^{-11}
		M	0.200	6.9×10^{-10}	0.100	5.6×10^{-10}	2.9×10^{-10}	1.9×10^{-10}	1.2×10^{-10}	9.5×10^{-11}
		S	0.020	7.3×10^{-10}	0.010	5.8×10^{-10}	3.0×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	1.0×10^{-10}
Pb-203	2.17 d	F	0.600	7.2×10^{-10}	0.200	5.8×10^{-10}	2.8×10^{-10}	1.7×10^{-10}	9.9×10^{-11}	8.5×10^{-11}
		M	0.200	1.3×10^{-9}	0.100	1.0×10^{-9}	5.4×10^{-10}	3.6×10^{-10}	2.5×10^{-10}	2.0×10^{-10}
		S	0.020	1.5×10^{-9}	0.010	1.1×10^{-9}	5.8×10^{-10}	3.8×10^{-10}	2.8×10^{-10}	2.2×10^{-10}
Pb-205	1.43×10^{7} a	F	0.600	1.1×10^{-9}	0.200	6.9×10^{-10}	4.0×10^{-10}	4.1×10^{-10}	4.3×10^{-10}	3.3×10^{-10}
		M	0.200	1.1×10^{-9}	0.100	7.7×10^{-10}	4.3×10^{-10}	3.2×10^{-10}	2.9×10^{-10}	2.5×10^{-10}
		S	0.020	2.9×10^{-9}	0.010	2.7×10^{-9}	1.7×10^{-9}	1.1×10^{-9}	9.2×10^{-10}	8.5×10^{-10}

Pb-209	3.25 h	F	0.600	1.8×10^{-10}	0.200	1.2×10^{-10}	5.3×10^{-11}	3.4×10^{-11}	1.9×10^{-11}	1.7×10^{-11}
		M	0.200	4.0×10^{-10}	0.100	2.7×10^{-10}	1.3×10^{-10}	9.2×10^{-11}	6.9×10^{-11}	5.6×10^{-11}
		S	0.020	4.4×10^{-10}	0.010	2.9×10^{-10}	1.4×10^{-10}	9.9×10^{-11}	7.5×10^{-11}	6.1×10^{-11}
Pb-210	22.3 a	F	0.600	4.7×10^{-6}	0.200	2.9×10^{-6}	1.5×10^{-6}	1.4×10^{-6}	1.3×10^{-6}	9.0×10^{-7}
		M	0.200	5.0×10^{-6}	0.100	3.7×10^{-6}	2.2×10^{-6}	1.5×10^{-6}	1.3×10^{-6}	1.1×10^{-6}
		S	0.020	1.8×10^{-5}	0.010	1.8×10^{-5}	1.1×10^{-5}	7.2×10^{-6}	5.9×10^{-6}	5.6×10^{-6}
Pb-211	0.601 h	F	0.600	2.5×10^{-8}	0.200	1.7×10^{-8}	8.7×10^{-9}	6.1×10^{-9}	4.6×10^{-9}	3.9×10^{-9}
		M	0.200	6.2×10^{-8}	0.100	4.5×10^{-8}	2.5×10^{-8}	1.9×10^{-8}	1.4×10^{-8}	1.1×10^{-8}
		S	0.020	6.6×10^{-8}	0.010	4.8×10^{-8}	2.7×10^{-8}	2.0×10^{-8}	1.5×10^{-8}	1.2×10^{-8}
Pb-212	10.6 h	F	0.600	1.9×10^{-7}	0.200	1.2×10^{-7}	5.4×10^{-8}	3.5×10^{-8}	2.0×10^{-8}	1.8×10^{-8}
		M	0.200	6.2×10^{-7}	0.100	4.6×10^{-7}	3.0×10^{-7}	2.2×10^{-7}	2.2×10^{-7}	1.7×10^{-7}
		S	0.020	6.7×10^{-7}	0.010	5.0×10^{-7}	3.3×10^{-7}	2.5×10^{-7}	2.4×10^{-7}	1.9×10^{-7}
Pb-214	0.447 h	F	0.600	2.2×10^{-8}	0.200	1.5×10^{-8}	6.9×10^{-9}	4.8×10^{-9}	3.3×10^{-9}	2.8×10^{-9}
		M	0.200	6.4×10^{-8}	0.100	4.6×10^{-8}	2.6×10^{-8}	1.9×10^{-8}	1.4×10^{-8}	1.4×10^{-8}
		S	0.020	6.9×10^{-8}	0.010	5.0×10^{-8}	2.8×10^{-8}	2.1×10^{-8}	1.5×10^{-8}	1.5×10^{-8}
Bismuth										
Bi-200	0.606 h	F	0.100	1.9×10^{-10}	0.050	1.5×10^{-10}	7.4×10^{-11}	4.5×10^{-11}	2.7×10^{-11}	2.2×10^{-11}
		M	0.100	2.5×10^{-10}	0.050	1.9×10^{-10}	9.9×10^{-11}	6.3×10^{-11}	4.1×10^{-11}	3.3×10^{-11}
Bi-201	1.80 h	F	0.100	4.0×10^{-10}	0.050	3.1×10^{-10}	1.5×10^{-10}	9.3×10^{-11}	5.4×10^{-11}	4.4×10^{-11}
		M	0.100	5.5×10^{-10}	0.050	4.1×10^{-10}	2.0×10^{-10}	1.3×10^{-10}	8.3×10^{-11}	6.6×10^{-11}
Bi-202	1.67 h	F	0.100	3.4×10^{-10}	0.050	2.8×10^{-10}	1.5×10^{-10}	9.0×10^{-11}	5.3×10^{-11}	4.3×10^{-11}
		M	0.100	4.2×10^{-10}	0.050	3.4×10^{-10}	1.8×10^{-10}	1.1×10^{-10}	6.9×10^{-11}	5.5×10^{-11}
Bi-203	11.8 h	F	0.100	1.5×10^{-9}	0.050	1.2×10^{-9}	6.4×10^{-10}	4.0×10^{-10}	2.3×10^{-10}	1.9×10^{-10}
		M	0.100	2.0×10^{-9}	0.050	1.6×10^{-9}	8.2×10^{-10}	5.3×10^{-10}	3.3×10^{-10}	2.6×10^{-10}
Bi-205	15.3 d	F	0.100	3.0×10^{-9}	0.050	2.4×10^{-9}	1.3×10^{-9}	8.0×10^{-10}	4.7×10^{-10}	3.8×10^{-10}
		M	0.100	5.5×10^{-9}	0.050	4.4×10^{-9}	2.5×10^{-9}	1.6×10^{-9}	1.2×10^{-9}	9.3×10^{-10}
Bi-206	6.24 d	F	0.100	6.1×10^{-9}	0.050	4.8×10^{-9}	2.5×10^{-9}	1.6×10^{-9}	9.1×10^{-10}	7.4×10^{-10}
		M	0.100	1.0×10^{-8}	0.050	8.0×10^{-9}	4.4×10^{-9}	2.9×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
Bi-207	38.0 a	F	0.100	4.3×10^{-9}	0.050	3.3×10^{-9}	1.7×10^{-9}	1.0×10^{-9}	6.0×10^{-10}	4.9×10^{-10}
		M	0.100	2.3×10^{-8}	0.050	2.0×10^{-8}	1.2×10^{-8}	8.2×10^{-9}	6.5×10^{-9}	5.6×10^{-9}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤ 1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Bi-210	5.01 d	F	0.100	1.1×10^{-8}	0.050	6.9×10^{-9}	3.2×10^{-9}	2.1×10^{-9}	1.3×10^{-9}	1.1×10^{-9}
		M	0.100	3.9×10^{-7}	0.050	3.0×10^{-7}	1.9×10^{-7}	1.3×10^{-7}	1.1×10^{-7}	9.3×10^{-8}
Bi-210m	3.00×10^{6} a	F	0.100	4.1×10^{-7}	0.050	2.6×10^{-7}	1.3×10^{-7}	8.3×10^{-8}	5.6×10^{-8}	4.6×10^{-8}
		M	0.100	1.5×10^{-5}	0.050	1.1×10^{-5}	7.0×10^{-6}	4.8×10^{-6}	4.1×10^{-6}	3.4×10^{-6}
Bi-212	1.01 h	F	0.100	6.5×10^{-8}	0.050	4.5×10^{-8}	2.1×10^{-8}	1.5×10^{-8}	1.0×10^{-8}	9.1×10^{-9}
		M	0.100	1.6×10^{-7}	0.050	1.1×10^{-7}	6.0×10^{-8}	4.4×10^{-8}	3.8×10^{-8}	3.1×10^{-8}
Bi-213	0.761 h	F	0.100	7.7×10^{-8}	0.050	5.3×10^{-8}	2.5×10^{-8}	1.7×10^{-8}	1.2×10^{-8}	1.0×10^{-8}
		M	0.100	1.6×10^{-7}	0.050	1.2×10^{-7}	6.0×10^{-8}	4.4×10^{-8}	3.6×10^{-8}	3.0×10^{-8}
Bi-214	0.332 h	F	0.100	5.0×10^{-8}	0.050	3.5×10^{-8}	1.6×10^{-8}	1.1×10^{-8}	8.2×10^{-9}	7.1×10^{-9}
		M	0.100	8.7×10^{-8}	0.050	6.1×10^{-8}	3.1×10^{-8}	2.2×10^{-8}	1.7×10^{-8}	1.4×10^{-8}
Polonium										
Po-203	0.612 h	F	0.200	1.9×10^{-10}	0.100	1.5×10^{-10}	7.7×10^{-11}	4.7×10^{-11}	2.8×10^{-11}	2.3×10^{-11}
		M	0.200	2.7×10^{-10}	0.100	2.1×10^{-10}	1.1×10^{-10}	6.7×10^{-11}	4.3×10^{-11}	3.5×10^{-11}
		S	0.020	2.8×10^{-10}	0.010	2.2×10^{-10}	1.1×10^{-10}	7.0×10^{-11}	4.5×10^{-11}	3.6×10^{-11}
Po-205	1.80 h	F	0.200	2.6×10^{-10}	0.100	2.1×10^{-10}	1.1×10^{-10}	6.6×10^{-11}	4.1×10^{-11}	3.3×10^{-11}
		M	0.200	4.0×10^{-10}	0.100	3.1×10^{-10}	1.7×10^{-10}	1.1×10^{-10}	8.1×10^{-11}	6.5×10^{-11}
		S	0.020	4.2×10^{-10}	0.010	3.2×10^{-10}	1.8×10^{-10}	1.2×10^{-10}	8.5×10^{-11}	6.9×10^{-11}
Po-207	5.83 h	F	0.200	4.8×10^{-10}	0.100	4.0×10^{-10}	2.1×10^{-10}	1.3×10^{-10}	7.3×10^{-11}	5.8×10^{-11}
		M	0.200	6.2×10^{-10}	0.100	5.1×10^{-10}	2.6×10^{-10}	1.6×10^{-10}	9.9×10^{-11}	7.8×10^{-11}
		S	0.020	6.6×10^{-10}	0.010	5.3×10^{-10}	2.7×10^{-10}	1.7×10^{-10}	1.0×10^{-10}	8.2×10^{-11}
Po-210	138 d	F	0.200	7.4×10^{-6}	0.100	4.8×10^{-6}	2.2×10^{-6}	1.3×10^{-6}	7.7×10^{-7}	6.1×10^{-7}
		M	0.200	1.5×10^{-5}	0.100	1.1×10^{-5}	6.7×10^{-6}	4.6×10^{-6}	4.0×10^{-6}	3.3×10^{-6}
		S	0.020	1.8×10^{-5}	0.010	1.4×10^{-5}	8.6×10^{-6}	5.9×10^{-6}	5.1×10^{-6}	4.3×10^{-6}

Astatine										
At-207	1.80 h	F	1.000	2.4×10^{-9}	1.000	1.7×10^{-9}	8.9×10^{-10}	5.9×10^{-10}	4.0×10^{-10}	3.3×10^{-10}
		M	1.000	9.2×10^{-9}	1.000	6.7×10^{-9}	4.3×10^{-9}	3.1×10^{-9}	2.9×10^{-9}	2.3×10^{-9}
At-211	7.21 h	F	1.000	1.4×10^{-7}	1.000	9.7×10^{-8}	4.3×10^{-8}	2.8×10^{-8}	1.7×10^{-8}	1.6×10^{-8}
		M	1.000	5.2×10^{-7}	1.000	3.7×10^{-7}	1.9×10^{-7}	1.4×10^{-7}	1.3×10^{-7}	1.1×10^{-7}
Francium										
Fr-222	0.240 h	F	1.000	9.1×10^{-8}	1.000	6.3×10^{-8}	3.0×10^{-8}	2.1×10^{-8}	1.6×10^{-8}	1.4×10^{-8}
Fr-223	0.363 h	F	1.000	1.1×10^{-8}	1.000	7.3×10^{-9}	3.2×10^{-9}	1.9×10^{-9}	1.0×10^{-9}	8.9×10^{-10}
Radium[a]										
Ra-223	11.4 d	F	0.600	3.0×10^{-6}	0.200	1.0×10^{-6}	4.9×10^{-7}	4.0×10^{-7}	3.3×10^{-7}	1.2×10^{-7}
		M	0.200	2.8×10^{-5}	0.100	2.1×10^{-5}	1.3×10^{-5}	9.9×10^{-6}	9.4×10^{-6}	7.4×10^{-6}
		S	0.020	3.2×10^{-5}	0.010	2.4×10^{-5}	1.5×10^{-5}	1.1×10^{-5}	1.1×10^{-5}	8.7×10^{-6}
Ra-224	3.66 d	F	0.600	1.5×10^{-6}	0.200	6.0×10^{-7}	2.9×10^{-7}	2.2×10^{-7}	1.7×10^{-7}	7.5×10^{-8}
		M	0.200	1.1×10^{-5}	0.100	8.2×10^{-6}	5.3×10^{-6}	3.9×10^{-6}	3.7×10^{-6}	3.0×10^{-6}
		S	0.020	1.2×10^{-5}	0.010	9.2×10^{-6}	5.9×10^{-6}	4.4×10^{-6}	4.2×10^{-6}	3.4×10^{-6}
Ra-225	14.8 d	F	0.600	4.0×10^{-6}	0.200	1.2×10^{-6}	5.6×10^{-7}	4.6×10^{-7}	3.8×10^{-7}	1.3×10^{-7}
		M	0.200	2.4×10^{-5}	0.100	1.8×10^{-5}	1.1×10^{-5}	8.4×10^{-6}	7.9×10^{-6}	6.3×10^{-6}
		S	0.020	2.8×10^{-5}	0.010	2.2×10^{-5}	1.4×10^{-5}	1.0×10^{-5}	9.8×10^{-6}	7.7×10^{-6}
Ra-226	1.60×10^{3} a	F	0.600	2.6×10^{-6}	0.200	9.4×10^{-7}	5.5×10^{-7}	7.2×10^{-7}	1.3×10^{-6}	3.6×10^{-7}
		M	0.200	1.5×10^{-5}	0.100	1.1×10^{-5}	7.0×10^{-6}	4.9×10^{-6}	4.5×10^{-6}	3.5×10^{-6}
		S	0.020	3.4×10^{-5}	0.010	2.9×10^{-5}	1.9×10^{-5}	1.2×10^{-5}	1.0×10^{-5}	9.5×10^{-6}
Ra-227	0.703 h	F	0.600	1.5×10^{-9}	0.200	1.2×10^{-9}	7.8×10^{-10}	6.1×10^{-10}	5.3×10^{-10}	4.6×10^{-10}
		M	0.200	8.0×10^{-10}	0.100	6.7×10^{-10}	4.4×10^{-10}	3.2×10^{-10}	2.9×10^{-10}	2.8×10^{-10}
		S	0.020	1.0×10^{-9}	0.010	8.5×10^{-10}	4.4×10^{-10}	2.9×10^{-10}	2.4×10^{-10}	2.2×10^{-10}
Ra-228	5.75 a	F	0.600	1.7×10^{-5}	0.200	5.7×10^{-6}	3.1×10^{-6}	3.6×10^{-6}	4.6×10^{-6}	9.0×10^{-7}
		M	0.200	1.5×10^{-5}	0.100	1.0×10^{-5}	6.3×10^{-6}	4.6×10^{-6}	4.4×10^{-6}	2.6×10^{-6}
		S	0.020	4.9×10^{-5}	0.010	4.8×10^{-5}	3.2×10^{-5}	2.0×10^{-5}	1.6×10^{-5}	1.6×10^{-5}

[a] The f_1 value for radium for 1 to 15 year olds for Type F is 0.3.

