

IAEA Safety Standards

for protecting people and the environment

Radiation Safety in the Use of Nuclear Gauges

Specific Safety Guide

No. SSG-58



IAEA

International Atomic Energy Agency



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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 Internet site

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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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RADIATION SAFETY
IN THE USE OF
NUCLEAR GAUGES

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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-58

RADIATION SAFETY IN THE USE OF NUCLEAR GAUGES

SPECIFIC SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2020

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1400 Vienna, Austria
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email: sales.publications@iaea.org
www.iaea.org/publications

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Printed by the IAEA in Austria

December 2020

STI/PUB/1881

IAEA Library Cataloguing in Publication Data

Names: International Atomic Energy Agency.

Title: Radiation safety in the use of nuclear gauges / International Atomic Energy Agency.

Description: Vienna : International Atomic Energy Agency, 2020. | Series: IAEA safety standards series, ISSN 1020-525X ; no. SSG-58 | Includes bibliographical references.

Identifiers: IAEAL 20-01369 | ISBN 978-92-0-106019-8 (paperback : alk. paper) | 978-92-0-105420-3 (PDF)

Subjects: LCSH: Radiation protection | Radiation — Safety measures | Gages | Radioactive substances — Safety measures

Classification: UDC 614.876:531.714 | STI/PUB/1881

FOREWORD

The IAEA's Statute authorizes the Agency to “establish or adopt... standards of safety for protection of health and minimization of danger to life and property” — standards that the IAEA must use in its own operations, and which States can apply by means of their regulatory provisions for nuclear and radiation safety. The IAEA does this in consultation with the competent organs of the United Nations and with the specialized agencies concerned. A comprehensive set of high quality standards under regular review is a key element of a stable and sustainable global safety regime, as is the IAEA's assistance in their application.

The IAEA commenced its safety standards programme in 1958. The emphasis placed on quality, fitness for purpose and continuous improvement has led to the widespread use of the IAEA standards throughout the world. The Safety Standards Series now includes unified Fundamental Safety Principles, which represent an international consensus on what must constitute a high level of protection and safety. With the strong support of the Commission on Safety Standards, the IAEA is working to promote the global acceptance and use of its standards.

Standards are only effective if they are properly applied in practice. The IAEA's safety services encompass design, siting and engineering safety, operational safety, radiation safety, safe transport of radioactive material and safe management of radioactive waste, as well as governmental organization, regulatory matters and safety culture in organizations. These safety services assist Member States in the application of the standards and enable valuable experience and insights to be shared.

Regulating safety is a national responsibility, and many States have decided to adopt the IAEA's standards for use in their national regulations. For 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 regulatory bodies and operators around the world to enhance safety in nuclear power generation and in nuclear applications in medicine, industry, agriculture and research.

Safety is not an end in itself but a prerequisite for the purpose of the protection of people in all States and of the environment — now and in the future. The risks associated with ionizing radiation must be assessed and controlled without unduly limiting the contribution of nuclear energy to equitable and sustainable development. Governments, regulatory bodies and operators everywhere must ensure that nuclear material and radiation sources are used beneficially, safely and ethically. The IAEA safety standards are designed to facilitate this, and I encourage all Member States to make use of them.

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.

