IAEA Safety Standards

for protecting people and the environment

Fundamental Safety Principles

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Safety Fundamentals

No. SF-1

IAEA
International Atomic Energy Agency

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

Under the terms of Article III of its Statute, the IAEA is authorized to establish or adopt standards of safety for protection of health and minimization of danger to life and property, and to provide for the application of these standards.

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety, and also general safety (i.e. all these areas of safety). The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Safety standards are coded according to their coverage: nuclear safety (NS), radiation safety (RS), transport safety (TS), waste safety (WS) and general safety (GS).

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The site provides the texts in English of published and draft safety standards. The texts of safety standards issued in Arabic, Chinese, French, Russian and Spanish, the IAEA Safety Glossary and a status report for safety standards under development are also available. For further information, please contact the IAEA at P.O. Box 100, A-1400 Vienna, Austria.

All users of IAEA safety standards are invited to inform the IAEA of experience in their use (e.g. as a basis for national regulations, for safety reviews and for training courses) for the purpose of ensuring that they continue to meet users' needs. Information may be provided via the IAEA Internet site or by post, as above, or by email to Official.Mail@iaea.org.

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FUNDAMENTAL SAFETY PRINCIPLES

IAEA SAFETY STANDARDS SERIES No. SF-1

FUNDAMENTAL SAFETY PRINCIPLES

SAFETY FUNDAMENTALS

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FOREWORD

by Mohamed ElBaradei
Director General

The IAEA's Statute authorizes the Agency to establish safety standards to protect health and minimize danger to life and property — standards which the IAEA must use in its own operations, and which a State can apply by means of its regulatory provisions for nuclear and radiation safety. A comprehensive body of safety standards under regular review, together with the IAEA's assistance in their application, has become a key element in a global safety regime.

In the mid-1990s, a major overhaul of the IAEA's safety standards programme was initiated, with a revised oversight committee structure and a systematic approach to updating the entire corpus of standards. The new standards that have resulted are of a high calibre and reflect best practices in Member States. With the assistance of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its safety standards.

Safety standards are only effective, however, if they are properly applied in practice. The IAEA's safety services — which range in scope from engineering safety, operational safety, and radiation, transport and waste safety to regulatory matters and safety culture in organizations — assist Member States in applying the standards and appraise their effectiveness. These safety services enable valuable insights to be shared and I continue to urge all Member States to make use of them.

Regulating nuclear and radiation safety is a national responsibility, and many Member States have decided to adopt the IAEA's safety standards for use in their national regulations. For the Contracting Parties to the various international safety conventions, IAEA standards provide a consistent, reliable means of ensuring the effective fulfilment of obligations under the conventions. The standards are also applied by designers, manufacturers and operators around the world to enhance nuclear and radiation safety in power generation, medicine, industry, agriculture, research and education.

The IAEA takes seriously the enduring challenge for users and regulators everywhere: that of ensuring a high level of safety in the use of nuclear materials and radiation sources around the world. Their continuing utilization for the benefit of humankind must be managed in a safe manner, and the IAEA safety standards are designed to facilitate the achievement of that goal.

PREFACE BY THE JOINT SPONSORING ORGANIZATIONS

The Board of Governors approved the publication of IAEA safety standards in the Safety Fundamentals category on the safety of nuclear installations in June 1993[1], on the safety of radioactive waste management in March 1995[2] and on radiation protection and the safety of radiation sources in June 1995[3].

In 1995, the Board requested the IAEA Secretariat to consider, at an appropriate time, the revision of the three Safety Fundamentals texts with the aim of combining them in a unified set of principles representing a common safety philosophy across all areas of application of the IAEA safety standards.

The distinction traditionally made between nuclear safety and radiation protection is hardly justifiable at the conceptual level. The principles for nuclear safety and radiation protection in the three Safety Fundamentals publications were technically compatible, but had been expressed differently.

In 2000, the Secretariat commenced the process of holding drafting meetings to prepare a text on a unified set of principles. The draft Safety Fundamentals text was developed by seeking a broad international consensus of opinion to provide assurance that the Fundamental Safety Principles are held by all IAEA Member States.