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for	Age 1-2 a	Age 2-7 a	Age 7-12 a	Age 12-17 a	Age > 17 a
			f_1	e(g)	g > 1 a	e(g)	e(g)	e(g)	e(g)	e(g)
Actinium										
Ac-224	2.90 h	F	0.005	1.3×10^{-7}	5.0×10^{-4}	8.9×10^{-8}	4.7×10^{-8}	3.1×10^{-8}	1.4×10^{-8}	1.1×10^{-8}
		M	0.005	4.2×10^{-7}	5.0×10^{-4}	3.2×10^{-7}	2.0×10^{-7}	1.5×10^{-7}	1.4×10^{-7}	1.1×10^{-7}
		S	0.005	4.6×10^{-7}	5.0×10^{-4}	3.5×10^{-7}	2.2×10^{-7}	1.7×10^{-7}	1.6×10^{-7}	1.3×10^{-7}
Ac-225	10.0 d	F	0.005	1.1×10^{-5}	5.0×10^{-4}	7.7×10^{-6}	4.0×10^{-6}	2.6×10^{-6}	1.1×10^{-6}	8.8×10^{-7}
		M	0.005	2.8×10^{-5}	5.0×10^{-4}	2.1×10^{-5}	1.3×10^{-5}	1.0×10^{-5}	9.3×10^{-6}	7.4×10^{-6}
		S	0.005	3.1×10^{-5}	5.0×10^{-4}	2.3×10^{-5}	1.5×10^{-5}	1.1×10^{-5}	1.1×10^{-5}	8.5×10^{-6}
Ac-226	1.21 d	F	0.005	1.5×10^{-6}	5.0×10^{-4}	1.1×10^{-6}	4.0×10^{-7}	2.6×10^{-7}	1.2×10^{-7}	9.6×10^{-8}
		M	0.005	4.3×10^{-6}	5.0×10^{-4}	3.2×10^{-6}	2.1×10^{-6}	1.5×10^{-6}	1.5×10^{-6}	1.2×10^{-6}
		S	0.005	4.7×10^{-6}	5.0×10^{-4}	3.5×10^{-6}	2.3×10^{-6}	1.7×10^{-6}	1.6×10^{-6}	1.3×10^{-6}
Ac-227	21.8 a	F	0.005	1.7×10^{-3}	5.0×10^{-4}	1.6×10^{-3}	1.0×10^{-3}	7.2×10^{-4}	5.6×10^{-4}	5.5×10^{-4}
		M	0.005	5.7×10^{-4}	5.0×10^{-4}	5.5×10^{-4}	3.9×10^{-4}	2.6×10^{-4}	2.3×10^{-4}	2.2×10^{-4}
		S	0.005	2.2×10^{-4}	5.0×10^{-4}	2.0×10^{-4}	1.3×10^{-4}	8.7×10^{-5}	7.6×10^{-5}	7.2×10^{-5}
Ac-228	6.13 h	F	0.005	1.8×10^{-7}	5.0×10^{-4}	1.6×10^{-7}	9.7×10^{-8}	5.7×10^{-8}	2.9×10^{-8}	2.5×10^{-8}
		M	0.005	8.4×10^{-8}	5.0×10^{-4}	7.3×10^{-8}	4.7×10^{-8}	2.9×10^{-8}	2.0×10^{-8}	1.7×10^{-8}
		S	0.005	6.4×10^{-8}	5.0×10^{-4}	5.3×10^{-8}	3.3×10^{-8}	2.2×10^{-8}	1.9×10^{-8}	1.6×10^{-8}
Thorium										
Th-226	0.515 h	F	0.005	1.4×10^{-7}	5.0×10^{-4}	1.0×10^{-7}	4.8×10^{-8}	3.4×10^{-8}	2.5×10^{-8}	2.2×10^{-8}
		M	0.005	3.0×10^{-7}	5.0×10^{-4}	2.1×10^{-7}	1.1×10^{-7}	8.3×10^{-8}	7.0×10^{-8}	5.8×10^{-8}
		S	0.005	3.1×10^{-7}	5.0×10^{-4}	2.2×10^{-7}	1.2×10^{-7}	8.8×10^{-8}	7.5×10^{-8}	6.1×10^{-8}
Th-227	18.7 d	F	0.005	8.4×10^{-6}	5.0×10^{-4}	5.2×10^{-6}	2.6×10^{-6}	1.6×10^{-6}	1.0×10^{-6}	6.7×10^{-7}
		M	0.005	3.2×10^{-5}	5.0×10^{-4}	2.5×10^{-5}	1.6×10^{-5}	1.1×10^{-5}	1.1×10^{-5}	8.5×10^{-6}
		S	0.005	3.9×10^{-5}	5.0×10^{-4}	3.0×10^{-5}	1.9×10^{-5}	1.4×10^{-5}	1.3×10^{-5}	1.0×10^{-5}
Th-228	1.91 a	F	0.005	1.8×10^{-4}	5.0×10^{-4}	1.5×10^{-4}	8.3×10^{-5}	5.2×10^{-5}	3.6×10^{-5}	2.9×10^{-5}
		M	0.005	1.3×10^{-4}	5.0×10^{-4}	1.1×10^{-4}	6.8×10^{-5}	4.6×10^{-5}	3.9×10^{-5}	3.2×10^{-5}
		S	0.005	1.6×10^{-4}	5.0×10^{-4}	1.3×10^{-4}	8.2×10^{-5}	5.5×10^{-5}	4.7×10^{-5}	4.0×10^{-5}

Th-229	7.34×10^{3} a	F	0.005	5.4×10^{-4}	5.0×10^{-4}	5.1×10^{-4}	3.6×10^{-4}	2.9×10^{-4}	2.4×10^{-4}	2.4×10^{-4}
		M	0.005	2.3×10^{-4}	5.0×10^{-4}	2.1×10^{-4}	1.6×10^{-4}	1.2×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
		S	0.005	2.1×10^{-4}	5.0×10^{-4}	1.9×10^{-4}	1.3×10^{-4}	8.7×10^{-5}	7.6×10^{-5}	7.1×10^{-5}
Th-230	7.70×10^{4} a	F	0.005	2.1×10^{-4}	5.0×10^{-4}	2.0×10^{-4}	1.4×10^{-4}	1.1×10^{-4}	9.9×10^{-5}	1.0×10^{-4}
		M	0.005	7.7×10^{-5}	5.0×10^{-4}	7.4×10^{-5}	5.5×10^{-5}	4.3×10^{-5}	4.2×10^{-5}	4.3×10^{-5}
		S	0.005	4.0×10^{-5}	5.0×10^{-4}	3.5×10^{-5}	2.4×10^{-5}	1.6×10^{-5}	1.5×10^{-5}	1.4×10^{-5}
Th-231	1.06 d	F	0.005	1.1×10^{-9}	5.0×10^{-4}	7.2×10^{-10}	2.6×10^{-10}	1.6×10^{-10}	9.2×10^{-11}	7.8×10^{-11}
		M	0.005	2.2×10^{-9}	5.0×10^{-4}	1.6×10^{-9}	8.0×10^{-10}	4.8×10^{-10}	3.8×10^{-10}	3.1×10^{-10}
		S	0.005	2.4×10^{-9}	5.0×10^{-4}	1.7×10^{-9}	7.6×10^{-10}	5.2×10^{-10}	4.1×10^{-10}	3.3×10^{-10}
Th-232	1.40×10^{10} a	F	0.005	2.3×10^{-4}	5.0×10^{-4}	2.2×10^{-4}	1.6×10^{-4}	1.3×10^{-4}	1.2×10^{-4}	1.1×10^{-4}
		M	0.005	8.3×10^{-5}	5.0×10^{-4}	8.1×10^{-5}	6.3×10^{-5}	5.0×10^{-5}	4.7×10^{-5}	4.5×10^{-5}
		S	0.005	5.4×10^{-5}	5.0×10^{-4}	5.0×10^{-5}	3.7×10^{-5}	2.6×10^{-5}	2.5×10^{-5}	2.5×10^{-5}
Th-234	24.1 d	F	0.005	4.0×10^{-8}	5.0×10^{-4}	2.5×10^{-8}	1.1×10^{-8}	6.1×10^{-9}	3.5×10^{-9}	2.5×10^{-9}
		M	0.005	3.9×10^{-8}	5.0×10^{-4}	2.9×10^{-8}	1.5×10^{-8}	1.0×10^{-8}	7.9×10^{-9}	6.6×10^{-9}
		S	0.005	4.1×10^{-8}	5.0×10^{-4}	3.1×10^{-8}	1.7×10^{-8}	1.1×10^{-8}	9.1×10^{-9}	7.7×10^{-9}
Protactinium										
Pa-227	0.638 h	M	0.005	3.6×10^{-7}	5.0×10^{-4}	2.6×10^{-7}	1.4×10^{-7}	1.0×10^{-7}	9.0×10^{-8}	7.4×10^{-8}
		S	0.005	3.8×10^{-7}	5.0×10^{-4}	2.8×10^{-7}	1.5×10^{-7}	1.1×10^{-7}	8.1×10^{-8}	8.0×10^{-8}
Pa-228	22.0 h	M	0.005	2.6×10^{-7}	5.0×10^{-4}	2.1×10^{-7}	1.3×10^{-7}	8.8×10^{-8}	7.7×10^{-8}	6.4×10^{-8}
		S	0.005	2.9×10^{-7}	5.0×10^{-4}	2.4×10^{-7}	1.5×10^{-7}	1.0×10^{-7}	9.1×10^{-8}	7.5×10^{-8}
Pa-230	17.4 d	M	0.005	2.4×10^{-6}	5.0×10^{-4}	1.8×10^{-6}	1.1×10^{-6}	8.3×10^{-7}	7.6×10^{-7}	6.1×10^{-7}
		S	0.005	2.9×10^{-6}	5.0×10^{-4}	2.2×10^{-6}	1.4×10^{-6}	1.0×10^{-6}	9.6×10^{-7}	7.6×10^{-7}
Pa-231	3.27×10^{4} a	M	0.005	2.2×10^{-4}	5.0×10^{-4}	2.3×10^{-4}	1.9×10^{-4}	1.5×10^{-4}	1.5×10^{-4}	1.4×10^{-4}
		S	0.005	7.4×10^{-5}	5.0×10^{-4}	6.9×10^{-5}	5.2×10^{-5}	3.9×10^{-5}	3.6×10^{-5}	3.4×10^{-5}
Pa-232	1.31 d	M	0.005	1.9×10^{-8}	5.0×10^{-4}	1.8×10^{-8}	1.4×10^{-8}	1.1×10^{-8}	1.0×10^{-8}	1.0×10^{-8}
		S	0.005	1.0×10^{-8}	5.0×10^{-4}	8.7×10^{-9}	5.9×10^{-9}	4.1×10^{-9}	3.7×10^{-9}	3.5×10^{-9}
Pa-233	27.0 d	M	0.005	1.5×10^{-8}	5.0×10^{-4}	1.1×10^{-8}	6.5×10^{-9}	4.7×10^{-9}	4.1×10^{-9}	3.3×10^{-9}
		S	0.005	1.7×10^{-8}	5.0×10^{-4}	1.3×10^{-8}	7.5×10^{-9}	5.5×10^{-9}	4.9×10^{-9}	3.9×10^{-9}
Pa-234	6.70 h	M	0.005	2.8×10^{-9}	5.0×10^{-4}	2.0×10^{-9}	1.0×10^{-9}	6.8×10^{-10}	4.7×10^{-10}	3.8×10^{-10}
		S	0.005	2.9×10^{-9}	5.0×10^{-4}	2.1×10^{-9}	1.1×10^{-9}	7.1×10^{-10}	5.0×10^{-10}	4.0×10^{-10}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Uranium										
U-230	20.8 d	F	0.040	3.2×10^{-6}	0.020	1.5×10^{-6}	7.2×10^{-7}	5.4×10^{-7}	4.1×10^{-7}	3.8×10^{-7}
		M	0.040	4.9×10^{-5}	0.020	3.7×10^{-5}	2.4×10^{-5}	1.8×10^{-5}	1.7×10^{-5}	1.3×10^{-5}
		S	0.020	5.8×10^{-5}	0.002	4.4×10^{-5}	2.8×10^{-5}	2.1×10^{-5}	2.0×10^{-5}	1.6×10^{-5}
U-231	4.20 d	F	0.040	8.9×10^{-10}	0.020	6.2×10^{-10}	3.1×10^{-10}	1.4×10^{-10}	1.0×10^{-10}	6.2×10^{-11}
		M	0.040	2.4×10^{-9}	0.020	1.7×10^{-9}	9.4×10^{-10}	5.5×10^{-10}	4.6×10^{-10}	3.8×10^{-10}
		S	0.020	2.6×10^{-9}	0.002	1.9×10^{-9}	9.0×10^{-10}	6.1×10^{-10}	4.9×10^{-10}	4.0×10^{-10}
U-232	72.0 a	F	0.040	1.6×10^{-5}	0.020	1.0×10^{-5}	6.9×10^{-6}	6.8×10^{-6}	7.5×10^{-6}	4.0×10^{-6}
		M	0.040	3.0×10^{-5}	0.020	2.4×10^{-5}	1.6×10^{-5}	1.1×10^{-5}	1.0×10^{-5}	7.8×10^{-6}
		S	0.020	1.0×10^{-4}	0.002	9.7×10^{-5}	6.6×10^{-5}	4.3×10^{-5}	3.8×10^{-5}	3.7×10^{-5}
U-233	1.58×10^{5} a	F	0.040	2.2×10^{-6}	0.020	1.4×10^{-6}	9.4×10^{-7}	8.4×10^{-7}	8.6×10^{-7}	5.8×10^{-7}
		M	0.040	1.5×10^{-5}	0.020	1.1×10^{-5}	7.2×10^{-6}	4.9×10^{-6}	4.3×10^{-6}	3.6×10^{-6}
		S	0.020	3.4×10^{-5}	0.002	3.0×10^{-5}	1.9×10^{-5}	1.2×10^{-5}	1.1×10^{-5}	9.6×10^{-6}
U-234	2.44×10^{5} a	F	0.040	2.1×10^{-6}	0.020	1.4×10^{-6}	9.0×10^{-7}	8.0×10^{-7}	8.2×10^{-7}	5.6×10^{-7}
		M	0.040	1.5×10^{-5}	0.020	1.1×10^{-5}	7.0×10^{-6}	4.8×10^{-6}	4.2×10^{-6}	3.5×10^{-6}
		S	0.020	3.3×10^{-5}	0.002	2.9×10^{-5}	1.9×10^{-5}	1.2×10^{-5}	1.0×10^{-5}	9.4×10^{-6}
U-235	7.04×10^{8} a	F	0.040	2.0×10^{-6}	0.020	1.3×10^{-6}	8.5×10^{-7}	7.5×10^{-7}	7.7×10^{-7}	5.2×10^{-7}
		M	0.040	1.3×10^{-5}	0.020	1.0×10^{-5}	6.3×10^{-6}	4.3×10^{-6}	3.7×10^{-6}	3.1×10^{-6}
		S	0.020	3.0×10^{-5}	0.002	2.6×10^{-5}	1.7×10^{-5}	1.1×10^{-5}	9.2×10^{-6}	8.5×10^{-6}
U-236	2.34×10^{7} a	F	0.040	2.0×10^{-6}	0.020	1.3×10^{-6}	8.5×10^{-7}	7.5×10^{-7}	7.8×10^{-7}	5.3×10^{-7}
		M	0.040	1.4×10^{-5}	0.020	1.0×10^{-5}	6.5×10^{-6}	4.5×10^{-6}	3.9×10^{-6}	3.2×10^{-6}
		S	0.020	3.1×10^{-5}	0.002	2.7×10^{-5}	1.8×10^{-5}	1.1×10^{-5}	9.5×10^{-6}	8.7×10^{-6}
U-237	6.75 d	F	0.040	1.8×10^{-9}	0.020	1.5×10^{-9}	6.6×10^{-10}	4.2×10^{-10}	1.9×10^{-10}	1.8×10^{-10}
		M	0.040	7.8×10^{-9}	0.020	5.7×10^{-9}	3.3×10^{-9}	2.4×10^{-9}	2.1×10^{-9}	1.7×10^{-9}
		S	0.020	8.7×10^{-9}	0.002	6.4×10^{-9}	3.7×10^{-9}	2.7×10^{-9}	2.4×10^{-9}	1.9×10^{-9}