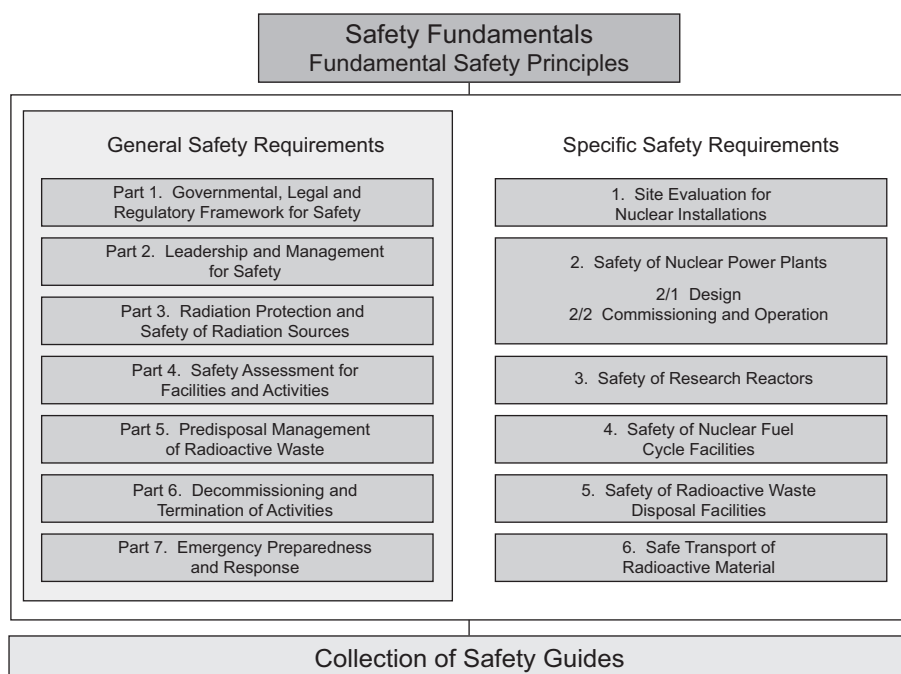


FIG. 1. The long term structure of the IAEA Safety Standards Series.

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.

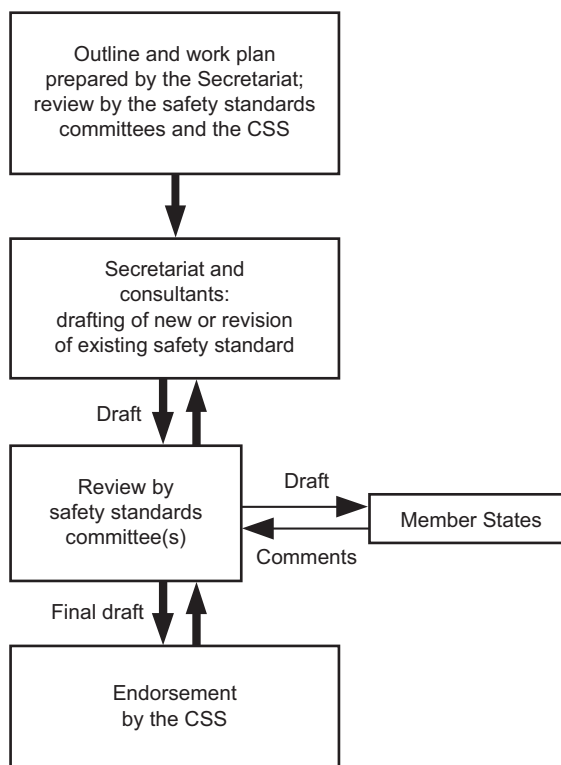


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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 defined in the IAEA Safety Glossary (see <http://www-ns.iaea.org/standards/safety-glossary.htm>). 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. As stated in IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1]: “**The fundamental safety objective is to protect people and the environment from harmful effects of ionizing radiation.**” Paragraph 2.1 of SF-1 [1] states:

“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.”

1.2. Paragraph 2.2 of SF-1 [1] states:

“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.”

1.3. There are several hundred thousand nuclear gauges incorporating a radioactive source or a radiation generator in use all over the world. They have been used in a wide range of industries [2] to improve the quality of products, optimize processes, and save energy and materials. The economic benefits have been amply demonstrated and there is clear evidence that nuclear gauge technology can be used safely and will continue to play an important role in a wide range of industries.

1.4. There are three main categories of nuclear gauge used in industry [2]:

- (a) Transmission gauges, used to measure density, thickness and levels of materials: The source housing and the radiation detector are on opposite sides of the material under investigation and the radiation is attenuated as it travels through the material. Such gauges traditionally used radioactive sources (beta and gamma); however, X ray generators are increasingly being used and are now a popular type of radiation source in transmission gauges.

- (b) Backscatter gauges, used to measure the thickness of coatings: The detector and source housing are on the same side of the material and therefore the detector has to be shielded from the primary radiation. The radiation enters the material, interacts with it and scatters back. Radioactive sources (beta, gamma and occasionally neutron) are typically used in such gauges. The back-scattered radiation is measured by the radiation detector and is related to the coating thickness.
- (c) Reactive gauges, for example used for elemental analysis: Certain radiation sources (X ray and neutron) can cause fluorescent X ray emissions in the material being analysed. X ray generators and neutron sources (radioactive sources or radiation generators) are used in some reactive gauges.

Annex I presents an overview of the main radiation sources used in nuclear gauges for different applications.

1.5. IAEA Safety Standards Series No. RS-G-1.9, Categorization of Radioactive Sources [3] provides a relative ranking of radioactive sources in terms of their potential to cause severe deterministic effects (i.e. how potentially hazardous they could be if misused). The categorization system set out in RS-G-1.9 has five categories, wherein sources in Category 1 are considered to be the most ‘dangerous’. Radioactive sources used in nuclear gauges normally fall into Category 3 or Category 4.

