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IAEA SAFETY STANDARDS

No. SSG-91

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Protection of Workers Against Exposure Due to Radon

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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. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available on the IAEA web site:

<http://www-ns.iaea.org/standards/>

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: Vienna International Centre, PO Box 100, 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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The IAEA provides for the application of the standards and, under the terms of Articles III and VIII.C of its Statute, makes available and fosters the exchange of information relating to peaceful nuclear activities and serves as an intermediary among its Member States for this purpose.

Reports on safety in nuclear activities are issued as **Safety Reports**, which provide practical examples and detailed methods that can be used in support of the safety standards.

Other safety related IAEA publications are issued as **Emergency Preparedness and Response** publications, **Radiological Assessment Reports**, the International Nuclear Safety Group's **INSAG Reports**, **Technical Reports** and **TECDOCs**. The IAEA also issues reports on radiological accidents, training manuals and practical manuals, and other special safety related publications.

Security related publications are issued in the **IAEA Nuclear Security Series**.

The **IAEA Nuclear Energy Series** comprises informational publications to encourage and assist research on, and the development and practical application of, nuclear energy for peaceful purposes. It includes reports and guides on the status of and advances in technology, and on experience, good practices and practical examples in the areas of nuclear power, the nuclear fuel cycle, radioactive waste management and decommissioning.

PROTECTION OF WORKERS
AGAINST EXPOSURE
DUE TO RADON

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world".

IAEA SAFETY STANDARDS SERIES No. SSG-91

PROTECTION OF WORKERS AGAINST EXPOSURE DUE TO RADON

SPECIFIC SAFETY GUIDE

JOINTLY SPONSORED BY THE INTERNATIONAL ATOMIC ENERGY
AGENCY AND INTERNATIONAL LABOUR OFFICE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2024

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Vienna International Centre
PO Box 100
1400 Vienna, Austria
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email: sales.publications@iaea.org
www.iaea.org/publications

© IAEA, 2024

Printed by the IAEA in Austria

November 2024

STI/PUB/2098

<https://doi.org/10.61092/iaea.ie56-5u7i>

IAEA Library Cataloguing in Publication Data

Names: International Atomic Energy Agency.

Title: Protection of workers against exposure due to radon / International Atomic Energy Agency.

Description: Vienna : International Atomic Energy Agency, 2024. | Series: IAEA safety standards series, ISSN 1020-525X ; no. SSG-91 | Includes bibliographical references.

Identifiers: IAEAL 24-01701 | ISBN 978-92-0-126924-9 (paperback : alk. paper) | ISBN 978-92-0-127124-2 (pdf) | ISBN 978-92-0-127024-5 (epub)

Subjects: LCSH: Radon — Safety measures. | Radiation — Safety measures. | Radon — Health aspects. | Nuclear industry — Employees — Safety measures.

Classification: UDC 614.876 | STI/PUB/2098

FOREWORD

by Rafael Mariano Grossi
Director General

The IAEA's Statute authorizes it to "establish...standards of safety for protection of health and minimization of danger to life and property". These are standards that the IAEA must apply to its own operations, and that States can apply through their national regulations.

The IAEA started its safety standards programme in 1958 and there have been many developments since. As Director General, I am committed to ensuring that the IAEA maintains and improves upon this integrated, comprehensive and consistent set of up to date, user friendly and fit for purpose safety standards of high quality. Their proper application in the use of nuclear science and technology should offer a high level of protection for people and the environment across the world and provide the confidence necessary to allow for the ongoing use of nuclear technology for the benefit of all.

Safety is a national responsibility underpinned by a number of international conventions. The IAEA safety standards form a basis for these legal instruments and serve as a global reference to help parties meet their obligations. While safety standards are not legally binding on Member States, they are widely applied. They have become an indispensable reference point and a common denominator for the vast majority of Member States that have adopted these standards for use in national regulations to enhance safety in nuclear power generation, research reactors and fuel cycle facilities as well as in nuclear applications in medicine, industry, agriculture and research.

The IAEA safety standards are based on the practical experience of its Member States and produced through international consensus. The involvement of the members of the Safety Standards Committees, the Nuclear Security Guidance Committee and the Commission on Safety Standards is particularly important, and I am grateful to all those who contribute their knowledge and expertise to this endeavour.

The IAEA also uses these safety standards when it assists Member States through its review missions and advisory services. This helps Member States in the application of the standards and enables valuable experience and insight to be shared. Feedback from these missions and services, and lessons identified from events and experience in the use and application of the safety standards, are taken into account during their periodic revision.

I believe the IAEA safety standards and their application make an invaluable contribution to ensuring a high level of safety in the use of nuclear technology. I encourage all Member States to promote and apply these standards, and to work with the IAEA to uphold their quality now and in the future.