U-238	4.47 × 10^9 a	F	0.040	1.9 × 10^{-6}	0.020	1.3 × 10^{-6}	8.2 × 10^{-7}	7.3 × 10^{-7}	7.4 × 10^{-7}	5.0 × 10^{-7}
		M	0.040	1.2 × 10^{-5}	0.020	9.4 × 10^{-6}	5.9 × 10^{-6}	4.0 × 10^{-6}	3.4 × 10^{-6}	2.9 × 10^{-6}
		S	0.020	2.9 × 10^{-5}	0.002	2.5 × 10^{-5}	1.6 × 10^{-5}	1.0 × 10^{-5}	8.7 × 10^{-6}	8.0 × 10^{-6}
U-239	0.392 h	F	0.040	1.0 × 10^{-10}	0.020	6.6 × 10^{-11}	2.9 × 10^{-11}	1.9 × 10^{-11}	1.2 × 10^{-11}	1.0 × 10^{-11}
		M	0.040	1.8 × 10^{-10}	0.020	1.2 × 10^{-10}	5.6 × 10^{-11}	3.8 × 10^{-11}	2.7 × 10^{-11}	2.2 × 10^{-11}
		S	0.020	1.9 × 10^{-10}	0.002	1.2 × 10^{-10}	5.9 × 10^{-11}	4.0 × 10^{-11}	2.9 × 10^{-11}	2.4 × 10^{-11}
U-240	14.1 h	F	0.040	2.4 × 10^{-9}	0.020	1.6 × 10^{-9}	7.1 × 10^{-10}	4.5 × 10^{-10}	2.3 × 10^{-10}	2.0 × 10^{-10}
		M	0.040	4.6 × 10^{-9}	0.020	3.1 × 10^{-9}	1.7 × 10^{-9}	1.1 × 10^{-9}	6.5 × 10^{-10}	5.3 × 10^{-10}
		S	0.020	4.9 × 10^{-9}	0.002	3.3 × 10^{-9}	1.6 × 10^{-9}	1.1 × 10^{-9}	7.0 × 10^{-10}	5.8 × 10^{-10}
Neptunium										
Np-232	0.245 h	F	0.005	2.0 × 10^{-10}	5.0 × 10^{-4}	1.9 × 10^{-10}	1.2 × 10^{-10}	1.1 × 10^{-10}	1.1 × 10^{-10}	1.2 × 10^{-10}
		M	0.005	8.9 × 10^{-11}	5.0 × 10^{-4}	8.1 × 10^{-11}	5.5 × 10^{-11}	4.5 × 10^{-11}	4.7 × 10^{-11}	5.0 × 10^{-11}
		S	0.005	1.2 × 10^{-10}	5.0 × 10^{-4}	9.7 × 10^{-11}	5.8 × 10^{-11}	3.9 × 10^{-11}	2.5 × 10^{-11}	2.4 × 10^{-11}
Np-233	0.603 h	F	0.005	1.1 × 10^{-11}	5.0 × 10^{-4}	8.7 × 10^{-12}	4.2 × 10^{-12}	2.5 × 10^{-12}	1.4 × 10^{-12}	1.1 × 10^{-12}
		M	0.005	1.5 × 10^{-11}	5.0 × 10^{-4}	1.1 × 10^{-11}	5.5 × 10^{-12}	3.3 × 10^{-12}	2.1 × 10^{-12}	1.6 × 10^{-12}
		S	0.005	1.5 × 10^{-11}	5.0 × 10^{-4}	1.2 × 10^{-11}	5.7 × 10^{-12}	3.4 × 10^{-12}	2.1 × 10^{-12}	1.7 × 10^{-12}
Np-234	4.40 d	F	0.005	2.9 × 10^{-9}	5.0 × 10^{-4}	2.2 × 10^{-9}	1.1 × 10^{-9}	7.2 × 10^{-10}	4.3 × 10^{-10}	3.5 × 10^{-10}
		M	0.005	3.8 × 10^{-9}	5.0 × 10^{-4}	3.0 × 10^{-9}	1.6 × 10^{-9}	1.0 × 10^{-9}	6.5 × 10^{-10}	5.3 × 10^{-10}
		S	0.005	3.9 × 10^{-9}	5.0 × 10^{-4}	3.1 × 10^{-9}	1.6 × 10^{-9}	1.0 × 10^{-9}	6.8 × 10^{-10}	5.5 × 10^{-10}
Np-235	1.08 a	F	0.005	4.2 × 10^{-9}	5.0 × 10^{-4}	3.5 × 10^{-9}	1.9 × 10^{-9}	1.1 × 10^{-9}	7.5 × 10^{-10}	6.3 × 10^{-10}
		M	0.005	2.3 × 10^{-9}	5.0 × 10^{-4}	1.9 × 10^{-9}	1.1 × 10^{-9}	6.8 × 10^{-10}	5.1 × 10^{-10}	4.2 × 10^{-10}
		S	0.005	2.6 × 10^{-9}	5.0 × 10^{-4}	2.2 × 10^{-9}	1.3 × 10^{-9}	8.3 × 10^{-10}	6.3 × 10^{-10}	5.2 × 10^{-10}
Np-236	1.15 × 10^5 a	F	0.005	8.9 × 10^{-6}	5.0 × 10^{-4}	9.1 × 10^{-6}	7.2 × 10^{-6}	7.5 × 10^{-6}	7.9 × 10^{-6}	8.0 × 10^{-6}
		M	0.005	3.0 × 10^{-6}	5.0 × 10^{-4}	3.1 × 10^{-6}	2.7 × 10^{-6}	2.7 × 10^{-6}	3.1 × 10^{-6}	3.2 × 10^{-6}
		S	0.005	1.6 × 10^{-6}	5.0 × 10^{-4}	1.6 × 10^{-6}	1.3 × 10^{-6}	1.0 × 10^{-6}	1.0 × 10^{-6}	1.0 × 10^{-6}
Np-236	22.5 h	F	0.005	2.8 × 10^{-8}	5.0 × 10^{-4}	2.6 × 10^{-8}	1.5 × 10^{-8}	1.1 × 10^{-8}	8.9 × 10^{-9}	9.0 × 10^{-9}
		M	0.005	1.6 × 10^{-8}	5.0 × 10^{-4}	1.4 × 10^{-8}	8.9 × 10^{-9}	6.2 × 10^{-9}	5.6 × 10^{-9}	5.3 × 10^{-9}
		S	0.005	1.6 × 10^{-8}	5.0 × 10^{-4}	1.3 × 10^{-8}	8.5 × 10^{-9}	5.7 × 10^{-9}	4.8 × 10^{-9}	4.2 × 10^{-9}
Np-237	2.14 × 10^6 a	F	0.005	9.8 × 10^{-5}	5.0 × 10^{-4}	9.3 × 10^{-5}	6.0 × 10^{-5}	5.0 × 10^{-5}	4.7 × 10^{-5}	5.0 × 10^{-5}
		M	0.005	4.4 × 10^{-5}	5.0 × 10^{-4}	4.0 × 10^{-5}	2.8 × 10^{-5}	2.2 × 10^{-5}	2.2 × 10^{-5}	2.3 × 10^{-5}
		S	0.005	3.7 × 10^{-5}	5.0 × 10^{-4}	3.2 × 10^{-5}	2.1 × 10^{-5}	1.4 × 10^{-5}	1.3 × 10^{-5}	1.2 × 10^{-5}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age $g \leq 1$ a f_1	Age $g \leq 1$ a e(g)	f_1 for $g > 1$ a	Age 1–2 a e(g)	Age 2–7 a e(g)	Age 7–12 a e(g)	Age 12–17 a e(g)	Age > 17 a e(g)
Np-238	2.12 d	F	0.005	9.0×10^{-9}	5.0×10^{-4}	7.9×10^{-9}	4.8×10^{-9}	3.7×10^{-9}	3.3×10^{-9}	3.5×10^{-9}
		M	0.005	7.3×10^{-9}	5.0×10^{-4}	5.8×10^{-9}	3.4×10^{-9}	2.5×10^{-9}	2.2×10^{-9}	2.1×10^{-9}
		S	0.005	8.1×10^{-9}	5.0×10^{-4}	6.2×10^{-9}	3.2×10^{-9}	2.1×10^{-9}	1.7×10^{-9}	1.5×10^{-9}
Np-239	2.36 d	F	0.005	2.6×10^{-9}	5.0×10^{-4}	1.4×10^{-9}	6.3×10^{-10}	3.8×10^{-10}	2.1×10^{-10}	1.7×10^{-10}
		M	0.005	5.9×10^{-9}	5.0×10^{-4}	4.2×10^{-9}	2.0×10^{-9}	1.4×10^{-9}	1.2×10^{-9}	9.3×10^{-10}
		S	0.005	5.6×10^{-9}	5.0×10^{-4}	4.0×10^{-9}	2.2×10^{-9}	1.6×10^{-9}	1.3×10^{-9}	1.0×10^{-9}
Np-240	*1.08 h*	F	0.005	3.6×10^{-10}	5.0×10^{-4}	2.6×10^{-10}	1.2×10^{-10}	7.7×10^{-11}	4.7×10^{-11}	4.0×10^{-11}
		M	0.005	6.3×10^{-10}	5.0×10^{-4}	4.4×10^{-10}	2.2×10^{-10}	1.4×10^{-10}	1.0×10^{-10}	8.5×10^{-11}
		S	0.005	6.5×10^{-10}	5.0×10^{-4}	4.6×10^{-10}	2.3×10^{-10}	1.5×10^{-10}	1.1×10^{-10}	9.0×10^{-11}
Plutonium										
Pu-234	8.80 h	F	0.005	3.0×10^{-8}	5.0×10^{-4}	2.0×10^{-8}	9.8×10^{-9}	5.7×10^{-9}	3.6×10^{-9}	3.0×10^{-9}
		M	0.005	7.8×10^{-8}	5.0×10^{-4}	5.9×10^{-8}	3.7×10^{-8}	2.8×10^{-8}	2.6×10^{-8}	2.1×10^{-8}
		S	1.0×10^{-4}	8.7×10^{-8}	1.0×10^{-5}	6.6×10^{-8}	4.2×10^{-8}	3.1×10^{-8}	3.0×10^{-8}	2.4×10^{-8}
Pu-235	0.422 h	F	0.005	1.0×10^{-11}	5.0×10^{-4}	7.9×10^{-12}	3.9×10^{-12}	2.2×10^{-12}	1.3×10^{-12}	1.0×10^{-12}
		M	0.005	1.3×10^{-11}	5.0×10^{-4}	1.0×10^{-11}	5.0×10^{-12}	2.9×10^{-12}	1.9×10^{-12}	1.4×10^{-12}
		S	1.0×10^{-4}	1.3×10^{-11}	1.0×10^{-5}	1.0×10^{-11}	5.1×10^{-12}	3.0×10^{-12}	1.9×10^{-12}	1.5×10^{-12}
Pu-236	2.85 a	F	0.005	1.0×10^{-4}	5.0×10^{-4}	9.5×10^{-5}	6.1×10^{-5}	4.4×10^{-5}	3.7×10^{-5}	4.0×10^{-5}
		M	0.005	4.8×10^{-5}	5.0×10^{-4}	4.3×10^{-5}	2.9×10^{-5}	2.1×10^{-5}	1.9×10^{-5}	2.0×10^{-5}
		S	1.0×10^{-4}	3.6×10^{-5}	1.0×10^{-5}	3.1×10^{-5}	2.0×10^{-5}	1.4×10^{-5}	1.2×10^{-5}	1.0×10^{-5}
Pu-237	45.3 d	F	0.005	2.2×10^{-9}	5.0×10^{-4}	1.6×10^{-9}	7.9×10^{-10}	4.8×10^{-10}	2.9×10^{-10}	2.6×10^{-10}
		M	0.005	1.9×10^{-9}	5.0×10^{-4}	1.4×10^{-9}	8.2×10^{-10}	5.4×10^{-10}	4.3×10^{-10}	3.5×10^{-10}
		S	1.0×10^{-4}	2.0×10^{-9}	1.0×10^{-5}	1.5×10^{-9}	8.8×10^{-10}	5.9×10^{-10}	4.8×10^{-10}	3.9×10^{-10}
Pu-238	87.7 a	F	0.005	2.0×10^{-4}	5.0×10^{-4}	1.9×10^{-4}	1.4×10^{-4}	1.1×10^{-4}	1.0×10^{-4}	1.1×10^{-4}
		M	0.005	7.8×10^{-5}	5.0×10^{-4}	7.4×10^{-5}	5.6×10^{-5}	4.4×10^{-5}	4.3×10^{-5}	4.6×10^{-5}
		S	1.0×10^{-4}	4.5×10^{-5}	1.0×10^{-5}	4.0×10^{-5}	2.7×10^{-5}	1.9×10^{-5}	1.7×10^{-5}	1.6×10^{-5}