1.6. This Safety Guide is one of a number of Safety Guides on industrial uses of ionizing radiation, including for industrial irradiators, industrial radiography, well logging and radioisotope production facilities [4–7].

1.7. Unless otherwise stated, terms used in this Safety Guide have the meanings ascribed to them in the IAEA Safety Glossary [8].

1.8. It is assumed in this Safety Guide that an effective governmental, legal and regulatory infrastructure for radiation safety for the use of nuclear gauges is in place in the State.

OBJECTIVE

1.9. The objective of this Safety Guide is to provide recommendations on how to meet the relevant requirements of IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [9] in relation to the use of nuclear gauges.

1.10. The guidance in this publication is aimed primarily at operating organizations that are authorized to use nuclear gauges, as well as their employees and radiation protection officers. The guidance will also be of interest to regulatory bodies, and to designers, manufacturers, suppliers, and maintenance and servicing organizations of nuclear gauges.

SCOPE

1.11. This Safety Guide provides recommendations on the design, construction and use of fixed (i.e. installed) nuclear gauges and portable (mobile) nuclear gauges. This Safety Guide specifically considers: the responsibilities of relevant parties; the installation, use, maintenance and decommissioning of nuclear gauges; developing safety assessments and local rules; radiation monitoring; transport of radioactive material; and arrangements for preparedness and response for incidents and accidents.

1.12. This Safety Guide also provides information on the need for appropriate nuclear security measures and provides recommendations on their interfaces with safety measures, but does not provide specific guidance on aspects of nuclear security. Additional guidance on nuclear security can be found in the IAEA Nuclear Security Series.

1.13. The use of radiation sources for security purposes (e.g. X ray inspection of luggage for dangerous items) is outside the scope of this Safety Guide.

STRUCTURE

1.14. Section 2 describes the duties and responsibilities of organizations and individuals in respect of nuclear gauges. The preparation of a safety assessment and a radiation protection programme for nuclear gauges are described in Sections 3 and 4, respectively. Recommendations on training of personnel are provided in Section 5. Sections 6 and 7 provide recommendations on individual monitoring of workers and workplace monitoring, respectively. Subsequent sections provide recommendations on the control of radioactive sources (Section 8), the security of radioactive sources (Section 9), the safe use of fixed nuclear gauges and portable nuclear gauges (Sections 10 and 11, respectively), and the safe transport of radioactive sources (Section 12). Preparedness for and response to emergencies involving gauging sources is described in Section 13.

1.15. An overview of nuclear gauge radiation sources and applications is provided in Annex I. Considerations for a safety assessment for nuclear gauges and for local rules for nuclear gauges are provided in Annex II. Some examples of incidents involving nuclear gauges are given in Annex III.

2. DUTIES AND RESPONSIBILITIES

GENERAL

2.1. IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [10] establishes requirements for the governmental, legal and regulatory infrastructure for safety of facilities and activities, including those associated with the use of nuclear gauges, and assigns duties and responsibilities to relevant parties. GSR Part 3 [9] provides the general framework for these duties and responsibilities, and this section provides recommendations on the various duties and responsibilities in the context of nuclear gauges.

THE GOVERNMENT AND THE REGULATORY BODY

2.2. Paragraph 2.15 of GSR Part 3 [9] states:

“The government shall establish legislation that, among other things:

- (a) Provides the statutory basis for requirements for protection and safety for all exposure situations;
- (b) Specifies that the prime responsibility for protection and safety rests with the person or organization responsible for facilities and activities that give rise to radiation risks;
- (c) Specifies the scope of its applicability;
- (d) Establishes and provides for maintaining an independent regulatory body with clearly specified functions and responsibilities for the regulation of protection and safety;
- (e) Provides for coordination between authorities with responsibilities relevant to protection and safety for all exposure situations.”

A sound legal and governmental infrastructure, including a national regulatory body with well defined responsibilities and functions, is vital for the achievement and maintenance of a high level of safety in the use of radiation sources in nuclear gauges.

2.3. Paragraph 2.16 of GSR Part 3 [9] states:

“The government shall ensure that the regulatory body is effectively independent, in making decisions relating to protection and safety, of persons and organizations using or promoting the use of radiation and radioactive material, so that it is free from any undue influence by interested parties and from any conflicts of interest; and shall ensure that it has functional separation from entities having responsibilities or interests that could unduly influence its decision making.”