PREFACE

Requirements for the protection of people from harmful consequences of exposure to ionizing radiation, for the safety of radiation sources and for protection of the environment are established in IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (GSR Part 3), which is jointly sponsored by the European Commission, the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the International Labour Organization (ILO), 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 present Safety Guide provides recommendations and guidance on meeting the requirements of GSR Part 3 for protection of workers against exposure due to radon in existing exposure situations and in planned exposure situations.

Recommendations and guidance are provided for dealing with exposure in workplaces such as buildings, underground locations and industrial premises involving the processing of naturally occurring radioactive material (NORM). The protection of workers in buildings with high occupancy factors for members of the public, such as schools, kindergartens and hospitals, is also addressed.

Recommendations and guidance are provided for the implementation of requirements for radiation protection through the application of a graded approach and the principles of justification and optimization of protection and safety, in order to identify workplaces of concern in a practical way. Recommendations on the protection of workers against exposure due to thoron are also provided.

This Safety Guide is jointly sponsored by the IAEA and the ILO. The IAEA gratefully acknowledges the contribution of experts from several Member States and from the ILO to the drafting and review of the text.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks 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.

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.

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.

A global nuclear safety regime is in place and is being continuously improved. IAEA safety standards, which support the implementation of binding international instruments and national safety infrastructures, are a cornerstone of this global regime. The IAEA safety standards constitute a useful tool for contracting parties to assess their performance under these international conventions.

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA 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, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, 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, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures¹ have in common the aim of protecting human life and health and the environment. 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.

The IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment from harmful effects of ionizing radiation. They are issued in the IAEA Safety Standards Series, which has three categories (see Fig. 1).

Safety Fundamentals

Safety Fundamentals present the fundamental safety objective and principles of protection and safety, and provide the basis for the safety requirements.

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. Requirements, including numbered ‘overarching’ requirements, are expressed as ‘shall’ statements. Many requirements are not addressed to a specific party, the implication being that the appropriate parties are responsible for fulfilling them.

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it

¹ See also publications issued in the IAEA Nuclear Security Series.

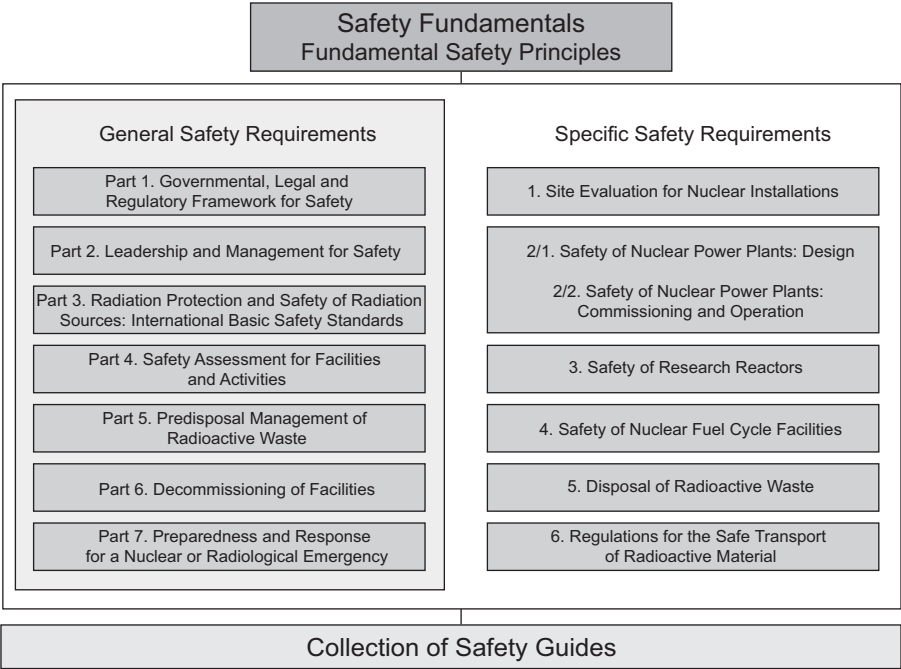


FIG. 1. The long term structure of the IAEA Safety Standards Series.

is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best practices, to help users striving to achieve high levels of safety. The recommendations provided in Safety Guides are expressed as ‘should’ statements.

APPLICATION OF THE IAEA SAFETY STANDARDS

The principal users of safety standards in IAEA Member States are regulatory bodies and other relevant national authorities. The IAEA safety standards are also used by co-sponsoring organizations and by many organizations that design, construct and operate nuclear facilities, as well as organizations involved in the use of radiation and radioactive sources.