Pu-239	2.41×10^{4} a	F	0.005	2.1×10^{-4}	5.0×10^{-4}	2.0×10^{-4}	1.5×10^{-4}	1.2×10^{-4}	1.1×10^{-4}	1.2×10^{-4}
		M	0.005	8.0×10^{-5}	5.0×10^{-4}	7.7×10^{-5}	6.0×10^{-5}	4.8×10^{-5}	4.7×10^{-5}	5.0×10^{-5}
		S	1.0×10^{-4}	4.3×10^{-5}	1.0×10^{-5}	3.9×10^{-5}	2.7×10^{-5}	1.9×10^{-5}	1.7×10^{-5}	1.6×10^{-5}
Pu-240	6.54×10^{3} a	F	0.005	2.1×10^{-4}	5.0×10^{-4}	2.0×10^{-4}	1.5×10^{-4}	1.2×10^{-4}	1.1×10^{-4}	1.2×10^{-4}
		M	0.005	8.0×10^{-5}	5.0×10^{-4}	7.7×10^{-5}	6.0×10^{-5}	4.8×10^{-5}	4.7×10^{-5}	5.0×10^{-5}
		S	1.0×10^{-4}	4.3×10^{-5}	1.0×10^{-5}	3.9×10^{-5}	2.7×10^{-5}	1.9×10^{-5}	1.7×10^{-5}	1.6×10^{-5}
Pu-241	14.4 a	F	0.005	2.8×10^{-6}	5.0×10^{-4}	2.9×10^{-6}	2.6×10^{-6}	2.4×10^{-6}	2.2×10^{-6}	2.3×10^{-6}
		M	0.005	9.1×10^{-7}	5.0×10^{-4}	9.7×10^{-7}	9.2×10^{-7}	8.3×10^{-7}	8.6×10^{-7}	9.0×10^{-7}
		S	1.0×10^{-4}	2.2×10^{-7}	1.0×10^{-5}	2.3×10^{-7}	2.0×10^{-7}	1.7×10^{-7}	1.7×10^{-7}	1.7×10^{-7}
Pu-242	3.76×10^{5} a	F	0.005	2.0×10^{-4}	5.0×10^{-4}	1.9×10^{-4}	1.4×10^{-4}	1.2×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
		M	0.005	7.6×10^{-5}	5.0×10^{-4}	7.3×10^{-5}	5.7×10^{-5}	4.5×10^{-5}	4.5×10^{-5}	4.8×10^{-5}
		S	1.0×10^{-4}	4.0×10^{-5}	1.0×10^{-5}	3.6×10^{-5}	2.5×10^{-5}	1.7×10^{-5}	1.6×10^{-5}	1.5×10^{-5}
Pu-243	4.95 h	F	0.005	2.7×10^{-10}	5.0×10^{-4}	1.9×10^{-10}	8.8×10^{-11}	5.7×10^{-11}	3.5×10^{-11}	3.2×10^{-11}
		M	0.005	5.6×10^{-10}	5.0×10^{-4}	3.9×10^{-10}	1.9×10^{-10}	1.3×10^{-10}	8.7×10^{-11}	8.3×10^{-11}
		S	1.0×10^{-4}	6.0×10^{-10}	1.0×10^{-5}	4.1×10^{-10}	2.0×10^{-10}	1.4×10^{-10}	9.2×10^{-11}	8.6×10^{-11}
Pu-244	8.26×10^{7} a	F	0.005	2.0×10^{-4}	5.0×10^{-4}	1.9×10^{-4}	1.4×10^{-4}	1.2×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
		M	0.005	7.4×10^{-5}	5.0×10^{-4}	7.2×10^{-5}	5.6×10^{-5}	4.5×10^{-5}	4.4×10^{-5}	4.7×10^{-5}
		S	1.0×10^{-4}	3.9×10^{-5}	1.0×10^{-5}	3.5×10^{-5}	2.4×10^{-5}	1.7×10^{-5}	1.5×10^{-5}	1.5×10^{-5}
Pu-245	10.5 h	F	0.005	1.8×10^{-9}	5.0×10^{-4}	1.3×10^{-9}	5.6×10^{-10}	3.5×10^{-10}	1.9×10^{-10}	1.6×10^{-10}
		M	0.005	3.6×10^{-9}	5.0×10^{-4}	2.5×10^{-9}	1.2×10^{-9}	8.0×10^{-10}	5.0×10^{-10}	4.0×10^{-10}
		S	1.0×10^{-4}	3.8×10^{-9}	1.0×10^{-5}	2.6×10^{-9}	1.3×10^{-9}	8.5×10^{-10}	5.4×10^{-10}	4.3×10^{-10}
Pu-246	10.9 d	F	0.005	2.0×10^{-8}	5.0×10^{-4}	1.4×10^{-8}	7.0×10^{-9}	4.4×10^{-9}	2.8×10^{-9}	2.5×10^{-9}
		M	0.005	3.5×10^{-8}	5.0×10^{-4}	2.6×10^{-8}	1.5×10^{-8}	1.1×10^{-8}	9.1×10^{-9}	7.4×10^{-9}
		S	1.0×10^{-4}	3.8×10^{-8}	1.0×10^{-5}	2.8×10^{-8}	1.6×10^{-8}	1.2×10^{-8}	1.0×10^{-8}	8.0×10^{-9}
Americium										
Am-237	1.22 h	F	0.005	9.8×10^{-11}	5.0×10^{-4}	7.3×10^{-11}	3.5×10^{-11}	2.2×10^{-11}	1.3×10^{-11}	1.1×10^{-11}
		M	0.005	1.7×10^{-10}	5.0×10^{-4}	1.2×10^{-10}	6.2×10^{-11}	4.1×10^{-11}	3.0×10^{-11}	2.5×10^{-11}
		S	0.005	1.7×10^{-10}	5.0×10^{-4}	1.3×10^{-10}	6.5×10^{-11}	4.3×10^{-11}	3.2×10^{-11}	2.6×10^{-11}
Am-238	1.63 h	F	0.005	4.1×10^{-10}	5.0×10^{-4}	3.8×10^{-10}	2.5×10^{-10}	2.0×10^{-10}	1.8×10^{-10}	1.9×10^{-10}
		M	0.005	3.1×10^{-10}	5.0×10^{-4}	2.6×10^{-10}	1.3×10^{-10}	9.6×10^{-11}	8.8×10^{-11}	9.0×10^{-11}
		S	0.005	2.7×10^{-10}	5.0×10^{-4}	2.2×10^{-10}	1.3×10^{-10}	8.2×10^{-11}	6.1×10^{-11}	5.4×10^{-11}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
			f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)
Am-239	11.9 h	F	0.005	8.1×10^{-10}	5.0×10^{-4}	5.8×10^{-10}	2.6×10^{-10}	1.6×10^{-10}	9.1×10^{-11}	7.6×10^{-11}
		M	0.005	1.5×10^{-9}	5.0×10^{-4}	1.1×10^{-9}	5.6×10^{-10}	3.7×10^{-10}	2.7×10^{-10}	2.2×10^{-10}
		S	0.005	1.6×10^{-9}	5.0×10^{-4}	1.1×10^{-9}	5.9×10^{-10}	4.0×10^{-10}	2.5×10^{-10}	2.4×10^{-10}
Am-240	2.12 d	F	0.005	2.0×10^{-9}	5.0×10^{-4}	1.7×10^{-9}	8.8×10^{-10}	5.7×10^{-10}	3.6×10^{-10}	2.3×10^{-10}
		M	0.005	2.9×10^{-9}	5.0×10^{-4}	2.2×10^{-9}	1.2×10^{-9}	7.7×10^{-10}	5.3×10^{-10}	4.3×10^{-10}
		S	0.005	3.0×10^{-9}	5.0×10^{-4}	2.3×10^{-9}	1.2×10^{-9}	7.8×10^{-10}	5.3×10^{-10}	4.3×10^{-10}
Am-241	4.32×10^2 a	F	0.005	1.8×10^{-4}	5.0×10^{-4}	1.8×10^{-4}	1.2×10^{-4}	1.0×10^{-4}	9.2×10^{-5}	9.6×10^{-5}
		M	0.005	7.3×10^{-5}	5.0×10^{-4}	6.9×10^{-5}	5.1×10^{-5}	4.0×10^{-5}	4.0×10^{-5}	4.2×10^{-5}
		S	0.005	4.6×10^{-5}	5.0×10^{-4}	4.0×10^{-5}	2.7×10^{-5}	1.9×10^{-5}	1.7×10^{-5}	1.6×10^{-5}
Am-242	16.0 h	F	0.005	9.2×10^{-8}	5.0×10^{-4}	7.1×10^{-8}	3.5×10^{-8}	2.1×10^{-8}	1.4×10^{-8}	1.1×10^{-8}
		M	0.005	7.6×10^{-8}	5.0×10^{-4}	5.9×10^{-8}	3.6×10^{-8}	2.4×10^{-8}	2.1×10^{-8}	1.7×10^{-8}
		S	0.005	8.0×10^{-8}	5.0×10^{-4}	6.2×10^{-8}	3.9×10^{-8}	2.7×10^{-8}	2.4×10^{-8}	2.0×10^{-8}
Am-242m	1.52×10^2 a	F	0.005	1.6×10^{-4}	5.0×10^{-4}	1.5×10^{-4}	1.1×10^{-4}	9.4×10^{-5}	8.8×10^{-5}	9.2×10^{-5}
		M	0.005	5.2×10^{-5}	5.0×10^{-4}	5.3×10^{-5}	4.1×10^{-5}	3.4×10^{-5}	3.5×10^{-5}	3.7×10^{-5}
		S	0.005	2.5×10^{-5}	5.0×10^{-4}	2.4×10^{-5}	1.7×10^{-5}	1.2×10^{-5}	1.1×10^{-5}	1.1×10^{-5}
Am-243	7.38×10^3 a	F	0.005	1.8×10^{-4}	5.0×10^{-4}	1.7×10^{-4}	1.2×10^{-4}	1.0×10^{-4}	9.1×10^{-5}	9.6×10^{-5}
		M	0.005	7.2×10^{-5}	5.0×10^{-4}	6.8×10^{-5}	5.0×10^{-5}	4.0×10^{-5}	4.0×10^{-5}	4.1×10^{-5}
		S	0.005	4.4×10^{-5}	5.0×10^{-4}	3.9×10^{-5}	2.6×10^{-5}	1.8×10^{-5}	1.6×10^{-5}	1.5×10^{-5}
Am-244	10.1 h	F	0.005	1.0×10^{-8}	5.0×10^{-4}	9.2×10^{-9}	5.6×10^{-9}	4.1×10^{-9}	3.5×10^{-9}	3.7×10^{-9}
		M	0.005	6.0×10^{-9}	5.0×10^{-4}	5.0×10^{-9}	3.2×10^{-9}	2.2×10^{-9}	2.0×10^{-9}	2.0×10^{-9}
		S	0.005	6.1×10^{-9}	5.0×10^{-4}	4.8×10^{-9}	2.4×10^{-9}	1.6×10^{-9}	1.4×10^{-9}	1.2×10^{-9}
Am-244m	0.433 h	F	0.005	4.6×10^{-10}	5.0×10^{-4}	4.0×10^{-10}	2.4×10^{-10}	1.8×10^{-10}	1.5×10^{-10}	1.6×10^{-10}
		M	0.005	3.3×10^{-10}	5.0×10^{-4}	2.1×10^{-10}	1.3×10^{-10}	9.2×10^{-11}	8.3×10^{-11}	8.4×10^{-11}
		S	0.005	3.0×10^{-10}	5.0×10^{-4}	2.2×10^{-10}	1.2×10^{-10}	8.1×10^{-11}	5.5×10^{-11}	5.7×10^{-11}

Am-245	2.05 h	F	0.005	2.1×10^{-10}	5.0×10^{-4}	1.4×10^{-10}	6.2×10^{-11}	4.0×10^{-11}	2.4×10^{-11}	2.1×10^{-11}
		M	0.005	3.9×10^{-10}	5.0×10^{-4}	2.6×10^{-10}	1.3×10^{-10}	8.7×10^{-11}	6.4×10^{-11}	5.3×10^{-11}
		S	0.005	4.1×10^{-10}	5.0×10^{-4}	2.8×10^{-10}	1.3×10^{-10}	9.2×10^{-11}	6.8×10^{-11}	5.6×10^{-11}
Am-246	0.650 h	F	0.005	3.0×10^{-10}	5.0×10^{-4}	2.0×10^{-10}	9.3×10^{-11}	6.1×10^{-11}	3.8×10^{-11}	3.3×10^{-11}
		M	0.005	5.0×10^{-10}	5.0×10^{-4}	3.4×10^{-10}	1.6×10^{-10}	1.1×10^{-10}	7.9×10^{-11}	6.6×10^{-11}
		S	0.005	5.3×10^{-10}	5.0×10^{-4}	3.6×10^{-10}	1.7×10^{-10}	1.2×10^{-10}	8.3×10^{-11}	6.9×10^{-11}
Am-246m	0.417 h	F	0.005	1.3×10^{-10}	5.0×10^{-4}	8.9×10^{-11}	4.2×10^{-11}	2.6×10^{-11}	1.6×10^{-11}	1.4×10^{-11}
		M	0.005	1.9×10^{-10}	5.0×10^{-4}	1.3×10^{-10}	6.1×10^{-11}	4.0×10^{-11}	2.6×10^{-11}	2.2×10^{-11}
		S	0.005	2.0×10^{-10}	5.0×10^{-4}	1.4×10^{-10}	6.4×10^{-11}	4.1×10^{-11}	2.7×10^{-11}	2.3×10^{-11}
Curium										
Cm-238	2.40 h	F	0.005	7.7×10^{-9}	5.0×10^{-4}	5.4×10^{-9}	2.6×10^{-9}	1.8×10^{-9}	9.2×10^{-10}	7.8×10^{-10}
		M	0.005	2.1×10^{-8}	5.0×10^{-4}	1.5×10^{-8}	7.9×10^{-9}	5.9×10^{-9}	5.6×10^{-9}	4.5×10^{-9}
		S	0.005	2.2×10^{-8}	5.0×10^{-4}	1.6×10^{-8}	8.6×10^{-9}	6.4×10^{-9}	6.1×10^{-9}	4.9×10^{-9}
Cm-240	27.0 d	F	0.005	8.3×10^{-6}	5.0×10^{-4}	6.3×10^{-6}	3.2×10^{-6}	2.0×10^{-6}	1.5×10^{-6}	1.3×10^{-6}
		M	0.005	1.2×10^{-5}	5.0×10^{-4}	9.1×10^{-6}	5.8×10^{-6}	4.2×10^{-6}	3.8×10^{-6}	3.2×10^{-6}
		S	0.005	1.3×10^{-5}	5.0×10^{-4}	9.9×10^{-6}	6.4×10^{-6}	4.6×10^{-6}	4.3×10^{-6}	3.5×10^{-6}
Cm-241	32.8 d	F	0.005	1.1×10^{-7}	5.0×10^{-4}	8.9×10^{-8}	4.9×10^{-8}	3.5×10^{-8}	2.8×10^{-8}	2.7×10^{-8}
		M	0.005	1.3×10^{-7}	5.0×10^{-4}	1.0×10^{-7}	6.6×10^{-8}	4.8×10^{-8}	4.4×10^{-8}	3.7×10^{-8}
		S	0.005	1.4×10^{-7}	5.0×10^{-4}	1.1×10^{-7}	6.9×10^{-8}	4.9×10^{-8}	4.5×10^{-8}	3.7×10^{-8}
Cm-242	163 d	F	0.005	2.7×10^{-5}	5.0×10^{-4}	2.1×10^{-5}	1.0×10^{-5}	6.1×10^{-6}	4.0×10^{-6}	3.3×10^{-6}
		M	0.005	2.2×10^{-5}	5.0×10^{-4}	1.8×10^{-5}	1.1×10^{-5}	7.3×10^{-6}	6.4×10^{-6}	5.2×10^{-6}
		S	0.005	2.4×10^{-5}	5.0×10^{-4}	1.9×10^{-5}	1.2×10^{-5}	8.2×10^{-6}	7.3×10^{-6}	5.9×10^{-6}
Cm-243	28.5 a	F	0.005	1.6×10^{-4}	5.0×10^{-4}	1.5×10^{-4}	9.5×10^{-5}	7.3×10^{-5}	6.5×10^{-5}	6.9×10^{-5}
		M	0.005	6.7×10^{-5}	5.0×10^{-4}	6.1×10^{-5}	4.2×10^{-5}	3.1×10^{-5}	3.0×10^{-5}	3.1×10^{-5}
		S	0.005	4.6×10^{-5}	5.0×10^{-4}	4.0×10^{-5}	2.6×10^{-5}	1.8×10^{-5}	1.6×10^{-5}	1.5×10^{-5}
Cm-244	18.1 a	F	0.005	1.5×10^{-4}	5.0×10^{-4}	1.3×10^{-4}	8.3×10^{-5}	6.1×10^{-5}	5.3×10^{-5}	5.7×10^{-5}
		M	0.005	6.2×10^{-5}	5.0×10^{-4}	5.7×10^{-5}	3.7×10^{-5}	2.7×10^{-5}	2.6×10^{-5}	2.7×10^{-5}
		S	0.005	4.4×10^{-5}	5.0×10^{-4}	3.8×10^{-5}	2.5×10^{-5}	1.7×10^{-5}	1.5×10^{-5}	1.3×10^{-5}
Cm-245	8.50×10^{3} a	F	0.005	1.9×10^{-4}	5.0×10^{-4}	1.8×10^{-4}	1.2×10^{-4}	1.0×10^{-4}	9.4×10^{-5}	9.9×10^{-5}
		M	0.005	7.3×10^{-5}	5.0×10^{-4}	6.9×10^{-5}	5.1×10^{-5}	4.1×10^{-5}	4.1×10^{-5}	4.2×10^{-5}
		S	0.005	4.5×10^{-5}	5.0×10^{-4}	4.0×10^{-5}	2.7×10^{-5}	1.9×10^{-5}	1.7×10^{-5}	1.6×10^{-5}

TABLE II-VII. (cont.)