The regulatory body should have no stake in the development and utilization of the technology that it is regulating.

2.4. Paragraph 2.17 of GSR Part 3 [9] states that: “The government shall ensure that the regulatory body has the legal authority, competence and resources necessary to fulfil its statutory functions and responsibilities.”

2.5. Requirement 3 of GSR Part 3 [9] states that: **“The regulatory body shall establish or adopt regulations and guides for protection and safety and shall establish a system to ensure their implementation.”** Many States have decided to adopt the IAEA’s standards for use in their national regulations.

2.6. Paragraph 2.30 of GSR Part 3 [9] states:

“The regulatory body shall establish a regulatory system for protection and safety that includes [see Ref. 10]:

- (a) Notification and authorization;
- (b) Review and assessment of facilities and activities;
- (c) Inspection of facilities and activities;
- (d) Enforcement of regulatory requirements;
- (e) The regulatory functions relevant to emergency exposure situations and existing exposure situations;
- (f) Provision of information to, and consultation with, parties affected by its decisions and, as appropriate, the public and other interested parties.”

2.7. Paragraph 2.31 of GSR Part 3 [9] states:

“The regulatory body shall adopt a graded approach to the implementation of the system of protection and safety, such that the application of regulatory requirements is commensurate with the radiation risks associated with the exposure situation.”

The graded approach should ensure that the application of regulatory resources is optimized while effectively verifying regulatory compliance.

2.8. Paragraph 2.32 of GSR Part 3 [9] states that: “The regulatory body shall ensure the application of the requirements for education, training, qualification and competence in protection and safety of all persons engaged in activities relevant to protection and safety.”

2.9. Paragraph 2.33 of GSR Part 3 [9] states:

“The regulatory body shall ensure that mechanisms are in place for the timely dissemination of information to relevant parties, such as suppliers of and users of sources, on lessons learned for protection and safety from regulatory experience and operating experience, and from incidents and accidents and the related findings. The mechanisms established shall, as appropriate, be used to provide relevant information to other relevant organizations at the national and international level.”

In many States, the regulatory body periodically communicates with relevant parties, such as suppliers of and users of sources, through newsletters that provide information on topics such as safe work practices and details of incidents involving radiation sources that have occurred in the State or elsewhere so that lessons learned can be implemented to improve protection and safety.

2.10. Paragraph 2.34 of GSR Part 3 [9] states:

“The regulatory body, in conjunction with other relevant authorities, shall specify requirements for acceptance and for performance, by regulation or by the application of published standards, for any manufactured or constructed source, device, equipment or facility that, when in use, has implications for protection and safety.”

2.11. Radioactive sources used in nuclear gauges should have the relevant characteristics, and meet the performance and safety testing criteria, specified in

ISO 2919 [11]. An example of acceptance and performance criteria for gauges designed for permanent installation is provided in IEC 62598 [12]. The regulatory body should establish or adopt performance standards and specific acceptance criteria for nuclear gauges and associated radiation sources that are authorized for distribution and use.

2.12. Paragraph 2.35 of GSR Part 3 [9] states (footnote omitted):

“The regulatory body shall make provision for establishing, maintaining and retrieving adequate records relating to facilities and activities. These records shall include:

- Registers of sealed sources and radiation generators;
- Records of doses from occupational exposure;
- Records relating to the safety of facilities and activities;
- Records that might be necessary for the shutdown and decommissioning or closure of facilities;
- Records of events, including non-routine releases of radioactive material to the environment;
- Inventories of radioactive waste...”

Records relating to the safety of nuclear gauges should also include inventories of radiation sources in use and of disused sources.

2.13. The regulatory body should also make provision for establishing, maintaining and retrieving adequate records of:

- (a) The transport of radioactive sources;
- (b) The location of radioactive sources;
- (c) Incidents involving radiation sources, such as loss of radioactive sources, damage to radioactive sources and theft of radioactive sources or radiation generators.

2.14. The regulatory body should perform inspection activities relating to the use of nuclear gauges [13]. These inspections should verify that the operating organization is in compliance with the regulatory requirements and with any conditions specified in the authorization. Periodic inspections of facilities and activities should be part of a schedule developed by the regulatory body; in addition, reactive inspections should be conducted in response to a request made by the operating organization, or after an incident. Inspections can be announced or unannounced, as deemed appropriate by the regulatory body. A graded approach

should be adopted in the conduct of inspections of facilities and activities such that the frequency and complexity of inspections are commensurate with the radiation risks associated with the facility or activity.