The Fundamental Safety Principles are jointly sponsored with the European Atomic Energy Community (Euratom), the Food and Agriculture Organization of the United Nations (FAO), the International Labour Organization (ILO), the International Maritime Organization (IMO), the OECD Nuclear Energy Agency (OECD/NEA), the Pan American Health Organization (PAHO), the United Nations Environment Programme (UNEP) and the World Health Organization (WHO) (the sponsoring organizations).

Application of the Fundamental Safety Principles will facilitate the application of international safety standards and will make for greater

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[1] INTERNATIONAL ATOMIC ENERGY AGENCY, The Safety of Nuclear Installations, Safety Series No. 110, IAEA, Vienna (1993).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, The Principles of Radioactive Waste Management, Safety Series No. 111-F, IAEA, Vienna (1995).

[3] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, Radiation Protection and the Safety of Radiation Sources, Safety Series No. 120, IAEA, Vienna (1996).

consistency between the arrangements of different States. It is therefore desirable that all States adhere to and advocate these principles. The principles will be binding on the IAEA in relation to its operations and on States in relation to operations assisted by the IAEA. States or sponsoring organizations may adopt the principles, at their own discretion, for application to their own activities.

In the preparation of the present text of the Fundamental Safety Principles, all the safety principles established in the earlier Safety Fundamentals publications for the three different areas were considered and consolidated into a coherent and consistent set of ten new principles. Some of the earlier safety principles that were found to be more appropriately expressed as requirements have been established as such in Safety Requirements publications.

The ten new Fundamental Safety Principles constitute the basis on which to establish safety requirements for protection against exposure to ionizing radiation under the IAEA's safety standards programme and provide the rationale for its wider safety related programme.

The totality of safety measures taken to ensure the protection of human life and health and the environment against exposure to radiation is detailed and technically complex. To the extent possible, however, the Fundamental Safety Principles have been drafted in language that is understandable to the non-specialist reader. The intention is to convey the basis and rationale for the safety standards for those at senior levels in government and regulatory bodies and those who, while responsible for making decisions concerning the uses of nuclear energy and radiation sources, may not be specialists in nuclear or radiation science and technology or in radiation protection and safety matters.

Unless otherwise stated, the usage of safety related words and terms in the text is to be interpreted as defined and explained in the IAEA Safety Glossary (http://www-ns.iaea.org/standards/safety-glossary.htm), in which usage in the different subject areas has been harmonized and where possible made consistent. Some generalized safety related words and terms have been used for the purpose of simplifying the text, and in these cases the meaning has been explained in footnotes. For the purpose of formulating safety requirements in specific areas, it may be necessary to clarify and elaborate on the meaning of terms — whose general meaning may be clear — in their context in specific standards to avoid ambiguity. Such clarifications and elaborations are left to the particular safety standards concerned.

The text was approved for promulgation as a Safety Fundamentals publication by the IAEA's Board of Governors in September 2006, and this Safety Fundamentals publication thus becomes the primary publication in the

IAEA Safety Standards Series, superseding the previous Safety Fundamentals publications issued in the former Safety Series.

The IAEA wishes to express its appreciation to all those who assisted in the drafting and review of this text and in the process of reaching a consensus.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation[1] and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks[2] to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled. Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

1.2. The IAEA is required by its Statute to promote international cooperation. Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences. International cooperation is facilitated by international safety related conventions, codes of conduct and safety standards.

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[1] 'Radiation' as used here means ionizing radiation.

[2] The term 'radiation risks' is used here in a general sense to refer to:

— Detrimental health effects of radiation exposure (including the likelihood of such effects occurring).

— Any other safety related risks (including those to ecosystems in the environment) that might arise as a direct consequence of:

- Exposure to radiation;
- The presence of radioactive material (including radioactive waste) or its release to the environment;
- A loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation.

For the purposes of the IAEA safety standards, it is assumed that there is no threshold level of radiation dose below which there are no associated radiation risks. Safety Requirements and Safety Guides specify the radiation exposures and other risks to which they refer.