The IAEA safety standards are applicable, as relevant, throughout the entire lifetime of all facilities and activities — existing and new — utilized for peaceful purposes and to protective actions to reduce existing radiation risks. They can be

used by States as a reference for their national regulations in respect of facilities and activities.

The IAEA's Statute makes the safety standards binding on the IAEA in relation to its own operations and also on States in relation to IAEA assisted operations.

The IAEA safety standards also form the basis for the IAEA's safety review services, and they are used by the IAEA in support of competence building, including the development of educational curricula and training courses.

International conventions contain requirements similar to those in the IAEA safety standards and make them binding on contracting parties. The IAEA safety standards, supplemented by international conventions, industry standards and detailed national requirements, establish a consistent basis for protecting people and the environment. There will also be some special aspects of safety that need to be assessed at the national level. For example, many of the IAEA safety standards, in particular those addressing aspects of safety in planning or design, are intended to apply primarily to new facilities and activities. The requirements established in the IAEA safety standards might not be fully met at some existing facilities that were built to earlier standards. The way in which IAEA safety standards are to be applied to such facilities is a decision for individual States.

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

DEVELOPMENT PROCESS FOR THE IAEA SAFETY STANDARDS

The preparation and review of the safety standards involves the IAEA Secretariat and five Safety Standards Committees, for emergency preparedness and response (EPReSC) (as of 2016), nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

All IAEA Member States may nominate experts for the Safety Standards Committees and may provide comments on draft standards. The membership of the Commission on Safety Standards is appointed by the Director General and includes senior governmental officials having responsibility for establishing national standards.

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards.

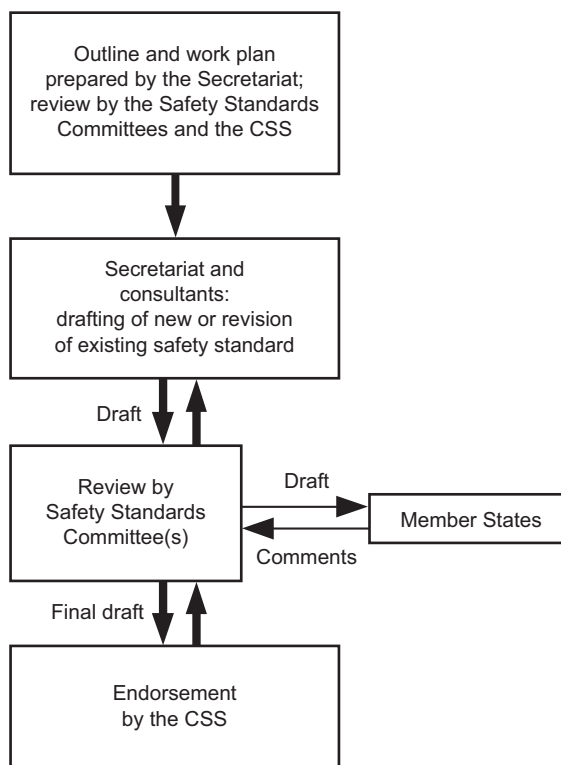


FIG. 2. The process for developing a new safety standard or revising an existing standard.

It articulates the mandate of the IAEA, the vision for the future application of the safety standards, policies and strategies, and corresponding functions and responsibilities.

INTERACTION WITH OTHER INTERNATIONAL ORGANIZATIONS

The findings of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 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. Some safety standards are developed in cooperation with other bodies in the United Nations system or other specialized agencies, including the Food and Agriculture Organization of the United Nations, the United Nations Environment Programme, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization and the World Health Organization.

INTERPRETATION OF THE TEXT

Safety related terms are to be understood as they appear in the IAEA Nuclear Safety and Security Glossary (see <https://www.iaea.org/resources/publications/iaea-nuclear-safety-and-security-glossary>). Otherwise, words are used with the spellings and meanings assigned to them in the latest edition of The Concise Oxford Dictionary. For Safety Guides, the English version of the text is the authoritative version.

The background and context of each standard in the IAEA Safety Standards Series and its objective, scope and structure are explained in Section 1, Introduction, of each publication.

Material for which there is no appropriate place in the body text (e.g. material that is subsidiary to or separate from the body text, is included in support of statements in the body text, or describes methods of calculation, procedures or limits and conditions) may be presented in appendices or annexes.

An appendix, if included, is considered to form an integral part of the safety standard. Material in an appendix has the same status as the body text, and the IAEA assumes authorship of it. Annexes and footnotes to the main text, if included, are used to provide practical examples or additional information or explanation. Annexes and footnotes are not integral parts of the main text. Annex material published by the IAEA is not necessarily issued under its authorship; material under other authorship may be presented in annexes to the safety standards. Extraneous material presented in annexes is excerpted and adapted as necessary to be generally useful.