2.15. Inspections should review a range of issues relating to the safe use of nuclear gauges, and should include the following:

- (a) Review of compliance with the conditions of the authorization to possess and use nuclear gauges; for example, checking that the inventory includes only those gauges and radiation sources that are authorized, and that gauges are used only for authorized purposes at authorized locations. The temporary use of gauges at client facilities should be subject to specific authorization conditions relating to temporary storage, operation and transport of the gauges. If any authorized source is missing or if any source is found to be not properly authorized, the matter should be investigated and appropriate actions implemented (an immediate search should be performed for missing sources, and any unauthorized sources should be brought under regulatory control).
- (b) Confirmation that radiation sources and nuclear gauges meet the acceptance criteria and performance criteria established by the regulatory body.
- (c) Measurement of radiation levels around nuclear gauges and confirmation of compliance with authorized levels.
- (d) Review of the records of workplace monitoring and of safety assessments performed by the operating organization, to determine whether (and under what circumstances) personal dosimetry is appropriate.
- (e) Observing the use of nuclear gauges, including procedures for safe use and, where appropriate, source handling procedures.
- (f) Checking the arrangements for the safety and security of each radiation source before the installation of the gauge, during its use and after the end of the useful life of the source.
- (g) Review of control measures (e.g. the conduct of periodic source inventory checks, controls to ensure that sources are only used by authorized individuals, use of appropriate engineered controls), storage conditions for portable gauges and for disused sources, and emergency procedures.
- (h) Review of compliance with regulatory requirements for transport of radioactive material (see Section 12), especially with regard to the use of portable gauges at client facilities.
- (i) Where appropriate, performance of on-site inspections at client facilities where portable gauges are being used.

2.16. Paragraph 2.38 of GSR Part 3 [9] states that: “The regulatory body shall establish, implement, assess and strive to continually improve a management system that is aligned with the goals of the regulatory body and that contributes to the achievement of those goals.”

2.17. Requirement 19 of GSR Part 3 [9] states:

“The government or the regulatory body shall establish and enforce requirements to ensure that protection and safety is optimized, and the regulatory body shall enforce compliance with dose limits for occupational exposure.”

The regulatory body should verify that appropriate measures are implemented by the operating organization so that dose limits for occupational exposure and for public exposure are not exceeded. The design requirements for nuclear gauges are stringent and, in general, the radiation levels around nuclear gauges are low. Therefore, while compliance with the dose limits is an important requirement, the main emphasis should be on ensuring that protection and safety is optimized.

2.18. Paragraph 3.69 of GSR Part 3 [9] states that: “The government or the regulatory body shall establish the responsibilities of employers, registrants and licensees with regard to application of the requirements for occupational exposure in planned exposure situations.”

2.19. In accordance with para. 3.72 of GSR Part 3 [9], before authorization of a new or modified practice involving a nuclear gauge, the regulatory body should review the design criteria and design features relating to the exposure and potential exposure of workers in all operational states, and in accident conditions. Only nuclear gauges that meet the design standards stipulated by the regulatory body should be permitted to be used. Because of the stringent design standards applicable to nuclear gauges, individual monitoring is expected to be limited to certain types of worker and certain types of gauge (see Section 6). However, in all cases, the regulatory body should verify that the operating organization complies with workplace monitoring requirements (see paras 3.96–3.98 of GSR Part 3 [9]) in all facilities and activities involving nuclear gauges.

2.20. The regulatory body should require that arrangements be made for the safety and security of radioactive sources, including financial provisions, where appropriate, for sources that have become disused. Specifically, the regulatory body should attach conditions to authorizations that require the operating organization to make arrangements for the safe and secure management of disused

sources, including, where applicable, agreements regarding the return of disused sources to the supplier, in accordance with the Code of Conduct on the Safety and Security of Radioactive Sources [14].

2.21. The regulatory body should require the operating organization to conduct periodic inventory checks of the radioactive sources in nuclear gauges, and to provide information, as appropriate, to the regulatory body for inclusion in a national register of radioactive sources [14].

2.22. There are certain activities relating to the use of nuclear gauges — such as installation of gauges, removal of gauges from service, and maintenance and repair of gauges — that involve or potentially affect components relating to the safety of the gauge (e.g. the source, source holder, source drive mechanism, shutter, shutter control or shielding). Such activities require specialized training and equipment in order to be performed safely; therefore, these activities are often performed by the gauge manufacturer, source supplier or other service provider. The regulatory body should establish requirements concerning the performance of such activities, which may include requirements for a specific authorization to perform these activities.