1.3. States have an obligation of diligence and duty of care and are expected to fulfil their national and international undertakings and obligations. International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

1.4. States also subscribe to international conventions relating to nuclear and radiation related activities conducted within their jurisdiction. The Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, the Convention on Nuclear Safety, and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management all place specific obligations on the Contracting Parties. The IAEA safety standards constitute a useful tool for Contracting Parties to assess their performance under these international conventions. The safety standards also support the application of the Code of Conduct on the Safety and Security of Radioactive Sources and the Code of Conduct on the Safety of Research Reactors.

1.5. The IAEA safety standards, comprising Safety Fundamentals, Safety Requirements and Safety Guides, are applied by the IAEA and joint sponsoring organizations to their own operations, and are recommended for use by States and national authorities and by other international organizations in relation to their own activities. International conventions and the IAEA safety standards, appropriately supplemented by industry standards and detailed national requirements, establish a consistent and comprehensive basis for the proper protection of people and the environment against radiation risks. In its operations, the IAEA will pursue the fundamental safety objective stated in Section 2 in accordance with the safety principles as set out here, and it will encourage its Member States to do likewise.

1.6. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) compiles, assesses and disseminates information on the health effects of radiation and on levels of exposure to radiation from different sources. Its findings and the recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP), are taken into account in developing the IAEA safety standards.

1.7. The scientific considerations underlying the IAEA safety standards provide an objective basis for decisions concerning safety; however, decision makers must also make informed judgements and determine how best to

balance the benefits of an action or an activity against the associated radiation risks and other risks and any other detrimental impacts to which it gives rise.

OBJECTIVE OF THIS PUBLICATION

1.8. The objective of this publication is to establish the fundamental safety objective, safety principles and concepts that provide the bases for the IAEA's safety standards and its safety related programme. Related requirements are established in the Safety Requirements publications. Guidance on meeting these requirements is provided in the related Safety Guides.

SCOPE

1.9. This publication states the fundamental safety objective and ten associated safety principles, and briefly describes their intent and purpose. The fundamental safety objective applies to all circumstances that give rise to radiation risks. The safety principles are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes[3], and to protective actions to reduce existing radiation risks. They provide the basis for requirements and measures for the protection of people and the environment against radiation risks and for the safety of facilities and activities that give rise to radiation risks, including, in particular, nuclear installations and uses of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

[3] The term 'facilities and activities — existing and new — utilized for peaceful purposes' is hereafter abbreviated for convenience to 'facilities and activities' as a general term encompassing any human activity that may cause people to be exposed to radiation risks arising from naturally occurring or artificial sources. 'Facilities' includes: nuclear facilities; irradiation installations; some mining and raw material processing facilities such as uranium mines; radioactive waste management facilities; and any other places where radioactive materials are produced, processed, used, handled, stored or disposed of — or where radiation generators are installed — on such a scale that consideration of protection and safety is required. 'Activities' includes: the production, use, import and export of radiation sources for industrial, research and medical purposes; the transport of radioactive material; the decommissioning of facilities; radioactive waste management activities such as the discharge of effluents; and some aspects of the remediation of sites affected by residues from past activities.

1.10. Safety measures and security measures have in common the aim of protecting human life and health and the environment. The safety principles concern the security of facilities and activities to the extent that they apply to measures that contribute to both safety and security, such as:

- Appropriate provisions in the design and construction of nuclear installations and other facilities;
- Controls on access to nuclear installations and other facilities to prevent the loss of, and the unauthorized removal, possession, transfer and use of, radioactive material;
- Arrangements for mitigating the consequences of accidents and failures, which also facilitate measures for dealing with breaches in security that give rise to radiation risks;
- Measures for the security of the management of radioactive sources and radioactive material.

Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

STRUCTURE

1.11. Section 2 states the fundamental safety objective. Section 3 presents the ten principles to be applied in order to achieve this objective and describes the intent and application of each principle.

2. SAFETY OBJECTIVE

The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.

2.1. This fundamental safety objective of protecting people — individually and collectively — and the environment has to be achieved without unduly limiting the operation of facilities or the conduct of activities that give rise to radiation risks. To ensure that facilities are operated and activities conducted so as to achieve the highest standards of safety that can reasonably be achieved, measures have to be taken:

(a) To control the radiation exposure of people and the release of radioactive material to the environment;
(b) To restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation;
(c) To mitigate the consequences of such events if they were to occur.