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1. INTRODUCTION

BACKGROUND

1.1. IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1], presents the fundamental safety objective and ten safety principles. Requirements designed to meet the fundamental safety objective and to apply the safety principles specified in SF-1 [1] are established in IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [2], which was jointly sponsored by the IAEA and seven other international organizations. GSR Part 3 [2] includes requirements for the protection of workers exposed to sources of radiation.

1.2. The World Health Organization has stated that radon is the second leading cause of lung cancer in the general population after smoking [3]. Early studies on underground miners demonstrated an increased incidence of lung cancer in uranium miners exposed to very high concentrations of radon and its progeny. Epidemiological studies summarized in reports of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [4, 5] and in publications of the International Commission on Radiological Protection (ICRP) [6, 7] have shown a significant association between workers' exposure due to radon and lung cancer. These studies reflect the importance of protecting workers from exposure due to radon.

1.3. GSR Part 3 [2] establishes requirements for the protection of workers against exposure due to radon. Recommendations on occupational radiation protection, including protection of workers against exposure due to radon, are provided in IAEA Safety Standards Series No. GSG-7, Occupational Radiation Protection [8].

1.4. Recent ICRP publications [6, 7, 9] have also been considered in preparing this Safety Guide. The prerequisites for protection of workers from all sources of radiation are set out by the International Labour Organization (ILO) [10]. The ILO's code of practice on the radiation protection of workers [11] has also been taken into account in this Safety Guide.

OBJECTIVE

1.5. This Safety Guide provides recommendations on meeting the requirements of GSR Part 3 [2] for protection of workers against exposure due to radon¹ in existing exposure situations and planned exposure situations.

1.6. This Safety Guide focuses on the identification of workplaces of concern with regard to exposure due to radon and on the implementation of requirements for radiation protection through the application of a graded approach and the principles of justification and optimization of protection and safety. The recommendations provided in this Safety Guide are intended for governments, regulatory bodies and other relevant authorities (especially those with little or no experience in radiation protection), employers, workers and service providers.

SCOPE

1.7. This Safety Guide provides recommendations on the protection of workers against exposure due to radon in existing exposure situations and planned exposure situations. This includes exposure in workplaces such as buildings, underground locations and industrial premises involving the processing of naturally occurring radioactive material (NORM)². The protection of workers in buildings with high occupancy factors for members of the public, such as schools, kindergartens and hospitals, is also addressed. Exposure to ²²⁰Rn (thoron) and its progeny is also considered in Appendix I. Recommendations on protection of the public against exposure due to radon in existing exposure situations are provided in IAEA Safety Standards Series No. SSG-32, Protection of the Public Against Exposure Indoors due to Radon and Other Natural Sources of Radiation [16].

¹ In this Safety Guide (and in the IAEA safety standards in general), the general phrase “exposure due to radon” is used, and this includes exposure to both ²²²Rn and its progeny.

² Specific information on protection from radon in workplaces, including those involving different industrial processes involving NORM, is provided in Refs [12-15].

1.8. The recommendations on specific remedial actions³ and protective actions⁴ provided in SSG-32 [16] are also applicable in workplaces. Further information is provided in Ref. [17].

STRUCTURE

1.9. Section 2 of this Safety Guide describes the framework for the protection of workers against exposure due to radon. Section 3 provides recommendations on the protection of workers against exposure due to radon in existing exposure situations. Section 4 provides recommendations on the protection of workers against exposure due to radon in planned exposure situations. The Appendices provide recommendations on the protection of workers against exposure due to thoron. The Annex provides information on radon measurement protocols and measurement equipment.

2. FRAMEWORK FOR PROTECTION OF WORKERS AGAINST EXPOSURE DUE TO RADON

TYPES OF EXPOSURE SITUATION

2.1. Based on the recommendations of ICRP Publication 103 [18], the requirements established in GSR Part 3 [2] address three different types of exposure situation: planned exposure situations, existing exposure situations and emergency exposure situations. For the protection of workers against exposure due to radon, this Safety Guide considers existing exposure situations and planned exposure situations. Radon is not likely to give rise to an emergency exposure situation.

2.2. An existing exposure situation is a situation of exposure that already exists when a decision on the need for control needs to be taken (see para. 1.20(c) of

³ A remedial action is defined as “The removal of a source or the reduction of its magnitude (in terms of activity or amount) for the purposes of preventing or reducing exposures that might otherwise occur in an emergency or in an existing exposure situation” [2].

⁴ Protective actions are defined as “An action for the purposes of avoiding or reducing doses that might otherwise be received in an emergency exposure situation or an existing exposure situation” [2].