THE OPERATING ORGANIZATION

2.23. With regard to nuclear gauges, the operating organization is typically the owner of the industrial facility in which fixed nuclear gauges are installed, or the company undertaking activities with portable nuclear gauges. The operating organization has the prime responsibility for protection and safety (see Requirements 4 and 9 of GSR Part 3 [9]) and is required to ensure that protection and safety is optimized (Requirement 11 of GSR Part 3 [9]). The manufacturers and suppliers of nuclear gauges that contain radiation sources are also operating organizations with their own responsibilities for protection and safety.

2.24. The operating organization is required to demonstrate commitment to protection and safety at the highest levels (para. 2.47 of GSR Part 3 [9]).

2.25. The operating organization is required to submit an application to the regulatory body for authorization to operate a facility or conduct an activity involving nuclear gauges (Requirement 7 of GSR Part 3 [9]). Consequently, for an authorized facility, the operating organization is normally also the licensee or registrant as defined in GSR Part 3 [9].

2.26. As stated in para. 2.42 of GSR Part 3 [9], the operating organization:

“shall establish and implement a protection and safety programme that is appropriate for the exposure situation. The protection and safety programme:

- (a) Shall adopt objectives for protection and safety in accordance with the requirements of [GSR Part 3];
- (b) Shall apply measures for protection and safety that are commensurate with the radiation risks associated with the exposure situation and that are adequate to ensure compliance with the requirements of [GSR Part 3].”

2.27. As stated in para. 2.43 of GSR Part 3 [9], the operating organization:

“shall ensure that, in the implementation of the protection and safety programme:

- (a) The measures and resources that are necessary for achieving the objectives for protection and safety have been determined and are duly provided;
- (b) The programme is periodically reviewed to assess its effectiveness and its continued fitness for purpose;
- (c) Any failures or shortcomings in protection and safety are identified and corrected, and steps are taken to prevent their recurrence;
- (d) Arrangements are made to consult with interested parties;
- (e) Appropriate records are maintained.”

Recommendations on establishing a radiation protection programme for nuclear gauges are given in Section 4 of this Safety Guide.

2.28. Paragraph 2.44 of GSR Part 3 [9] states:

“The relevant principal parties and other parties having specified responsibilities in relation to protection and safety shall ensure that all personnel engaged in activities relevant to protection and safety have appropriate education, training and qualification so that they understand their responsibilities and can perform their duties competently, with appropriate judgement and in accordance with procedures.”

Recommendations on the training and qualification of persons working with nuclear gauges are given in Section 5 of this Safety Guide.

2.29. The operating organization is required to allow access by authorized representatives of the regulatory body to conduct inspections of its facilities and activities and of its protection and safety records, and is required to cooperate in the conduct of inspections (para. 2.45 of GSR Part 3 [9]).

2.30. The operating organization is required to ensure that qualified experts (see paras 2.41–2.45) are identified and consulted as necessary on the proper observance of the requirements established in GSR Part 3 (para. 2.46 of GSR Part 3 [9]).

2.31. The operating organization is required to ensure that protection and safety is effectively integrated into its overall management system (Requirement 5 of GSR Part 3 [9]). The management system is required to be commensurate with the radiation risks associated with the number and type of nuclear gauges in the possession of the operating organization (para. 2.49 of GSR Part 3 [9]).

2.32. As stated in para. 2.48 of GSR Part 3 [9], the operating organization (footnote omitted):

“shall ensure that the management system is designed and applied to enhance protection and safety by:

- (a) Applying the requirements for protection and safety coherently with other requirements, including requirements for operational performance, and coherently with guidelines for security;
- (b) Describing the planned and systematic actions necessary to provide adequate confidence that the requirements for protection and safety are fulfilled;
- (c) Ensuring that protection and safety are not compromised by other requirements;
- (d) Providing for the regular assessment of performance for protection and safety, and the application of lessons learned from experience;
- (e) Promoting safety culture.”

2.33. As stated in para. 2.50 of GSR Part 3 [9], the operating organization “shall be able to demonstrate the effective fulfilment of the requirements for protection and safety in the management system.”

2.34. As stated in para. 3.60 of GSR Part 3 [9], the operating organization “shall ensure that arrangements are made promptly for the safe management of and control over radiation generators and radioactive sources, including appropriate financial provision, once it has been decided to take them out of use.” Recommendations on

meeting the requirements relating to radiation generators and radioactive sources in nuclear gauges are provided in Section 10 of this Safety Guide.