2.2. The fundamental safety objective applies for all facilities and activities, and for all stages over the lifetime of a facility or radiation source, including planning, siting, design, manufacturing, construction, commissioning and operation, as well as decommissioning and closure. This includes the associated transport of radioactive material and management of radioactive waste.

2.3. Ten safety principles have been formulated, on the basis of which safety requirements are developed and safety measures are to be implemented in order to achieve the fundamental safety objective. The safety principles form a set that is applicable in its entirety; although in practice different principles may be more or less important in relation to particular circumstances, the appropriate application of all relevant principles is required.

3. SAFETY PRINCIPLES

INTRODUCTION

3.1. For the purposes of this publication, 'safety' means the protection of people and the environment against radiation risks, and the safety of facilities and activities that give rise to radiation risks. 'Safety' as used here and in the IAEA safety standards includes the safety of nuclear installations, radiation safety, the safety of radioactive waste management and safety in the transport of radioactive material; it does not include non-radiation-related aspects of safety.

3.2. Safety is concerned with both radiation risks under normal circumstances and radiation risks as a consequence of incidents[4], as well as with other possible

[4] 'Incidents' includes initiating events, accident precursors, near misses, accidents and unauthorized acts (including malicious and non-malicious acts).

direct consequences of a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation. Safety measures include actions to prevent incidents and arrangements put in place to mitigate their consequences if they were to occur.

Principle 1: Responsibility for safety

The prime responsibility for safety must rest with the person or organization responsible for facilities and activities that give rise to radiation risks.

3.3. The person or organization responsible for any facility or activity that gives rise to radiation risks or for carrying out a programme of actions to reduce radiation exposure has the prime responsibility for safety[5].

3.4. Authorization to operate a facility or conduct an activity may be granted to an operating organization or to an individual, known as the licensee[6].

3.5. The licensee retains the prime responsibility for safety throughout the lifetime of facilities and activities, and this responsibility cannot be delegated. Other groups, such as designers, manufacturers and constructors, employers, contractors, and consignors and carriers, also have legal, professional or functional responsibilities with regard to safety.

3.6. The licensee is responsible for:

— Establishing and maintaining the necessary competences;
— Providing adequate training and information;
— Establishing procedures and arrangements to maintain safety under all conditions;
— Verifying appropriate design and the adequate quality of facilities and activities and of their associated equipment;
— Ensuring the safe control of all radioactive material that is used, produced, stored or transported;
— Ensuring the safe control of all radioactive waste that is generated.

[5] Not having an authorization would not exonerate the person or organization responsible for the facility or activity from the responsibility for safety.

[6] For the purposes of this publication, the term 'licensee' is used; other forms of authorization such as registration may apply. Under some circumstances, the government or an employer may assume responsibility for the safety of facilities and activities.

These responsibilities are to be fulfilled in accordance with applicable safety objectives and requirements as established or approved by the regulatory body, and their fulfilment is to be ensured through the implementation of the management system.

3.7. Since radioactive waste management can span many human generations, consideration must be given to the fulfilment of the licensee's (and regulator's) responsibilities in relation to present and likely future operations. Provision must also be made for the continuity of responsibilities and the fulfilment of funding requirements in the long term.

Principle 2: Role of government

An effective legal and governmental framework for safety, including an independent regulatory body, must be established and sustained.

3.8. A properly established legal and governmental framework provides for the regulation of facilities and activities that give rise to radiation risks and for the clear assignment of responsibilities. The government is responsible for the adoption within its national legal system of such legislation, regulations, and other standards and measures as may be necessary to fulfil all its national responsibilities and international obligations effectively, and for the establishment of an independent regulatory body.

3.9. Government authorities have to ensure that arrangements are made for preparing programmes of actions to reduce radiation risks, including actions in emergencies, for monitoring releases of radioactive substances to the environment and for disposing of radioactive waste. Government authorities have to provide for control over sources of radiation for which no other organization has responsibility, such as some natural sources, 'orphan sources'[7] and radioactive residues from some past facilities and activities.

3.10. The regulatory body must:

— Have adequate legal authority, technical and managerial competence, and human and financial resources to fulfil its responsibilities;

[7] An 'orphan source' is a radioactive source that is not under regulatory control, either because it has never been under regulatory control, or because it has been abandoned, lost, misplaced, stolen or otherwise transferred without proper authorization.