Nuclide	Physical half-life	Type	Age g ≤1 a		f_1 for	Age 1-2 a	Age 2-7 a	Age 7-12 a	Age 12-17 a	Age > 17 a
			f_1	e(g)	g > 1 a	e(g)	e(g)	e(g)	e(g)	e(g)
Cm-246	4.73×10^3 a	F	0.005	1.9×10^{-4}	5.0×10^{-4}	1.8×10^{-4}	1.2×10^{-4}	1.0×10^{-4}	9.4×10^{-5}	9.8×10^{-5}
		M	0.005	7.3×10^{-5}	5.0×10^{-4}	6.9×10^{-5}	5.1×10^{-5}	4.1×10^{-5}	4.1×10^{-5}	4.2×10^{-5}
		S	0.005	4.6×10^{-5}	5.0×10^{-4}	4.0×10^{-5}	2.7×10^{-5}	1.9×10^{-5}	1.7×10^{-5}	1.6×10^{-5}
Cm-247	1.56×10^7 a	F	0.005	1.7×10^{-4}	5.0×10^{-4}	1.6×10^{-4}	1.1×10^{-4}	9.4×10^{-5}	8.6×10^{-5}	9.0×10^{-5}
		M	0.005	6.7×10^{-5}	5.0×10^{-4}	6.3×10^{-5}	4.7×10^{-5}	3.7×10^{-5}	3.7×10^{-5}	3.9×10^{-5}
		S	0.005	4.1×10^{-5}	5.0×10^{-4}	3.6×10^{-5}	2.4×10^{-5}	1.7×10^{-5}	1.5×10^{-5}	1.4×10^{-5}
Cm-248	3.39×10^5 a	F	0.005	6.8×10^{-4}	5.0×10^{-4}	6.5×10^{-4}	4.5×10^{-4}	3.7×10^{-4}	3.4×10^{-4}	3.6×10^{-4}
		M	0.005	2.5×10^{-4}	5.0×10^{-4}	2.4×10^{-4}	1.8×10^{-4}	1.4×10^{-4}	1.4×10^{-4}	1.5×10^{-4}
		S	0.005	1.4×10^{-4}	5.0×10^{-4}	1.2×10^{-4}	8.2×10^{-5}	5.6×10^{-5}	5.0×10^{-5}	4.8×10^{-5}
Cm-249	1.07 h	F	0.005	1.8×10^{-10}	5.0×10^{-4}	9.8×10^{-11}	5.9×10^{-11}	4.6×10^{-11}	4.0×10^{-11}	4.0×10^{-11}
		M	0.005	2.4×10^{-10}	5.0×10^{-4}	1.6×10^{-10}	8.2×10^{-11}	5.8×10^{-11}	3.7×10^{-11}	3.3×10^{-11}
		S	0.005	2.4×10^{-10}	5.0×10^{-4}	1.6×10^{-10}	7.8×10^{-11}	5.3×10^{-11}	3.9×10^{-11}	3.3×10^{-11}
Cm-250	6.90×10^3 a	F	0.005	3.9×10^{-3}	5.0×10^{-4}	3.7×10^{-3}	2.6×10^{-3}	2.1×10^{-3}	2.0×10^{-3}	2.1×10^{-3}
		M	0.005	1.4×10^{-3}	5.0×10^{-4}	1.3×10^{-3}	9.9×10^{-4}	7.9×10^{-4}	7.9×10^{-4}	8.4×10^{-4}
		S	0.005	7.2×10^{-4}	5.0×10^{-4}	6.5×10^{-4}	4.4×10^{-4}	3.0×10^{-4}	2.7×10^{-4}	2.6×10^{-4}
Berkelium										
Bk-245	4.94 d	M	0.005	8.8×10^{-9}	5.0×10^{-4}	6.6×10^{-9}	4.0×10^{-9}	2.9×10^{-9}	2.6×10^{-9}	2.1×10^{-9}
Bk-246	1.83 d	M	0.005	2.1×10^{-9}	5.0×10^{-4}	1.7×10^{-9}	9.3×10^{-10}	6.0×10^{-10}	4.0×10^{-10}	3.3×10^{-10}
Bk-247	1.38×10^3 a	M	0.005	1.5×10^{-4}	5.0×10^{-4}	1.5×10^{-4}	1.1×10^{-4}	7.9×10^{-5}	7.2×10^{-5}	6.9×10^{-5}
Bk-249	320 d	M	0.005	3.3×10^{-7}	5.0×10^{-4}	3.3×10^{-7}	2.4×10^{-7}	1.8×10^{-7}	1.6×10^{-7}	1.6×10^{-7}
Bk-250	3.22 h	M	0.005	3.4×10^{-9}	5.0×10^{-4}	3.1×10^{-9}	2.0×10^{-9}	1.3×10^{-9}	1.1×10^{-9}	1.0×10^{-9}
Californium										
Cf-244	0.323 h	M	0.005	7.6×10^{-8}	5.0×10^{-4}	5.4×10^{-8}	2.8×10^{-8}	2.0×10^{-8}	1.6×10^{-8}	1.4×10^{-8}
Cf-246	1.49 d	M	0.005	1.7×10^{-6}	5.0×10^{-4}	1.3×10^{-6}	8.3×10^{-7}	6.1×10^{-7}	5.7×10^{-7}	4.5×10^{-7}

Cf-248	334 d	M	0.005	3.8×10^{-5}	5.0×10^{-4}	3.2×10^{-5}	2.1×10^{-5}	1.4×10^{-5}	1.0×10^{-5}	8.8×10^{-6}
Cf-249	3.50×10^{2} a	M	0.005	1.6×10^{-4}	5.0×10^{-4}	1.5×10^{-4}	1.1×10^{-4}	8.0×10^{-5}	7.2×10^{-5}	7.0×10^{-5}
Cf-250	13.1 a	M	0.005	1.1×10^{-4}	5.0×10^{-4}	9.8×10^{-5}	6.6×10^{-5}	4.2×10^{-5}	3.5×10^{-5}	3.4×10^{-5}
Cf-251	8.98×10^{2} a	M	0.005	1.6×10^{-4}	5.0×10^{-4}	1.5×10^{-4}	1.1×10^{-4}	8.1×10^{-5}	7.3×10^{-5}	7.1×10^{-5}
Cf-252	2.64 a	M	0.005	9.7×10^{-5}	5.0×10^{-4}	8.7×10^{-5}	5.6×10^{-5}	3.2×10^{-5}	2.2×10^{-5}	2.0×10^{-5}
Cf-253	17.8 d	M	0.005	5.4×10^{-6}	5.0×10^{-4}	4.2×10^{-6}	2.6×10^{-6}	1.9×10^{-6}	1.7×10^{-6}	1.3×10^{-6}
Cf-254	60.5 d	M	0.005	2.5×10^{-4}	5.0×10^{-4}	1.9×10^{-4}	1.1×10^{-4}	7.0×10^{-5}	4.8×10^{-5}	4.1×10^{-5}
Einsteinium										
Es-250	2.10 h	M	0.005	2.0×10^{-9}	5.0×10^{-4}	1.8×10^{-9}	1.2×10^{-9}	7.8×10^{-10}	6.4×10^{-10}	6.3×10^{-10}
Es-251	1.38 d	M	0.005	7.9×10^{-9}	5.0×10^{-4}	6.0×10^{-9}	3.9×10^{-9}	2.8×10^{-9}	2.6×10^{-9}	2.1×10^{-9}
Es-253	20.5 d	M	0.005	1.1×10^{-5}	5.0×10^{-4}	8.0×10^{-6}	5.1×10^{-6}	3.7×10^{-6}	3.4×10^{-6}	2.7×10^{-6}
Es-254	276 d	M	0.005	3.7×10^{-5}	5.0×10^{-4}	3.1×10^{-5}	2.0×10^{-5}	1.3×10^{-5}	1.0×10^{-5}	8.6×10^{-6}
Es-254m	1.64 d	M	0.005	1.7×10^{-6}	5.0×10^{-4}	1.3×10^{-6}	8.4×10^{-7}	6.3×10^{-7}	5.9×10^{-7}	4.7×10^{-7}
Fermium										
Fm-252	22.7 h	M	0.005	1.2×10^{-6}	5.0×10^{-4}	9.0×10^{-7}	5.8×10^{-7}	4.3×10^{-7}	4.0×10^{-7}	3.2×10^{-7}
Fm-253	3.00 d	M	0.005	1.5×10^{-6}	5.0×10^{-4}	1.2×10^{-6}	7.3×10^{-7}	5.4×10^{-7}	5.0×10^{-7}	4.0×10^{-7}
Fm-254	3.24 h	M	0.005	3.2×10^{-7}	5.0×10^{-4}	2.3×10^{-7}	1.3×10^{-7}	9.8×10^{-8}	7.6×10^{-8}	6.1×10^{-8}
Fm-255	20.1 h	M	0.005	1.2×10^{-6}	5.0×10^{-4}	7.3×10^{-7}	4.7×10^{-7}	3.5×10^{-7}	3.4×10^{-7}	2.7×10^{-7}
Fm-257	101 d	M	0.005	3.3×10^{-5}	5.0×10^{-4}	2.6×10^{-5}	1.6×10^{-5}	1.1×10^{-5}	8.8×10^{-6}	7.1×10^{-6}
Mendelevium										
Md-257	5.20 h	M	0.005	1.0×10^{-7}	5.0×10^{-4}	8.2×10^{-8}	5.1×10^{-8}	3.6×10^{-8}	3.1×10^{-8}	2.5×10^{-8}
Md-258	55.0 d	M	0.005	2.4×10^{-5}	5.0×10^{-4}	1.9×10^{-5}	1.2×10^{-5}	8.6×10^{-6}	7.3×10^{-6}	5.9×10^{-6}

TABLE II-VIII. LUNG ABSORPTION TYPES USED TO CALCULATE COMMITTED EFFECTIVE DOSE PER UNIT INTAKE VIA INHALATION FOR EXPOSURE TO PARTICULATE AEROSOLS OR TO GASES AND VAPOURS FOR MEMBERS OF THE PUBLIC

Element	Absorption type(s)[a]	ICRP Publication No. for details of biokinetic model and absorption type(s)
Hydrogen	F, M[b], S, G	Publications 56, 67 and 71
Beryllium	M, S	Publication 30, Part 3
Carbon	F, M[b], 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[b], 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[b], S	Publications 69 and 71
Cobalt	F, M[b], S	Publications 67 and 71
Nickel	F, M[b], S, G	Publications 67 and 71
Copper	F, M, S	Publication 30, Part 2
Zinc	F, M[b], S	Publications 67 and 71
Gallium	F, M	Publication 30, Part 3

[a] For particulates: F: fast; M: moderate; S: slow; G: gases and vapours.

[b] Recommended default absorption type for particulate aerosol when no specific information is available (see ICRP Publication No. 71 (1996) (see footnote 42)).

TABLE II-VIII. (cont.)

Element	Absorption type(s)[a]	ICRP Publication No. for details of biokinetic model and absorption type(s)
Germanium	F, M	Publication 30, Part 3
Arsenic	M	Publication 30, Part 3
Selenium	F[b], M, S	Publications 69 and 71
Bromine	F, M	Publication 30, Part 2
Rubidium	F	Publication 30, Part 2
Strontium	F, M[b], S	Publications 67 and 71
Yttrium	M, S	Publication 30, Part 2
Zirconium	F, M[b], S	Publications 56, 67 and 71
Niobium	F, M[b], S	Publications 56, 67 and 71
Molybdenum	F, M[b], S	Publications 67 and 71
Technetium	F, M[b], S	Publications 67 and 71
Ruthenium	F, M[b], 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[b], 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[b], S	Publications 69 and 71
Tellurium	F, M[b], S, G	Publications 67 and 71
Iodine	F[b], M, S, G	Publications 56, 67 and 71
Caesium	F[b], M, S	Publications 56, 67 and 71
Barium	F, M[b], S	Publications 67 and 71
Lanthanum	F, M	Publication 30, Part 3
Cerium	F, M[b], 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

TABLE II-VIII. (cont.)

Element	Absorption type(s)[a]	ICRP Publication No. for details of biokinetic model and absorption type(s)
Europium	M	Publication 30, Part 3
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[b], S, G	Publications 67 and 71
Bismuth	F, M	Publication 30, Part 2
Polonium	F, M[b], S, G	Publications 67 and 71
Astatine	F, M	Publication 30, Part 3
Francium	F	Publication 30, Part 3
Radium	F, M[b], S	Publications 67 and 71
Actinium	F, M, S	Publication 30, Part 3
Thorium	F, M, S[b]	Publications 69 and 71
Protactinium	M, S	Publication 30, Part 3
Uranium	F, M[b], S	Publications 69 and 71

TABLE II-VIII. (cont.)

Element	Absorption type(s)[a]	ICRP Publication No. for details of biokinetic model and absorption type(s)
Neptunium	F, M[b], S	Publications 67 and 71
Plutonium	F, M[b], S	Publications 67 and 71
Americium	F, M[b], S	Publications 67 and 71
Curium	F, M[b], 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 II-IX. INHALATION: COMMITTED EFFECTIVE DOSE PER UNIT INTAKE e(g) ($Sv \cdot Bq^{-1}$) FOR SOLUBLE OR REACTIVE GASES AND VAPOURS

Nuclide	Physical half-life	Absorption[a]	% deposit	Age g ≤ 1 a: f_1	Age g ≤ 1 a: e(g)	f_1 for g > 1 a	Age 1–2 a e(g)	Age 2–7 a e(g)	Age 7–12 a e(g)	Age 12–17 a e(g)	Age > 17 a e(g)[b]
Tritiated water	12.3 a	V	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	[c]	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	[c]	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}
Nickel-59 carbonyl	7.50×10^{4} a	[c]	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	[c]	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}

[a] F: fast; V: material is taken to be completely and instantaneously transferred to body fluids.

[b] Applicable to both workers and adult members of the public.

[c] Deposition 30% : 10% : 20% : 40% (extrathoracic : bronchial : bronchiolar : alveolar-interstitial), 0.1 day retention half-time (see ICRP Publication No. 68 (1994) (see footnote 42)).

Nickel-65 carbonyl	2.52 h	c	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	c	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}
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}

TABLE II-IX. (cont.)

Nuclide	Physical half-life	Absorption[a]	% deposit	Age g ≤ 1 a		f_1 for g > 1 a	Age 1–2 a	Age 2–7 a	Age 7–12 a	Age 12–17 a	Age > 17 a
				f_1	e(g)		e(g)	e(g)	e(g)	e(g)	e(g)[b]
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}
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}
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	[d]	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	[d]	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^{2} a	[d]	70	1.000	9.4×10^{-8}	1.000	8.3×10^{-8}	6.2×10^{-8}	5.0×10^{-8}	4.3×10^{-8}	4.0×10^{-8}
Mercury-195 vapour	9.90 h	[d]	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	[d]	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	[d]	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	[d]	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	[d]	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	[d]	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}

[d] Deposition 10% : 20% : 40% (bronchial : bronchiolar : alveolar-interstitial), 1.7 day retention time (see ICRP Publication No. 68 (1994) (see footnote 42)).

TABLE II-X. EFFECTIVE DOSE RATE FOR EXPOSURE TO INERT GASES FOR ADULTS[a]

Nuclide	Physical half-life	Effective dose rate per unit integrated air concentration ($Sv \cdot d^{-1}/Bq \cdot m^{-3}$)[a]
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}

[a] Applicable to both workers and adult members of the public.

Schedule III

GUIDANCE LEVELS OF DOSE, DOSE RATE AND ACTIVITY FOR MEDICAL EXPOSURE

GUIDANCE LEVELS FOR DIAGNOSTIC RADIOLOGICAL PROCEDURES

TABLE III-I. GUIDANCE LEVELS OF DOSE FOR DIAGNOSTIC RADIOGRAPHY FOR A TYPICAL ADULT PATIENT

Examination		Entrance surface dose per radiograph[a] (mGy)
	AP	10
Lumbar spine	LAT	30
	LSJ	40
Abdomen, intravenous urography and cholecystography	AP	10
Pelvis	AP	10
Hip joint	AP	10
Chest	PA	0.4
	LAT	1.5
Thoracic spine	AP	7
	LAT	20
Dental	Periapical	7
	AP	5
Skull	PA	5
	LAT	3

Notes: PA: posterior–anterior projection; LAT: lateral projection; LSJ: lumbo-sacral-joint projection; AP: anterior-posterior projection.

[a] In air with backscatter. These values are for conventional film–screen combination in the relative speed of 200. For high speed film–screen combinations (400–600), the values should be reduced by a factor of 2 to 3.

TABLE III-II. DOSE GUIDANCE LEVELS FOR COMPUTED TOMOGRAPHY FOR A TYPICAL ADULT PATIENT

Examination	Multiple scan average dose[a] (mGy)
Head	50
Lumbar spine	35
Abdomen	25

[a] Derived from measurements on the axis of rotation in water equivalent phantoms, 15 cm in length and 16 cm (head) and 30 cm (lumbar spine and abdomen) in diameter.

TABLE III-III. DOSE GUIDANCE LEVELS FOR MAMMOGRAPHY FOR A TYPICAL ADULT PATIENT

Average glandular dose per cranio-caudal projection[a]
1 mGy (without grid)
3 mGy (with grid)

[a] Determined in a 4.5 cm compressed breast consisting of 50% glandular and 50% adipose tissue, for film-screen systems and dedicated Mo-target Mo-filter mammography units.

TABLE III-IV. DOSE RATE GUIDANCE LEVELS FOR FLUOROSCOPY FOR A TYPICAL ADULT PATIENT

Mode of operation	Entrance surface dose rate[a] (mGy/min)
Normal	25
High level[b]	100

[a] In air with backscatter.

[b] For fluoroscopes that have an optional 'high level' operational mode, such as those frequently used in interventional radiology.