Safety culture

2.35. Because of the engineered safety features incorporated into the design of nuclear gauges, there is a relatively low reliance on the observance of safe working procedures. Therefore, there is a risk that safety might be taken for granted and that safety culture might not be assigned its due importance in facilities using nuclear gauges. In accordance with para. 2.51 of GSR Part 3 [9], the operating organization should promote and maintain safety culture by doing the following:

- (a) Promoting individual and collective commitment to protection and safety at all levels of the organization, including staff responsible for administration, security and storage facilities, as well as workers involved in the operation and maintenance of nuclear gauges.
- (b) Ensuring a common understanding of the key aspects of safety culture within the organization.
- (c) Supporting individuals and teams in performing their tasks safely and successfully, with account taken of the interactions between individuals, the nuclear gauge technology and the organization. For example, if maintenance work is to be performed in the vicinity of a gauge installation, coordination among the maintenance staff, gauge operating staff and the radiation protection officer is necessary.
- (d) Encouraging open communication and participation of gauge operating staff, the radiation protection officer(s) and other workers in the facility in the development and implementation of policies and procedures dealing with protection and safety relating to nuclear gauges.
- (e) Ensuring accountability of the organization and of individuals at all levels for protection and safety in the procurement, storage, installation, operation, maintenance, handling and safe management of sources until their safe disposal after the end of their useful life.
- (f) Encouraging a questioning and learning attitude, discouraging complacency with regard to protection and safety and providing means by which the organization continually seeks to develop and strengthen its safety culture.

2.36. The operating organization should also ensure that personnel feel free to raise safety concerns without fear of retaliation, intimidation, harassment or discrimination.

Human factors

2.37. Paragraph 2.52 of GSR Part 3 [9] states:

“The principal parties and other parties having specified responsibilities in relation to protection and safety, as appropriate, shall take into account human factors and shall support good performance and good practices to prevent human and organizational failures, by ensuring among other things that:

- (a) Sound ergonomic principles are followed in the design of equipment and the development of operating procedures, so as to facilitate the safe operation and use of equipment, to minimize the possibility that operator errors could lead to accidents, and to reduce the possibility that indications of normal conditions and abnormal conditions could be misinterpreted.
- (b) Appropriate equipment, safety systems and procedural requirements are provided, and other necessary provision is made:
 - (i) To reduce, as far as practicable, the possibility that human errors or inadvertent actions could give rise to accidents or to other incidents leading to the exposure of any person;
 - (ii) To provide means for detecting human errors and for correcting them or compensating for them;
 - (iii) To facilitate protective actions and corrective actions in the event of failures of safety systems or failures of measures for protection and safety.”

RADIATION PROTECTION OFFICERS

2.38. Paragraph 3.94(e) of GSR Part 3 [9] states:

“Employers, registrants and licensees, in consultation with workers or through their representatives where appropriate....Shall designate, as appropriate, a radiation protection officer in accordance with criteria established by the regulatory body.”

It should be ensured that any person designated as a radiation protection officer is suitably qualified and trained (see Section 5).

2.39. Paragraph 3.96 of GSR Part 3 [9] states:

“Registrants and licensees, in cooperation with employers where appropriate, shall establish, maintain and keep under review a programme for workplace monitoring under the supervision of a radiation protection officer or qualified expert.”

2.40. The radiation protection officer should be a person technically competent in radiation protection in relation to the use of nuclear gauges, and who is designated by the operating organization to oversee the application of relevant requirements. The appointment of the radiation protection officer should be done in writing and the radiation protection officer’s roles and responsibilities should be integrated into the job description.

QUALIFIED EXPERTS

2.41. As stated in para. 2.46 of GSR Part 3 [9], the operating organization “shall ensure that qualified experts are identified and are consulted as necessary on the proper observance of [GSR Part 3].” A qualified expert is 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, for example in radiation protection and the safe operation of nuclear gauges [8].

2.42. The government is required to establish requirements for the formal recognition of qualified experts (para. 2.21 of GSR Part 3 [9]). ‘Formal recognition’ means documented acknowledgment or accreditation by the relevant authority that a person has the qualifications, training, education, experience and expertise required for the responsibilities that he or she will bear in relation to the use of nuclear gauges [9]. The procedure for formal recognition of qualified experts may vary from State to State.

2.43. The operating organization may consult with one or more qualified experts on matters relevant to radiation safety, such as the design of nuclear gauges and associated facilities, radiation shielding calculations, and testing and maintenance of workplace monitoring instruments. The responsibility for compliance with regulatory requirements cannot be delegated to the qualified expert and always remains with the operating organization.