— Be effectively independent of the licensee and of any other body, so that it is free from any undue pressure from interested parties;
— Set up appropriate means of informing parties in the vicinity, the public and other interested parties, and the information media about the safety aspects (including health and environmental aspects) of facilities and activities and about regulatory processes;
— Consult parties in the vicinity, the public and other interested parties, as appropriate, in an open and inclusive process.

Governments and regulatory bodies thus have an important responsibility in establishing standards and establishing the regulatory framework for protecting people and the environment against radiation risks. However, the prime responsibility for safety rests with the licensee.

3.11. In the event that the licensee is a branch of government, this branch must be clearly identified as distinct from and effectively independent of the branches of government with responsibilities for regulatory functions.

Principle 3: Leadership and management for safety

Effective leadership and management for safety must be established and sustained in organizations concerned with, and facilities and activities that give rise to, radiation risks.

3.12. Leadership in safety matters has to be demonstrated at the highest levels in an organization. Safety has to be achieved and maintained by means of an effective management system. This system has to integrate all elements of management so that requirements for safety are established and applied coherently with other requirements, including those for human performance, quality and security, and so that safety is not compromised by other requirements or demands. The management system also has to ensure the promotion of a safety culture, the regular assessment of safety performance and the application of lessons learned from experience.

3.13. A safety culture that governs the attitudes and behaviour in relation to safety of all organizations and individuals concerned must be integrated in the management system. Safety culture includes:

— Individual and collective commitment to safety on the part of the leadership, the management and personnel at all levels;
— Accountability of organizations and of individuals at all levels for safety;

— Measures to encourage a questioning and learning attitude and to discourage complacency with regard to safety.

3.14. An important factor in a management system is the recognition of the entire range of interactions of individuals at all levels with technology and with organizations. To prevent human and organizational failures, human factors have to be taken into account and good performance and good practices have to be supported.

3.15. Safety has to be assessed for all facilities and activities, consistent with a graded approach. Safety assessment involves the systematic analysis of normal operation and its effects, of the ways in which failures might occur and of the consequences of such failures. Safety assessments cover the safety measures necessary to control the hazard, and the design and engineered safety features are assessed to demonstrate that they fulfil the safety functions required of them. Where control measures or operator actions are called on to maintain safety, an initial safety assessment has to be carried out to demonstrate that the arrangements made are robust and that they can be relied on. A facility may only be constructed and commissioned or an activity may only be commenced once it has been demonstrated to the satisfaction of the regulatory body that the proposed safety measures are adequate.

3.16. The process of safety assessment for facilities and activities is repeated in whole or in part as necessary later in the conduct of operations in order to take into account changed circumstances (such as the application of new standards or scientific and technological developments), the feedback of operating experience, modifications and the effects of ageing. For operations that continue over long periods of time, assessments are reviewed and repeated as necessary. Continuation of such operations is subject to these reassessments demonstrating to the satisfaction of the regulatory body that the safety measures remain adequate.

3.17. Despite all measures taken, accidents may occur. The precursors to accidents have to be identified and analysed, and measures have to be taken to prevent the recurrence of accidents. The feedback of operating experience from facilities and activities — and, where relevant, from elsewhere — is a key means of enhancing safety. Processes must be put in place for the feedback and analysis of operating experience, including initiating events, accident precursors, near misses, accidents and unauthorized acts, so that lessons may be learned, shared and acted upon.

Principle 4: Justification of facilities and activities

Facilities and activities that give rise to radiation risks must yield an overall benefit.

3.18. For facilities and activities to be considered justified, the benefits that they yield must outweigh the radiation risks to which they give rise. For the purposes of assessing benefit and risk, all significant consequences of the operation of facilities and the conduct of activities have to be taken into account.

3.19. In many cases, decisions relating to benefit and risk are taken at the highest levels of government, such as a decision by a State to embark on a nuclear power programme. In other cases, the regulatory body may determine whether proposed facilities and activities are justified.