GUIDANCE LEVELS FOR DIAGNOSTIC PROCEDURES IN NUCLEAR MEDICINE

TABLE III-V. GUIDANCE LEVELS OF ACTIVITY FOR PROCEDURES IN NUCLEAR MEDICINE FOR A TYPICAL ADULT PATIENT

Test	Radio-nuclide	Chemical form[a]	Maximum usual activity per test[b] (MBq)
Bone			
Bone imaging	$^{99}Tc^{m}$	Phosphonate and Phosphate compounds	600
Bone imaging by single photon emission computerized tomography (SPECT)	$^{99}Tc^{m}$	Phosponate and Phosphate compounds	800
Bone marrow imaging	$^{99}Tc^{m}$	Labelled colloid	400
Brain			
Brain imaging (static)	$^{99}Tc^{m}$	TcO_4^-	500
	$^{99}Tc^{m}$	Diethylenetriaminepenta-acetic acid (DTPA), gluconate and glucoheptonate	500
Brain imaging (SPECT)	$^{99}Tc^{m}$	TcO_4^-	800
	$^{99}Tc^{m}$	DTPA, gluconate and glucoheptonate	800
	$^{99}Tc^{m}$	Exametazime	500
Cerebral blood flow	^{133}Xe	In isotonic sodium chloride solution	400
	$^{99}Tc^{m}$	Hexamethyl propylene amine oxime (HM-PAO)	500
Cisternography	^{111}In	DTPA	40
Lacrimal			
Lacrimal drainage	$^{99}Tc^{m}$	TcO_4^1	4
	$^{99}Tc^{m}$	Labelled colloid	4
Thyroid			
Thyroid imaging	$^{99}Tc^{m}$	TcO_4^-	200
	^{123}I	I^-	20
Thyroid metastases (after ablation)	^{131}I	I^-	400
Parathyroid imaging	^{201}Tl	Tl^+, chloride	80

TABLE III-V. (cont.)

Test	Radio-nuclide	Chemical form[a]	Maximum usual activity per test[b] (MBq)
Lung			
Lung ventilation imaging	$^{81}Kr^{m}$	Gas	6000
	$^{99}Tc^{m}$	DTPA-aerosol	80
Lung ventilation study	^{133}Xe	Gas	400
	^{127}Xe	Gas	200
Lung perfusion imaging	$^{81}Kr^{m}$	Aqueous solution	6000
	$^{99}Tc^{m}$	Human albumin (macroaggregates or microspheres)	100
Lung perfusion imaging (with venography)	$^{99}Tc^{m}$	Human albumin (macroaggregates or microspheres)	160
Lung perfusion studies	^{133}Xe	Isotonic solution	200
	^{127}Xe	Isotonic chloride solution	200
Lung imaging (SPECT)	^{99}Tc	Macroaggregated albumin (MAA)	200
Liver and spleen			
Liver and spleen imaging	$^{99}Tc^{m}$	Labelled colloid	80
Functional biliary system imaging	$^{99}Tc^{m}$	Iminodiacetates and equivalent agents	150
Spleen imaging	$^{99}Tc^{m}$	Labelled denaturated red blood cells	100
Liver imaging (SPECT)	$^{99}Tc^{m}$	Labelled colloid	200
Cardiovascular			
First pass blood flow studies	$^{99}Tc^{m}$	TcO_4^-	800
	$^{99}Tc^{m}$	DTPA	800
	$^{99}Tc^{m}$	Macroaggregated globulin 3	400
Blood pool imaging	$^{99}Tc^{m}$	Human albumin complex	40
Cardiac and vascular imaging/probe studies	$^{99}Tc^{m}$	Human albumin complex	800
Myocardial imaging/probe studies	$^{99}Tc^{m}$	Labelled normal red blood cells	800

TABLE III-V. (cont.)

Test	Radio-nuclide	Chemical form[a]	Maximum usual activity per test[b] (MBq)
Myocardial imaging	$^{99}Tc^{m}$	Phosphonate and phosphate compounds	600
Myocardial imaging (SPECT)	$^{99}Tc^{m}$	Isonitriles	300
	^{201}Tl	Tl^{+} chloride	100
	$^{99}Tc^{m}$	Phosphonate and phosphate compounds	800
	$^{99}Tc^{m}$	Isonitriles	600
Stomach, gastrointestinal tract			
Stomach/salivary gland imaging	$^{99}Tc^{m}$	TcO_4^-	40
Meckel's diverticulum imaging	$^{99}Tc^{m}$	TcO_4^-	400
Gastrointestinal bleeding	$^{99}Tc^{m}$	Labelled colloid	400
	$^{99}Tc^{m}$	Labelled normal red blood cells	400
Oesophageal transit and reflux	$^{99}Tc^{m}$	Labelled colloid	40
	$^{99}Tc^{m}$	Non-absorbable compounds	40
Gastric emptying	$^{99}Tc^{m}$	Non-absorbable compounds	12
	^{111}In	Non-absorbable compounds	12
	$^{113}In^{m}$	Non-absorbable compounds	12
Kidney, urinary system and adrenals			
Renal imaging	$^{99}Tc^{m}$	Dimercaptosuccinic acid	160
Renal imaging/renography	$^{99}Tc^{m}$	DTPA, gluconate and glucoheptonate	350
	$^{99}Tc^{m}$	Macroaggregated globulin 3	100
	^{123}I	O-iodohippurate	20
Adrenal imaging	^{75}Se	Selenorcholesterol	8

TABLE III-V. (cont.)

Test	Radio-nuclide	Chemical form[a]	Maximum usual activity per test[b] (MBq)
Miscellaneous			
Tumour or abscess imaging	^{67}Ga	Citrate	300
	^{201}Tl	Chloride	100
Tumour imaging	$^{99}Tc^{m}$	Dimercaptosuccinic acid	400
Neuroectodermal tumour imaging	^{123}I	Meta-iodo-benzyl guanidine	400
	^{131}I	Meta-iodo-benzyl guanidine	20
Lymph node imaging	$^{99}Tc^{m}$	Labelled colloid	80
Abscess imaging	$^{99}Tc^{m}$	Exametazime labelled white cells	400
	^{111}In	Labelled white cells	20
Thrombus imaging	^{111}In	Labelled platelets	20

[a] In some countries some of the compounds are considered obsolete.
[b] In some countries the typical values are lower than those indicated in the table.

GUIDANCE LEVEL OF ACTIVITY FOR DISCHARGE FROM HOSPITAL

TABLE III-VI. GUIDANCE LEVEL FOR MAXIMUM ACTIVITY FOR PATIENTS IN THERAPY ON DISCHARGE FROM HOSPITAL

Radionuclide	Activity (MBq)
Iodine-131	1100[a]

[a] In some countries a level of 400 MBq is used as an example of good practice.

Schedule IV

DOSE LEVELS AT WHICH INTERVENTION IS EXPECTED TO BE UNDERTAKEN UNDER ANY CIRCUMSTANCES

IV-1. Table IV-I gives action levels of dose for acute exposure by organ or tissue. Table IV-II gives action levels of dose rate for chronic exposure by organ or tissue.

TABLE IV-I. ACTION LEVEL OF DOSE FOR ACUTE EXPOSURE

Organ or tissue	Projected absorbed dose to the organ or tissue in less than 2 days (Gy)
Whole body (bone marrow)	1
Lung	6
Skin	3
Thyroid	5
Lens of the eye	2
Gonads	3

Note: The possibility of deterministic effects for doses greater than about 0.1 Gy (delivered over less than 2 days) to the foetus should be taken into account in considering the justification and optimization of actual action levels for immediate protection.

TABLE IV-II. ACTION LEVEL OF DOSE RATE FOR CHRONIC EXPOSURE

Organ or tissue	Equivalent dose rate ($Gy \cdot a^{-1}$)
Gonads	0.2
Lens of the eye	0.1
Bone marrow	0.4

Schedule V

GUIDELINES FOR INTERVENTION LEVELS AND ACTION LEVELS IN EMERGENCY EXPOSURE SITUATIONS

V-1. Intervention levels are expressed in terms of avertable dose, i.e. a protective action is indicated if the dose that can be averted is greater than the corresponding intervention level. In determining the dose that can be averted, due account should be taken of delays in taking a protective action and of any other factor that could interfere with the action or inhibit its effectiveness.

V-2. The values of avertable dose specified in intervention levels refer to the average over suitably chosen samples of the population, not to the most exposed (i.e., critical groups of) individuals. However, projected doses to critical groups of individuals should be kept within the dose levels specified in Schedule IV.

V-3. General principles governing the selection of intervention levels for radiological emergencies have been recommended by the ICRP[43] together with the broad range of values within which such levels can be expected to fall.

V-4. The IAEA has developed values resulting from the generic application of these principles to the more common forms of protective action.[44]

V-5. Site specific intervention levels may be higher or in some cases lower than these generic optimized values owing to consideration of site specific or situation specific factors. These may include, among others, the presence of special populations (e.g. hospital patients, residents of old-age homes or prisoners), the existence of hazardous weather conditions or compounding hazards (e.g. earthquakes or hazardous chemicals), and special problems associated with transport or due to high population densities and other unique characteristics of the site or the accidental release.

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[43] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Principles for Intervention for Protection of the Public in a Radiological Emergency, ICRP Publication No. 63, *Ann. ICRP* **22** 4, Pergamon Press, Oxford (1993).

[44] INTERNATIONAL ATOMIC ENERGY AGENCY, Intervention Criteria in a Nuclear or Radiation Emergency, Safety Series No. 109, IAEA, Vienna (1994).

V-6. With these factors taken into consideration, the values specified hereinafter can be taken as starting points for the judgements required for decisions to select intervention levels for emergency exposure situations:

URGENT PROTECTIVE ACTIONS: SHELTERING, EVACUATION, IODINE PROPHYLAXIS

V-7. The generic optimized intervention level for sheltering is 10 mSv of avertable dose in a period of no more than 2 days. Authorities may wish to advise sheltering at lower intervention levels for shorter periods or so as to facilitate further countermeasures, e.g. evacuation.

V-8. The generic optimized intervention value for temporary evacuation is 50 mSv of avertable dose[45] in a period of no more than 1 week. Authorities may wish to initiate evacuation at lower intervention levels for shorter periods, and also where evacuation can be carried out quickly and easily, e.g. for small groups of people. Higher intervention levels may be appropriate in situations where evacuation would be difficult, e.g. for large population groups or if there is inadequate transport.

V-9. The generic optimized intervention value for iodine prophylaxis is 100 mGy of avertable committed absorbed dose to the thyroid due to radioiodine.

GENERIC ACTION LEVELS FOR FOODSTUFFS

V-10. Generic action levels for foodstuffs are given in Table V-I[46]. For practical reasons, the criteria for separate radionuclide groups shall be applied independently to the sum of the activities of the radionuclides in each group.

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[45] In some countries a value of 100 mSv of avertable dose is considered to be the more realistic level for temporary evacuation. The ICRP has recommended that evacuation would almost always be justified for an averable dose of 500 mSv (or equivalent dose to the skin of 5000 mSv), and that the range of optimized values would be lower than this by no more than a factor of ten (see ICRP Publication No. 63 (footnote 42), p. 23). General recommendations are given in ICRP, Principles of Monitoring for the Radiation Protection of the Population, ICRP Publication No. 43, *Ann. ICRP* **15** 1, Pergamon Press, Oxford (1985).

[46] The Table is based on, and consistent with, the Codex Alimentarius Commission's guideline levels for radionuclides in food moving in international trade following accidental contamination (Joint FAO/WHO Food Standards Programme, Codex Alimentarius Commission, Codex Alimentarius, Volume 1 (1991) Section 6.1, 'Levels for Radionuclides'), but it is limited to the nuclides usually considered relevant to emergency exposure situations.

TABLE V-I. GENERIC ACTION LEVELS FOR FOODSTUFFS

Radionuclides	Foods destined for general consumption (kBq/kg)	Milk, infant foods and drinking water (kBq/kg)
Cs-134, Cs-137, Ru-103, Ru-106, Sr-89	1	1
I-131		0.1
Sr-90	0.1	
Am-241, Pu-238, Pu-239	0.01	0.001

V-11. Paragraphs V-11–V-16 in Appendix V provide additional conditions that pertain to the use of these values in intervention situations.

TEMPORARY RELOCATION AND PERMANENT RESETTLEMENT

V-12. The generic optimized intervention levels for initiating and terminating temporary relocation are 30 mSv in a month and 10 mSv in a month, respectively. If the dose accumulated in a month is not expected to fall below this level within a year or two, permanent resettlement with no expectation of return to homes should be considered. Permanent resettlement should also be considered if the lifetime dose is projected to exceed 1 Sv.

V-13. The doses to be compared with these intervention levels are the total doses from all routes of exposure that can be avoided by taking the countermeasure but usually this will exclude food and water.

Schedule VI

GUIDELINES FOR ACTION LEVELS IN CHRONIC EXPOSURE SITUATIONS

VI-1. Although the concept of action levels for chronic exposure situations is of more general application, so far an international consensus on numerical values only exists in respect of radon. Guidelines are therefore only given for chronic exposure to radon.

RADON IN DWELLINGS

VI-2. Optimized action levels relating to chronic exposure involving radon in dwellings should, in most situations, fall within a yearly average concentration of 200 to 600 $Bq \cdot m^{-3}$ of ^{222}Rn in air.

RADON IN WORKPLACES

VI-3. The action level for remedial action relating to chronic exposure situations involving radon in workplaces is a yearly average concentration of 1000 Bq of ^{222}Rn per cubic metre of air[47].

[47] The International Commission on Radiological Protection has recommended that the action levels for occupational exposure to radon can fall in the range 500–1500 $Bq \cdot m^{-3}$. (See INTERNATIONAL COMMISSION ON RADIATION PROTECTION, Protection against Radon-222 at Home and at Work, ICRP Publication No. 65, *Ann. ICRP* **23** 2, Pergamon Press, Oxford and New York (1993).)

GLOSSARY

GLOSSARY

The following definitions apply for the purposes of the Standards.

Absorbed dose

The fundamental dosimetric quantity D, defined as:

$$D = \frac{d\epsilon}{dm}$$

where $d\epsilon$ is the mean energy imparted by ionizing radiation to matter in a volume element and dm is the mass of matter in the volume element. The energy can be averaged over any defined volume, the average dose being equal to the total energy imparted in the volume divided by the mass in the volume. The SI unit of absorbed dose is the joule per kilogram ($J \cdot kg^{-1}$), termed the gray (Gy).

Accident

Any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

Action level

The level of dose rate or activity concentration above which remedial actions or protective actions should be carried out in chronic exposure or emergency exposure situations.

Activation

The production of radionuclides by irradiation.

Activity

The quantity A for an amount of radionuclide in a given energy state at a given time, defined as:

$$A = \frac{dN}{dt}$$

where dN is the expectation value of the number of spontaneous nuclear transformations from the given energy state in the time interval dt. The SI unit of activity is the reciprocal second (s^{-1}), termed the becquerel (Bq).

Agricultural countermeasure

Action taken to reduce contamination of food, agricultural or forestry products before they reach consumers.

Ambient dose equivalent

The quantity H*(d) at a point in a radiation field, defined as the dose equivalent that would be produced by the corresponding aligned and expanded field in the ICRU sphere at a depth d on the radius opposing the direction of the aligned field. A depth d = 10 mm is recommended for strongly penetrating radiation.

Annual limit on intake (ALI)

The intake by inhalation, ingestion or through the skin of a given radionuclide in a year by the reference man which would result in a committed dose equal to the relevant dose limit. The ALI is expressed in units of activity.

Applicant

Any legal person who applies to the Regulatory Authority for authorization to undertake any of the actions described in the General Obligations for practices of the Standards (see paras 2.7 and 2.8).

Approved

Approved by the Regulatory Authority.

Authorization

A permission granted in a document by the Regulatory Authority to a legal person who has submitted an application to carry out a practice or any other action described in the General Obligations for practices of the Standards (see paras 2.7 and 2.8). The authorization can take the form of a registration or a licence.

Authorized

Granted an authorization by the Regulatory Authority.

Average mammary glandular dose

The theoretical average absorbed dose D_g in the mammary gland which, for purposes of mammography, can be calculated from:

$$D_g = D_{gN} X_a$$

where D_{gN} is the average absorbed dose in the mammary gland resulting from an incident exposure in air of 2.58×10^{-4} C·kg^{-1} and X_a is the incident exposure in air, and where for X ray tubes with molybdenum targets and molybdenum filters operating at 0.3 mm Al half-value layer and for a tissue composition of 50% adipose tissue and 50% gland, D_{gN} can be inferred from the following:

Breast thickness (cm)	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
D_{gN}	2.2	1.95	1.75	1.55	1.4	1.25	1.15	1.05	0.95

D_{gN} is expressed in mGy per 2.58×10^{-4} C·kg^{-1}.

Avertable dose

The dose to be saved by a protective action; that is, the difference between the dose to be expected with the protective action and that to be expected without it.

Chronic exposure

Exposure persisting in time.