2.44. Qualified experts do not necessarily have to be employees of the operating organization; they may be appointed on a part time basis or for a specific period or purpose. The qualified expert should satisfy all the requirements for qualification or certification criteria specified by the State where the nuclear gauge is being used and have suitable experience (i.e. with facilities and activities involving nuclear gauges).

2.45. The qualified expert should work in close cooperation with the radiation protection officer to ensure that all the necessary duties and tasks are performed.

WORKERS

2.46. A worker is 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 [8].

2.47. Workers are required to fulfil their obligations and perform their duties for protection and safety (Requirement 22 of GSR Part 3 [9]). In particular, para. 3.83 of GSR Part 3 [9] states:

“Workers:

- (a) Shall follow any applicable rules and procedures for protection and safety as specified by the employer, registrant or licensee;
- (b) Shall use properly the monitoring equipment and personal protective equipment provided;
- (c) Shall cooperate with the employer, registrant or licensee with regard to protection and safety, and programmes for workers’ health surveillance and programmes for dose assessment;
- (d) Shall provide to the employer, registrant or licensee such information on their past and present work that is relevant for ensuring effective and comprehensive protection and safety for themselves and others;
- (e) Shall abstain from any wilful action that could put themselves or others in situations that would not be in accordance with the requirements of [GSR Part 3];
- (f) Shall accept such information, instruction and training in protection and safety as will enable them to conduct their work in accordance with the requirements of [GSR Part 3].”

2.48. Paragraph 3.84 of GSR Part 3 [9] states that: “A worker who identifies circumstances that could adversely affect protection and safety shall report such circumstances to the employer, registrant or licensee as soon as possible.” Employers should not take adverse or punitive actions against a worker who reports such circumstances.

COOPERATION BETWEEN EMPLOYERS AND REGISTRANTS AND LICENSEES

2.49. Requirement 23 of GSR Part 3 [9] states that: “Employers and registrants and licensees shall cooperate to the extent necessary for compliance by all responsible parties with the requirements for protection and safety.” An example of such cooperation is that which is expected to occur between the operating organization using a portable gauge and the client (i.e. the owner of the site on which the gauge is used; see paras 2.56–2.61).

2.50. Paragraph 3.85 of GSR Part 3 [9] states:

“If workers are engaged in work that involves or that 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 cooperate to the extent necessary for compliance by both parties with the requirements of [GSR Part 3].”

This requirement would apply, for example, in the case of contractors undertaking work close to (but not directly involving) installed nuclear gauges. It would also apply to the use of portable nuclear gauges on sites where there are already other sources of radiation present.

2.51. Paragraph 3.86 of GSR Part 3 [9] states:

“Cooperation between the employer and the registrant or licensee shall include, where appropriate:

- (a) The development and use of specific restrictions on exposure and other means of ensuring that the measures for protection and safety for workers who are engaged in work that involves or could involve a source that is not under the control of their employer are at least as good as those for employees of the registrant or licensee;

- (b) Specific assessments of the doses received by workers as specified in (a) above;
- (c) A clear allocation and documentation of the responsibilities of the employer and those of the registrant or licensee for protection and safety.”

2.52. Paragraph 3.87 of GSR Part 3 [9] states:

“As part of the cooperation between parties, the registrant or licensee responsible for the source or for the exposure as appropriate:

- (a) Shall obtain from the employers, including self-employed persons, the previous occupational exposure history of workers...and any other necessary information;
- (b) Shall provide appropriate information to the employer, including any available information relevant for compliance with the requirements of [GSR Part 3] that the employer requests;
- (c) Shall provide both the worker and the employer with the relevant exposure records.”

WORKERS ON SHORT TERM CONTRACTS (ITINERANT WORKERS)

2.53. Operating organizations that hire workers on a short term basis (e.g. using density gauges in connection with construction of roads, bridges) should ensure that such workers have the same level of protection and safety as workers employed on a permanent basis. Such short term workers (sometimes called itinerant workers) typically work for a relatively short period of time (e.g. a few weeks) with the operating organization before leaving to work for another employer. It should be ensured that such working practices are in compliance with regulatory requirements.

2.54. The relevant responsibilities of the operating organization and the itinerant worker should be clearly specified in the contractual arrangements. The operating organization should request information on any occupational exposure received by the itinerant worker, as well as details of any health surveillance up to the time the worker commences work.

2.55. The operating organization and the itinerant worker should fulfil their respective responsibilities, as specified in regulations. The operating organization