3.20. Medical radiation exposure of patients — whether for diagnosis or treatment — is a special case, in that the benefit is primarily to the patient. The justification for such exposure is therefore considered first with regard to the specific procedure to be used and then on a patient by patient basis. The justification relies on clinical judgement as to whether a diagnostic or therapeutic procedure would be beneficial. Such clinical judgement is mainly a matter for medical practitioners. For this reason, medical practitioners must be properly trained in radiation protection.

Principle 5: Optimization of protection

Protection must be optimized to provide the highest level of safety that can reasonably be achieved.

3.21. The safety measures that are applied to facilities and activities that give rise to radiation risks are considered optimized if they provide the highest level of safety that can reasonably be achieved throughout the lifetime of the facility or activity, without unduly limiting its utilization.

3.22. To determine whether radiation risks are as low as reasonably achievable, all such risks, whether arising from normal operations or from abnormal or accident conditions, must be assessed (using a graded approach) a priori and periodically reassessed throughout the lifetime of facilities and activities. Where there are interdependences between related actions or between their associated risks (e.g. for different stages of the lifetime of facilities and

activities, for risks to different groups or for different steps in radioactive waste management), these must also be considered. Account also has to be taken of uncertainties in knowledge.

3.23. The optimization of protection requires judgements to be made about the relative significance of various factors, including:

— The number of people (workers and the public) who may be exposed to radiation;
— The likelihood of their incurring exposures;
— The magnitude and distribution of radiation doses received;
— Radiation risks arising from foreseeable events;
— Economic, social and environmental factors.

The optimization of protection also means using good practices and common sense to avoid radiation risks as far as is practical in day to day activities.

3.24. The resources devoted to safety by the licensee, and the scope and stringency of regulations and their application, have to be commensurate with the magnitude of the radiation risks and their amenability to control. Regulatory control may not be needed where this is not warranted by the magnitude of the radiation risks.

Principle 6: Limitation of risks to individuals

Measures for controlling radiation risks must ensure that no individual bears an unacceptable risk of harm.

3.25. Justification and optimization of protection do not in themselves guarantee that no individual bears an unacceptable risk of harm. Consequently, doses and radiation risks must be controlled within specified limits.

3.26. Conversely, because dose limits and risk limits represent a legal upper bound of acceptability, they are insufficient in themselves to ensure the best achievable protection under the circumstances, and they therefore have to be supplemented by the optimization of protection. Thus both the optimization of protection and the limitation of doses and risks to individuals are necessary to achieve the desired level of safety.

Principle 7: Protection of present and future generations

People and the environment, present and future, must be protected against radiation risks.

3.27. Radiation risks may transcend national borders and may persist for long periods of time. The possible consequences, now and in the future, of current actions have to be taken into account in judging the adequacy of measures to control radiation risks. In particular:

— Safety standards apply not only to local populations but also to populations remote from facilities and activities.
— Where effects could span generations, subsequent generations have to be adequately protected without any need for them to take significant protective actions.

3.28. Whereas the effects of radiation exposure on human health are relatively well understood, albeit with uncertainties[8], the effects of radiation on the environment have been less thoroughly investigated. The present system of radiation protection generally provides appropriate protection of ecosystems in the human environment against harmful effects of radiation exposure. The general intent of the measures taken for the purposes of environmental protection has been to protect ecosystems against radiation exposure that would have adverse consequences for populations of a species (as distinct from individual organisms).

3.29. Radioactive waste must be managed in such a way as to avoid imposing an undue burden on future generations; that is, the generations that produce the waste have to seek and apply safe, practicable and environmentally acceptable solutions for its long term management. The generation of radioactive waste must be kept to the minimum practicable level by means of appropriate design measures and procedures, such as the recycling and reuse of material.

[8] In particular, assumptions have to be made owing to uncertainties concerning the health effects of radiation exposure at low doses and low dose rates.

Principle 8: Prevention of accidents

All practical efforts must be made to prevent and mitigate nuclear or radiation accidents.

3.30. The most harmful consequences arising from facilities and activities have come from the loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or other source of radiation. Consequently, to ensure that the likelihood of an accident having harmful consequences is extremely low, measures have to be taken:

— To prevent the occurrence of failures or abnormal conditions (including breaches of security) that could lead to such a loss of control;
— To prevent the escalation of any such failures or abnormal conditions that do occur;
— To prevent the loss of, or the loss of control over, a radioactive source or other source of radiation.