Clearance

Removal of radioactive materials or radioactive objects within authorized practices from any further control by the Regulatory Authority[48].

Clearance levels

Values, established by the Regulatory Authority and expressed in terms of activity concentrations and/or total activity, at or below which sources of radiation may be released from regulatory control.

Collective dose

An expression for the total radiation dose incurred by a population, defined as the product of the number of individuals exposed to a source and their average radiation dose. The collective dose is expressed in man-sieverts (man·Sv). (See collective effective dose.)

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[48] Radioactive discharges are governed by authorization rather than by clearance.

Collective effective dose

The total effective dose S to a population, defined as:

$$S = \sum_i E_i \cdot N_i$$

where E_i is the average effective dose in the population subgroup i and N_i is the number of individuals in the subgroup. It can also be defined by the integral:

$$S = \int_0^\infty E \frac{dN}{dE} dE$$

where $\frac{dN}{dE} dE$ is the number of individuals receiving an effective dose between E and E+dE.

The collective effective dose S_k committed by an event, a decision or a finite portion of a practice k is given by:

$$S_k = \int_0^\infty \dot{S}_k(t)\, dt$$

where $\dot{S}_k(t)$ is the collective effective dose rate at time t caused by k.

Committed dose

Committed effective dose and/or committed equivalent dose.

Committed absorbed dose

The quantity $D(\tau)$, defined as:

$$D(\tau) = \int_{t_0}^{t_0+\tau} \dot{D}(t)\, dt$$

where t_0 is the time of intake, $\dot{D}(t)\, dt$ is the absorbed dose rate at time t and τ is the time elapsed after an intake of radioactive substances. When τ is not specified it will be taken to be 50 years for adults and to age 70 years for intakes by children.

Committed effective dose

The quantity $E(\tau)$, defined as:

$$E(\tau) = \sum_T w_T \cdot H_T(\tau)$$

where $H_T(\tau)$ is the committed equivalent dose to tissue T over the integration time τ. When τ is not specified, it will be taken to be 50 years for adults and to age 70 years for intakes by children.

Committed equivalent dose

The quantity $H(\tau)$, defined as:

$$H_T(\tau) = \int_{t_0}^{t_0+\tau} \dot{H}_T(t)\,dt$$

where t_0 is the time of intake, $\dot{H}_T(t)$ is the equivalent dose rate at time t in an organ or tissue T and τ is the time elapsed after an intake of radioactive substances. When τ is not specified it will be taken to be 50 years for adults and to age 70 years for intakes by children.

Consumer product

Device such as a smoke detector, luminous dial or ion generating tube that contains a small amount of radioactive substances.

Containment

Methods or physical structures that prevent the dispersion of radioactive substances.

Contamination

The presence of radioactive substances in or on a material or the human body or other place where they are undesirable or could be harmful.

Controlled area

A controlled area is any area in which specific protection measures and safety provisions are or could be required for:

(a) controlling normal exposures or preventing the spread of contamination during normal working conditions; and
(b) preventing or limiting the extent of potential exposures.

Countermeasure

An action aimed at alleviating the consequences of an accident.

Critical group

A group of members of the public which is reasonably homogeneous with respect to its exposure for a given radiation source and given exposure pathway and is typical of individuals receiving the highest effective dose or equivalent dose (as applicable) by the given exposure pathway from the given source.

Decontamination

The removal or reduction of contamination by a physical or chemical process.

Defence in depth

The application of more than a single protective measure for a given safety objective such that the objective is achieved even if one of the protective measures fails.

Deterministic effect

A radiation effect for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose.

Detriment

The total harm that would eventually be experienced by an exposed group and its descendents as a result of the group's exposure to radiation from a source.

Directional dose equivalent

The quantity $H'(d, \Omega)$ at a point in a radiation field, defined as the dose equivalent that would be produced by the corresponding expanded field in the ICRU sphere at depth d on a radius in a specified direction Ω. A depth $d = 0.07$ mm is recommended for weakly penetrating radiation.

Dose

A measure of the radiation received or 'absorbed' by a target. The quantities termed absorbed dose, organ dose, equivalent dose, effective dose, committed equivalent dose or committed effective dose are used, depending on the context. The modifying terms are often omitted when they are not necessary for defining the quantity of interest.

Dose constraint

A prospective and source related restriction on the individual dose delivered by the source which serves as a bound in the optimization of protection and safety of the source. For occupational exposures, dose constraint is a source related value of individual dose used to limit the range of options considered in the process of optimization. For public exposure, the dose constraint is an upper bound on the annual doses that members of the public should receive from the planned operation of any controlled source. The exposure to which the dose constraint applies is the annual dose to any critical group, summed over all exposure pathways, arising from the predicted operation of the controlled source. The dose constraint for each source is intended to ensure that the sum of doses to the critical group from all controlled sources remains within the dose limit. For medical exposure the dose constraint levels should be interpreted as guidance levels, except when used in optimizing the protection of persons exposed for medical research purposes or of persons, other than workers, who assist in the care, support or comfort of exposed patients.

Dose equivalent

A quantity used by the International Commission on Radiation Units and Measurements (ICRU) in defining the operational quantities ambient dose equivalent, directional dose equivalent and personal dose equivalent. The quantity dose equivalent has been superseded for radiation protection purposes by equivalent dose. For an explanation of these terms, see INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Quantities and Units in Radiation Protection Dosimetry, ICRU Publication No. 51, ICRU, Bethesda, MD (1993).

Dose limit

The value of the effective dose or the equivalent dose to individuals from controlled practices that shall not be exceeded.

Dose–area product

The product of the cross-sectional area of a radiation beam and the average dose delivered, which is used in diagnostic radiology as a measure of energy imparted.

Effective dose

The quantity E, defined as a summation of the tissue equivalent doses, each multiplied by the appropriate tissue weighting factor:

$$E = \sum_T w_T \cdot H_T$$

where H_T is the equivalent dose in tissue T and w_T is the tissue weighting factor for tissue T. From the definition of equivalent dose, it follows that:

$$E = \sum_T w_T \cdot \sum_R w_R \cdot D_{T,R}$$

where w_R is the radiation weighting factor for radiation R and $D_{T,R}$ is the average absorbed dose in the organ or tissue T. The unit of effective dose is $J \cdot kg^{-1}$, termed the sievert (Sv).

Emergency plan

A set of procedures to be implemented in the event of an accident.

Employer

A legal person with recognized responsibility, commitment and duties towards a worker in his or her employment by virtue of a mutually agreed relationship. (A self-employed person is regarded as being both an employer and a worker.)

Entrance surface dose

Absorbed dose in the centre of the field at the surface of entry of radiation for a patient undergoing a radiodiagnostic examination, expressed in air and with backscatter.

Equilibrium factor

The ratio F of the equilibrium equivalent concentration of radon to the actual radon concentration, where the equilibrium equivalent concentration is the activity concentration of radon in equilibrium with its short lived progeny having the same potential alpha energy concentration as the actual non-equilibrium mixture.

Equivalent dose

The quantity $H_{T,R}$, defined as:

$$H_{T,R} = D_{T,R} \cdot w_R$$

where $D_{T,R}$ is the absorbed dose delivered by radiation type R averaged over a tissue or organ T and w_R is the radiation weighting factor for radiation type R.

When the radiation field is composed of different radiation types with different values of w_R, the equivalent dose is:

$$H_T = \sum_R w_R \cdot D_{T,R}$$

The unit of equivalent dose is $J \cdot kg^{-1}$, termed the sievert (Sv).

Ethical Review Committee

A committee of independent persons to advise on the conditions of exposure and the dose constraints to be applied to the medical exposure of individuals exposed for biomedical research purposes when there is no direct benefit to the exposed individual.

Excluded

Outside the scope of the Standards.

Exposure

The act or condition of being subject to irradiation. Exposure can be either external exposure (irradiation by sources outside the body) or internal exposure (irradiation by sources inside the body). Exposure can be classified as either normal exposure or potential exposure; either occupational, medical or public exposure; and, in intervention situations, either emergency exposure or chronic exposure. The term exposure is also used in radiodosimetry to express the amount of ionization produced in air by ionizing radiation (see Average mammary glandular dose).

Exposure pathways

The routes by which radioactive material can reach or irradiate humans.

Guidance level

A level of a specified quantity above which appropriate actions should be considered. In some circumstances, actions may need to be considered when the specified quantity is substantially below the guidance level.

Guidance level for medical exposure

A value of dose, dose rate or activity selected by professional bodies in consultation with the Regulatory Authority to indicate a level above which there should be a review by medical practitioners in order to determine whether or not the value is excessive, taking into account the particular circumstances and applying sound clinical judgement.

Health professional

An individual who has been accredited through appropriate national procedures to practice a profession related to health (e.g. medicine, dentistry, chiropractic, paediatry, nursing, medical physics, radiation and nuclear medical technology, radiopharmacy, occupational health).

Health surveillance

Medical supervision intended to ensure the initial and continuous fitness of workers for their intended task.

High energy radiotherapy equipment

X ray equipment and other types of radiation generators capable of operating at generating potentials above 300 kV, and radionuclide teletherapy equipment.

Imaging devices

Electronic equipment used for imaging in diagnostic radiology and nuclear medicine (e.g. image convertors, gamma cameras).

Installation processing radioactive substances

Any installation processing radioactive substances for which the yearly throughput is higher than 10 000 times the exemption activity levels presented in Table I-I.

Intake

The process of taking radionuclides into the body by inhalation or ingestion or through the skin.

Intervening Organization

An organization designated or otherwise recognized by a Government as being responsible for managing or implementing any aspect of an intervention.

Intervention

Any action intended to reduce or avert exposure or the likelihood of exposure to sources which are not part of a controlled practice or which are out of control as a consequence of an accident.

Intervention level

The level of avertable dose at which a specific protective action or remedial action is taken in an emergency exposure situation or a chronic exposure situation.

Investigation level

The value of a quantity such as effective dose, intake, or contamination per unit area or volume at or above which an investigation should be conducted.

Ionizing radiation

For the purposes of radiation protection, radiation capable of producing ion pairs in biological material(s).

Irradiation installations

A structure or an installation that houses a particle accelerator, X ray apparatus or large radioactive source and that can produce high radiation fields. Properly designed structures provide shielding and other protection and are equipped with safety devices such as interlocks which prevent inadvertent entry into the high radiation field. Irradiation installations include installations for external beam radiation therapy, installations for sterilization or preservation of commercial products and some installations for industrial radiography.

Kerma

The quantity K, defined as:

$$K = \frac{dE_{tr}}{dm}$$

where dE_{tr} is the sum of the initial kinetic energies of all charged ionizing particles liberated by uncharged ionizing particles in a material of mass dm. The SI unit of kerma is the joule per kilogram ($J \cdot kg^{-1}$), termed gray (Gy).

Legal person

Any organization, corporation, partnership, firm, association, trust, estate, public or private institution, group, political or administrative entity or other persons designated in accordance with national legislation, who or which has responsibility and authority for any action taken under these Standards.

Licence

An authorization granted by the Regulatory Authority on the basis of a safety assessment and accompanied by specific requirements and conditions to be complied with by the licensee.

Licensee

The holder of a current licence granted for a practice or source who has recognized rights and duties for the practice or source, particularly in relation to protection and safety.

Limit

The value of a quantity used in certain specified activities or circumstances that must not be exceeded.

Medical exposure

Exposure incurred by patients as part of their own medical or dental diagnosis or treatment; by persons, other than those occupationally exposed, knowingly while voluntarily helping in the support and comfort of patients; and by volunteers in a programme of biomedical research involving their exposure.

Medical practitioner

An individual who: (a) has been accredited through appropriate national procedures as a health professional; (b) fulfils the national requirements on training and experience for prescribing procedures involving medical exposure; and (c) is a registrant or a licensee, or a worker who has been designated by a registered or licensed employer for the purpose of prescribing procedures involving medical exposure.

Member of the public

In a general sense, any individual in the population except, for the purposes of the Standards, when subject to occupational or medical exposure. For the purpose of verifying compliance with the annual dose limit for public exposure, the representative individual in the relevant critical group.

Mine or mill processing radioactive ores

Installation for mining, milling or processing ores containing uranium series or thorium series radionuclides.

A mine processing radioactive ores is any mine that yields ores containing uranium series or thorium series radionuclides, either in sufficient quantities or concentrations to warrant exploitation or, when present in conjunction with other substances being mined, in quantities or concentrations that require radiation protection measures to be taken as determined by the Regulatory Authority.

A mill processing radioactive ores is any facility for processing radioactive ores from mines as here defined to produce a physical or chemical concentrate.

Monitoring

The measurement of dose or contamination for reasons related to the assessment or control of exposure to radiation or radioactive substances, and the interpretation of the results.

Multiple scan average dose

A term used in computed tomography and defined as:

$$\mathrm{MSAD} = \frac{1}{I} \int_{-n/2}^{+n/2} D(z)\, dz$$

where n is the total number of scans in a clinical series, I is the distance increment that separates scans and D(z) is the dose at position z, parallel to the z (rotational) axis.

Natural exposure

An exposure delivered by natural sources.

Natural sources

Naturally occurring sources of radiation, including cosmic radiation and terrestrial sources of radiation.

Normal exposure

An exposure which is expected to be received under normal operating conditions of an installation or a source, including possible minor mishaps that can be kept under control.

Notification

A document submitted to the Regulatory Authority by a legal person to notify an intention to carry out a practice or any other action described in the General Obligations for practices of the Standards (see paras 2.7 and 2.8).

Nuclear fuel cycle

All operations associated with the production of nuclear energy, including mining, milling, processing and enrichment of uranium or thorium; manufacture of nuclear fuel; operation of nuclear reactors; reprocessing of nuclear fuel; decommissioning; and any activity for radioactive waste management and any research or development activity related to any of the foregoing.

Nuclear installation

A nuclear fuel fabrication plant, nuclear reactor (including critical and subcritical assemblies), research reactor, nuclear power plant, spent fuel storage facility, enrichment plant or reprocessing facility.

Occupational exposure

All exposures of workers incurred in the course of their work, with the exception of exposures excluded from the Standards and exposures from practices or sources exempted by the Standards.

Organ dose

The mean dose D_T in a specified tissue or organ T of the human body, given by:

$$D_T = (1/m_T) \int_{m_T} D\,dm$$

where m_T is the mass of the tissue or organ and D is the absorbed dose in the mass element dm.

Personal dose equivalent

The quantity defined for both strongly and weakly penetrating radiations as $H_p(d)$, the dose equivalent in soft tissue below a specified point on the body at an appropriate depth d. The relevant depths for the purposes of the Standards are generally d = 10 mm for strongly penetrating radiation and d = 0.07 mm for weakly penetrating radiation.

Planning target volume

A geometrical concept used in radiotherapy for planning treatment with consideration of the net effect of movements of the patient and of the tissues to be irradiated, variations in size and shape of the tissue, and variations in beam geometry such as beam size and beam direction.

Potential alpha energy (of radon progeny and thoron progeny)

The total alpha energy ultimately emitted during the decay of radon progeny and thoron progeny through the decay chain, up to but not including ^{210}Pb for progeny of ^{222}Rn and to stable ^{208}Pb for progeny of ^{220}Rn.

Potential exposure

Exposure that is not expected to be delivered with certainty but that may result from an accident at a source or owing to an event or sequence of events of a probabilistic nature, including equipment failures and operating errors.

Practice

Any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.

Projected dose

The dose to be expected if no protective or remedial action is taken.

Protection and safety

The protection of people against exposure to ionizing radiation or radioactive substances and the safety of radiation sources, including the means for achieving such protection and safety, such as the various procedures and devices for keeping people's doses and risks as low as can reasonably be achieved and below prescribed dose constraints, as well as the means for preventing accidents and for mitigating the consequences of accidents should they occur.

Protective action

An intervention intended to avoid or reduce doses to members of the public in chronic or emergency exposure situations.

Public exposure

Exposure incurred by members of the public from radiation sources, excluding any occupational or medical exposure and the normal local natural background radiation but including exposure from authorized sources and practices and from intervention situations.

Qualified expert

An individual who, by virtue of certification by appropriate boards or societies, professional licences or academic qualifications and experience, is duly recognized as having expertise in a relevant field of specialization, e.g. medical physics, radiation protection, occupational health, fire safety, quality assurance or any relevant engineering or safety specialty.

Radiation

See Ionizing radiation.

Radiation generator

Device capable of generating radiation, such as X rays, neutrons, electrons or other charged particles, which may be used for scientific, industrial or medical purposes.

Radiation protection officer

An individual technically competent in radiation protection matters relevant for a given type of practice who is designated by the registrant or licensee to oversee the application of the requirements of the Standards.

Radiation weighting factor

Multipliers (as follows) of absorbed dose used for radiation protection purposes to account for the relative effectiveness of different types of radiation in inducing health effects.

Type and energy range of radiation		Radiation weighting factor w_R
Photons, all energies		1
Electrons and muons, all energies[a]		1
Neutrons, energy	< 10 keV	5
	10 keV to 100 keV	10
	> 100 keV to 2 MeV	20
	> 2 MeV to 20 MeV	10
	> 20 MeV	5
Protons, other than recoil protons, energy > 2 MeV		5
Alpha particles, fission fragments, heavy nuclei		20

[a] Excluding Auger electrons emitted from nuclei to DNA, for which special microdosimetric considerations apply.

If calculation of the radiation weighting factor for neutrons requires a continuous function, the following approximation can be used, where E is the neutron energy in MeV:

$$w_R = 5 + 17\, e^{-(\ln(2E))^2/6}$$

For radiation types and energies not included in the table, w_R can be taken to be equal to $\bar{Q}$ at 10 mm depth in the ICRU sphere and can be obtained as follows:

$$\bar{Q} = \frac{1}{D}\int_0^\infty Q(L)\, D_L\, dL$$

where D is the absorbed dose, Q(L) is the quality factor in terms of the unrestricted linear energy transfer L in water, specified in ICRP Publication No. 60[49], and D_L is the distribution of D in L.

$$Q(L) = \begin{cases} 1 & \text{for } L \le 10 \\ 0.32L - 2.2 & \text{for } 10 < L < 100 \\ 300/\sqrt{L} & \text{for } L \ge 100 \end{cases}$$

where L is expressed in $keV \cdot \mu m^{-1}$.

Radioactive discharges

Radioactive substances arising from a source within a practice which are discharged as gases, aerosols, liquids or solids to the environment, generally with the purpose of dilution and dispersion.

Radioactive effluents

See Radioactive discharges.

Radioactive waste

Material, whatever its physical form, remaining from practices or interventions and for which no further use is foreseen (i) that contains or is contaminated with radioactive substances and has an activity or activity concentration higher than the level for clearance from regulatory requirements, and (ii) exposure to which is not excluded from the Standards.

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[49] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 1990 Recommendations of the International Commission on Radiological Protection, Publication No. 60, *Ann. ICRP* **21** 1–3, Pergamon Press, Oxford and New York (1991).

Radioactive waste management facility

Facility specifically designed to handle, treat, condition, temporarily store or permanently dispose of radioactive wastes.

Radon

The isotope ^{222}Rn of the element of atomic number 86.

Radon progeny

The short lived radioactive decay products of radon.

Recording level

A level of dose, exposure or intake specified by the Regulatory Authority at or above which values of dose, exposure or intake received by workers are to be entered in their individual exposure records.

Reference air kerma rate

The reference air kerma rate of a source is the kerma rate to air, in air, at a reference distance of one metre, corrected for air attenuation and scattering. This quantity is expressed in $\mu Gy \cdot h^{-1}$ at 1 m.

Reference level

Action level, intervention level, investigation level or recording level. Such levels may be established for any of the quantities determined in the practice of radiation protection.

Reference man

An idealized adult caucasian human defined by the ICRP for the purpose of radiation protection assessment[50].

Registrant

An applicant who is granted registration of a practice or source and has recognized rights and duties for such a practice or source, particularly in relation to protection and safety.

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[50] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Reference Man: Anatomical, Physiological and Metabolic Characteristics, ICRP Publication No. 23, Pergamon Press, Oxford (1976).

Registration

A form of authorization for practices of low or moderate risks whereby the legal person responsible for the practice has, as appropriate, prepared and submitted a safety assessment of the facilities and equipment to the Regulatory Authority. The practice or use is authorized with conditions or limitations as appropriate. The requirements for safety assessment and the conditions or limitations applied to the practice should be less severe than those for licensing.

Regulatory Authority

An authority or authorities designated or otherwise recognized by a government for regulatory purposes in connection with protection and safety.

Remedial action

Action taken when a specified action level is exceeded, to reduce radiation doses that might otherwise be received, in an intervention situation involving chronic exposure.

Risk

A multiattribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with actual or potential exposures. It relates to quantities such as the probability that specific deleterious consequences may arise and the magnitude and character of such consequences.

Safety assessment

A review of the aspects of design and operation of a source which are relevant to the protection of persons or the safety of the source, including the analysis of the provisions for safety and protection established in the design and operation of the source and the analysis of risks associated with normal conditions and accident situations.

Safety culture

The assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, protection and safety issues receive the attention warranted by their significance.

Sealed source

Radioactive material that is (a) permanently sealed in a capsule or (b) closely bounded and in a solid form. The capsule or material of a sealed source shall be strong enough to maintain leaktightness under the conditions of use and wear for which the source was designed, also under foreseeable mishaps.

Source

Anything that may cause radiation exposure, such as by emitting ionizing radiation or releasing radioactive substances or materials. For example, materials emitting radon are sources in the environment, a sterilization gamma irradiation unit is a source for the practice of radiation preservation of food, an X ray unit may be a source for the practice of radiodiagnosis, and a nuclear power plant is a source for the practice of generating electricity by nuclear power. A complex or multiple installation situated at one location or site may, as appropriate, be considered a single source for the purposes of application of the Standards.

Sponsoring Organizations

The Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the International Labour Organisation (ILO), the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA), the Pan American Health Organization (PAHO) and the World Health Organization (WHO).

Standards dosimetry laboratory

A laboratory designated by the relevant national authority for the purpose of developing, maintaining or improving primary or secondary standards for radiation dosimetry.

Stochastic effects of radiation

Radiation effects, generally occurring without a threshold level of dose, whose probability is proportional to the dose and whose severity is independent of the dose.

Supervised area

Any area not designated as a controlled area but for which occupational exposure conditions are kept under review even though specific protective measures and safety provisions are not normally needed.

Supplier

Any legal person to whom a registrant or licensee delegates duties, totally or partially, in relation to the design, manufacture, production or construction of a source. (An importer of a source is considered a supplier of the source.)

Thoron

The isotope ^{220}Rn of the element of atomic number 86.

Thoron progeny

The short lived radioactive decay products of thoron.

Tissue weighting factor

Multipliers (as follows) of the equivalent dose to an organ or tissue used for radiation protection purposes to account for the different sensitivities of different organs and tissues to the induction of stochastic effects of radiation.

Tissue or organ	Tissue weighting factor w_T
Gonads	0.20
Bone marrow (red)	0.12
Colon[a]	0.12
Lung	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Oesophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surface	0.01
Remainder[b]	0.05

[a] The weighting factor for the colon is applied to the mass average of the equivalent dose in the walls of the upper and lower large intestine.

[b] For the purposes of calculation, the remainder is composed of adrenal glands, brain, extrathoracic region, small intestine, kidney, muscle, pancreas, spleen, thymus and uterus. In those exceptional cases in which the most exposed remainder tissue receives the highest committed equivalent dose of all organs, a weighting factor of 0.025 shall be applied to that tissue or organ and a weighting factor of 0.025 to the average dose in the rest of the remainder as defined here.

Unsealed source

A source that does not meet the definition of a sealed source.

Worker

Any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection. (A self-employed person is regarded as having the duties of both an employer and a worker.)

Working level

A unit for potential alpha energy concentration (i.e. the sum of the total energy per unit volume of air carried by alpha particles emitted during the complete decay of each atom and its progeny in a unit volume of air) resulting from the presence of radon progeny or thoron progeny equal to emission of 1.3×10^5 MeV of alpha energy per litre of air. In SI units the WL corresponds to 2.1×10^{-5} $J \cdot m^{-3}$.

Working level month (WLM)

A unit of exposure to radon progeny or thoron progeny.

$$1 \text{ WLM} = 170 \text{ WL} \cdot \text{h}$$

One working level month is equivalent to 3.54 $mJ \cdot h \cdot m^{-3}$.

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Meetings of the Interagency Committee on Radiation Safety

WHO, Geneva: 4–5 February 1991
CEC, Brussels: 19–20 October 1992
PAHO, Washington, DC: 19 April 1993

Meetings of the Joint Secretariat

OECD/NEA, Paris: 9–12 April 1991
IAEA, Vienna: 9–13 December 1991
OECD/NEA, Paris: 21–23 October 1992
PAHO, Washington, DC: 20–23 April 1993

Technical Committee Meetings

IAEA, Vienna: 14–18 December 1992, 13–17 December 1993,
29 August–2 September 1994

Senior Experts Meeting

IAEA, Vienna: 24–28 February 1992

Consultants Meetings

London: 24–28 June 1991; Ottawa: 23–27 September 1991;
Vienna: 6–10 January 1992, 20–24 January 1992,
23–27 March 1992, 9–13 November 1992, 7–19 November 1993

Ad Hoc Working Group on Dose Limitation in Specific Occupations

ILO, Geneva: 29 March–1 April 1993

Ad Hoc Working Group on Potential Exposures

OECD/NEA, Paris: 8–10 March 1993

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THE SPONSORING ORGANIZATIONS

The *FAO* was established in 1945 to supersede the International Institute of Agriculture. Among its aims is to secure improvements in the efficiency of the production and distribution of food and agricultural products. FAO's main tasks are: carrying out major programmes of technical advice and assistance for the agricultural community; collection, analysis and dissemination of information; advising governments on policy and planning; and providing opportunities for governments and experts to meet and discuss food and agricultural issues. FAO provides advice and assistance to its member governments, through a variety of formal and informal channels, on all aspects of production, distribution and consumption of food and agricultural products in accordance with current needs. In 1962, the FAO and the WHO established the Codex Alimentarius Commission with the aims of: protecting the health of consumers and ensuring fair practices in the food trade; promoting co-ordination of all food standards work and undertakings by international governmental and non-governmental organizations; determining priorities and initiating and guiding the preparation of draft standards through and with the aid of appropriate organizations and publishing these standards in a Codex Alimentarius; and amending published standards after appropriate survey in the light of development. The major interests of FAO in the Standards relate to the Codex Alimentarius and to the subject of agricultural countermeasures in the event of a radiological accident.

The *IAEA* was established in 1957. Its statutory objective is to seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. One of the IAEA's functions is "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 the State's activities in the field of atomic energy." Moreover, with respect to any IAEA project, or other arrangement where the IAEA is requested by the parties concerned to apply safeguards, the IAEA has the right and responsibility, to the extent relevant to the project or arrangement, "to require the observance of any health and safety measure prescribed by the Agency" and "to send into the territory of the recipient State or States inspectors ... to determine whether there is compliance with [such] health and safety measures ". The Standards are intended inter alia to facilitate the discharging of these functions, rights and responsibilities of the IAEA.

The *ILO* was established in 1919 by the Treaty of Versailles to bring governments, employers and trade unions together for united action in the cause of social justice and better living conditions everywhere. It is a tripartite organization, with worker and employer representatives taking part in its work on equal status with those of governments. The ILO was an autonomous part of the League of Nations and in 1946 it became the first specialized agency associated with the United Nations. The protection of the worker against sickness, disease and injury arising from employment is one of the tasks assigned to the ILO in the words of the Preamble of its Constitution. One of the main features of the ILO, in addition to its tripartite structure, is its standard-setting activity. Some sixty international conventions and recommendations concern the protection of workers against occupational hazards. In 1949, the ILO published a set of practical international standards on radiation protection which were revised and considerably extended in 1957 and were incorporated into the ILO Manual of Industrial Radiation Protection. In 1960, the International Labour Conference adopted the Radiation Protection Convention (No. 115) and Recommendation (No. 114). The Convention applies to all activities involving exposure of workers to ionizing radiations in the course of their work and provides that all appropriate steps shall be taken to ensure effective protection of workers in the light of knowledge available at the time. The Recommendation adds that due regard should be given to the recommendations made from time to time by the International Commission on Radiological Protection and standards adopted by other competent organizations. In 1986, the ILO Governing Body approved the publication of a Code of Practice for the radiation protection of workers (ionizing radiations) which gives practical guidance on the implementation of a radiation protection programme at the enterprise level and takes into account the provisions of the IAEA's Basic Safety Standards for Radiation Protection (1982). Some other international labour standards of the ILO are also relevant to the protection of workers against ionizing radiations, notably the Occupational Cancer Convention and Recommendation (1974); the Working Environment (air pollution, noise and vibration) Convention and Recommendation (1977); and the List of Occupational Diseases appended to the Employment Injury Benefit Convention (1964).

The objective of the *OECD/NEA* is to further the development of the production and uses of nuclear energy for peaceful purposes through co-operation between the participating countries and harmonization of measures taken at the national level. One of the principal tasks of the NEA is "to contribute to the promotion, by responsible national authorities, of the protection of workers and the public against the hazards of ionizing radiations and of the preservation of the environment", as well as "to contribute to the promotion of the safety of nuclear installations and materials by responsible national authorities". These tasks are discharged by the NEA through the following standing technical committees: Committee on Radiation Protection and Public Health (CRPPH); Committee on the Safety of Nuclear Installations (CSNI); Committee on Nuclear Regulatory Activities (CNRA); Radioactive Waste Management Committee (RWMC). In particular, the CRPPH provides a forum for the exchange of experience in radiation protection policy issues, keeps all NEA activities under review from the point of view of radiation protection and public health, promotes the establishment of radiation protection standards and related data, promotes studies and joint co-operative activities in various fields concerning the protection of workers and members of the public.

PAHO, founded in 1902, initiated activities in radiological health in the 1950s, promoting public health aspects of radiation and providing fellowships for the training of physicians and other professionals in radiation medicine. Owing to the introduction of various activities associated with the peaceful application of nuclear energy in the member countries, a Radiation Protection Unit was established at the regional level in 1960. The objectives of the unit were "to encourage national health services to develop procedures and regulations and to adopt international standards for radiation protection connected with the use of X rays and radioisotopes and for the disposal of radioactive wastes; to promote the teaching of basic health physics, radiobiology and radiation protection in medical, dental, veterinary, public health and other professional schools, and to foster the use of radioisotopes for medical diagnosis, therapy and research." The radiological health activities of PAHO cover all aspects of diagnostic imaging, radiation therapy and nuclear medicine, including radiation protection. Consultation is provided for: planning radiological services, including: shielding design; specification, selection, acceptance testing, maintenance and repair of radiological equipment; review of diagnostic and therapeutic radiological procedures; calibration of radiation beams for diagnosis and treatment; physical and clinical dosimetry; radioactive waste disposal for medical facilities; development and implementation of quality assurance programmes; radiation accidents; and radiation emergency preparedness. Educational activities involve the organization of and participation in courses, workshops and seminars; the publication and dissemination of radiation related publications and audiovisual programmes, and the exchange of information on training programmes.

The *WHO*, which is a specialized agency of the United Nations, had its origin in the proposal made at the United Nations Conference held in San Francisco in 1945 that a specialized agency be created to deal with all matters relating to health. The Constitution came into force on 7 April 1948, the first World Health Assembly met in Geneva in June 1948, and on 1 September 1948 the permanent Organization was established. The work of the Organization is carried out by three organs: the World Health Assembly, the supreme authority, to which all Member States send delegates; the Executive Board, the executive organ of the Health Assembly; and a Secretariat under the Director-General. Through this Organization, the health professionals of nearly 180 countries exchange knowledge and experience, with the aim of making possible the attainment by all citizens of the world of a level of health that will permit them to lead a socially and economically productive life. WHO works through a decentralized organizational structure, with its headquarters in Geneva, and six regional offices — Africa, Americas, Eastern Mediterranean, Europe, South-East Asia and the Western Pacific, plus field offices in many countries. In addition to the use of its regular multinational staff to carry out its work, WHO depends upon: co-operative efforts with other international organizations; its WHO Collaborating Centres; its panels of expert advisers; and various non-governmental scientific and professional organizations, among which are the International Society of Radiology, the International Society of Radiographers and Radiological Technicians, and the International Organization for Medical Physics. By means of direct technical co-operation with its Member States, and by stimulating such co-operation among them, WHO promotes the development of comprehensive health services, the prevention and control of diseases, the improvement of environmental conditions, the development of health manpower, the co-ordination and development of biomedical and health services research, and the planning and implementation of health programmes. In the radiological area, WHO's interests cover the use of radiation in medicine as well as radiation hygiene.

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