3.31. The primary means of preventing and mitigating the consequences of accidents is 'defence in depth'. Defence in depth is implemented primarily through the combination of a number of consecutive and independent levels of protection that would have to fail before harmful effects could be caused to people or to the environment. If one level of protection or barrier were to fail, the subsequent level or barrier would be available. When properly implemented, defence in depth ensures that no single technical, human or organizational failure could lead to harmful effects, and that the combinations of failures that could give rise to significant harmful effects are of very low probability. The independent effectiveness of the different levels of defence is a necessary element of defence in depth.

3.32. Defence in depth is provided by an appropriate combination of:

— An effective management system with a strong management commitment to safety and a strong safety culture.
— Adequate site selection and the incorporation of good design and engineering features providing safety margins, diversity and redundancy, mainly by the use of:
  • Design, technology and materials of high quality and reliability;
  • Control, limiting and protection systems and surveillance features;
  • An appropriate combination of inherent and engineered safety features.

— Comprehensive operational procedures and practices as well as accident management procedures.

3.33. Accident management procedures must be developed in advance to provide the means for regaining control over a nuclear reactor core, nuclear chain reaction or other source of radiation in the event of a loss of control and for mitigating any harmful consequences.

Principle 9: Emergency preparedness and response

Arrangements must be made for emergency preparedness and response for nuclear or radiation incidents.

3.34. The primary goals of preparedness and response for a nuclear or radiation emergency are:

— To ensure that arrangements are in place for an effective response at the scene and, as appropriate, at the local, regional, national and international levels, to a nuclear or radiation emergency;
— To ensure that, for reasonably foreseeable incidents, radiation risks would be minor;
— For any incidents that do occur, to take practical measures to mitigate any consequences for human life and health and the environment.

3.35. The licensee, the employer, the regulatory body and appropriate branches of government have to establish, in advance, arrangements for preparedness and response for a nuclear or radiation emergency at the scene, at local, regional and national levels and, where so agreed between States, at the international level.

3.36. The scope and extent of arrangements for emergency preparedness and response have to reflect:

— The likelihood and the possible consequences of a nuclear or radiation emergency;
— The characteristics of the radiation risks;
— The nature and location of the facilities and activities.

Such arrangements include:

— Criteria set in advance for use in determining when to take different protective actions;
— The capability to take actions to protect and inform personnel at the scene, and if necessary the public, during an emergency.

3.37. In developing the emergency response arrangements, consideration has to be given to all reasonably foreseeable events. Emergency plans have to be exercised periodically to ensure the preparedness of the organizations having responsibilities in emergency response.

3.38. When urgent protective actions must be taken promptly in an emergency, it may be acceptable for emergency workers to receive, on the basis of informed consent, doses that exceed the occupational dose limits normally applied — but only up to a predetermined level.

Principle 10: Protective actions to reduce existing or unregulated radiation risks

Protective actions to reduce existing or unregulated radiation risks must be justified and optimized.

3.39. Radiation risks may arise in situations other than in facilities and activities that are in compliance with regulatory control. In such situations, if the radiation risks are relatively high, consideration has to be given to whether protective actions can reasonably be taken to reduce radiation exposures and to remediate adverse conditions.

— One type of situation concerns radiation of essentially natural origin. Such situations include exposure to radon gas in dwellings and workplaces, for example, for which remedial actions can be taken if necessary. However, in many situations there is little that can practicably be done to reduce exposure to natural sources of radiation.
— A second type of situation concerns exposure that arises from human activities conducted in the past that were never subject to regulatory control, or that were subject to an earlier, less rigorous regime of control. An example is situations in which radioactive residues remain from former mining operations.

— A third type of situation concerns protective actions, such as remediation measures, taken following an uncontrolled release of radionuclides to the environment.

3.40. In all of these cases, the protective actions considered each have some foreseeable economic, social and, possibly, environmental costs and may entail some radiation risks (e.g. to workers carrying out such actions). The protective actions are considered justified only if they yield sufficient benefit to outweigh the radiation risks and other detriments associated with taking them. Furthermore, protective actions must be optimized to produce the greatest benefit that is reasonably achievable in relation to the costs.

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