

# IAEA Safety Standards

for protecting people and the environment

## Regulatory Control of Radioactive Discharges to the Environment

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United Nations  
Environment Programme

## General Safety Guide

### No. GSG-9



**IAEA**

International Atomic Energy Agency

# IAEA SAFETY STANDARDS AND 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. 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

<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](mailto:Official.Mail@iaea.org).

## RELATED PUBLICATIONS

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.

REGULATORY CONTROL  
OF RADIOACTIVE DISCHARGES  
TO THE ENVIRONMENT

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. GSG-9

REGULATORY CONTROL  
OF RADIOACTIVE DISCHARGES  
TO THE ENVIRONMENT

GENERAL SAFETY GUIDE

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INTERNATIONAL ATOMIC ENERGY AGENCY  
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INTERNATIONAL ATOMIC ENERGY AGENCY  
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## **FOREWORD**

**by Yukiya Amano**  
**Director General**

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.



## 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 the IAEA Safety Requirements for Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards (IAEA Safety Standards Series No. GSR Part 3). GSR Part 3 is jointly sponsored by the European Commission, the Food and Agriculture Organization of the United Nations, the IAEA, the International Labour Organization, the OECD Nuclear Energy Agency, the Pan American Health Organization, the United Nations Environment Programme and the World Health Organization.

Three related Safety Guides were prepared to provide generic guidance on meeting the requirements of GSR Part 3 for protection of the public and protection of the environment, as follows:

- IAEA Safety Standards Series No. GSG-8, Radiation Protection of the Public and the Environment, which provides guidance on the framework for protection of the public and the environment;
- IAEA Safety Standards Series No. GSG-9, Regulatory Control of Radioactive Discharges to the Environment, which provides guidance on application of the principles of radiation protection and the safety objectives associated with the control of discharges and on the process for authorization of discharges;
- IAEA Safety Standards Series No. GSG-10, Prospective Radiological Environmental Impact Assessment for Facilities and Activities, which describes a framework and methodologies for prospective radiological environmental impact assessment.

These three Safety Guides are jointly sponsored by the IAEA and UN Environment, the leading global environmental authority, which sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system, and serves as an authoritative advocate for the global environment. The recommendations provided in these three Safety Guides, together with the requirements of GSR Part 3, provide a basis for including environmental considerations in the assessment and management of radioactive releases. In this context, UN Environment encourages the application of these recommendations in all its Member States, and their use as a foundation for the development of national regulations on protection of the environment from harmful effects of ionizing radiation.



# 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 measures<sup>1</sup> 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.

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<sup>1</sup> See also publications issued in the IAEA Nuclear Security Series.

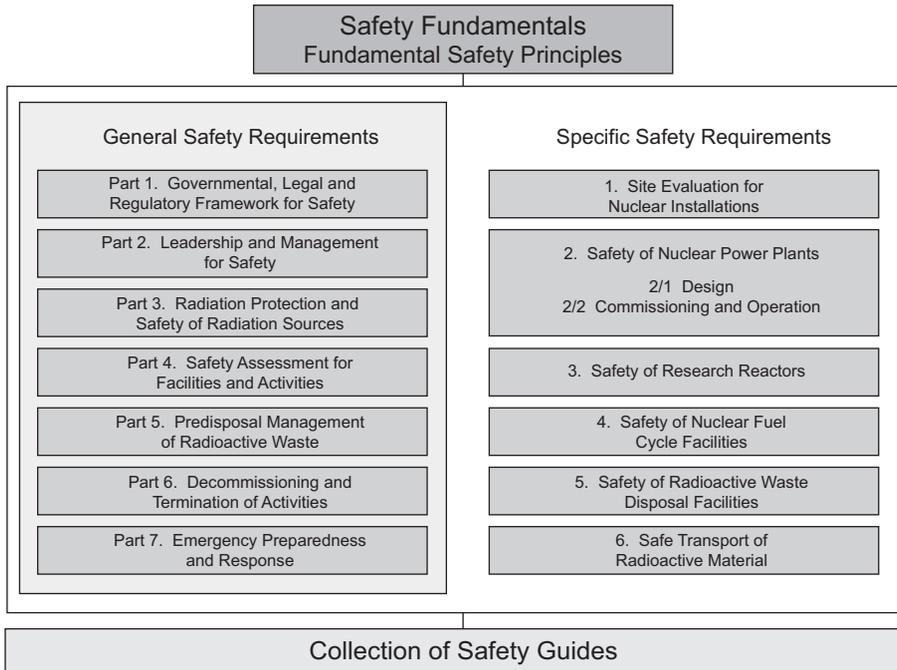


FIG. 1. The long term structure of the IAEA Safety Standards Series.

## Safety Guides

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

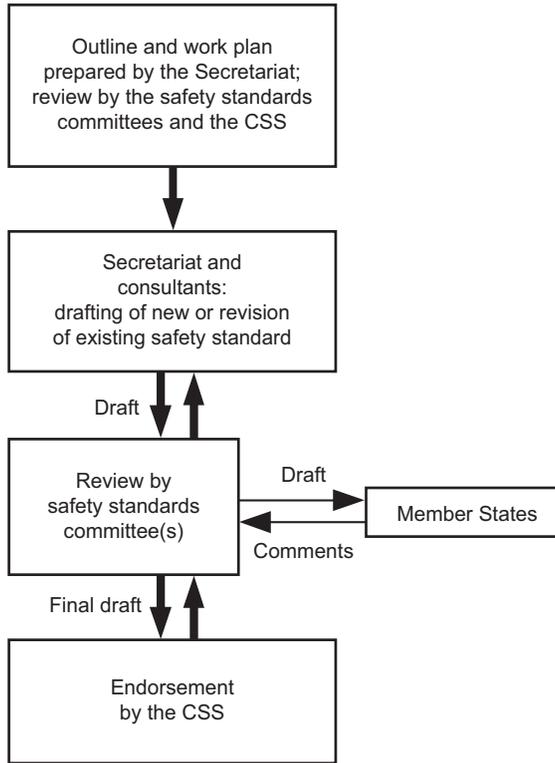


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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. 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. Facilities and activities<sup>1</sup> that give rise to radiation risks are required to be designed, built, authorized, operated and maintained so as to prevent radioactive releases to the environment or to minimize the consequences of such releases and to provide adequate levels of protection of the public and the environment [3].

1.2. Some facilities and activities, during normal operation, generate gaseous and liquid effluents that contain small amounts of radionuclides that may expose the public and the environment to low levels of radiation. In many cases, the complete prevention of the release of such effluents is technically difficult or extremely costly to achieve. In all cases, the resulting doses to any member of the public must be below established limits.

1.3. In accordance with the requirements for optimization of radiation protection, it can be concluded that, if releases are controlled such that “the magnitude of individual doses, the number of individuals (workers and members of the public) subject to exposure and the likelihood of exposure [are] ‘as low as reasonably achievable, economic and social factors being taken into account’ (ALARA)” [3], then such releases may be acceptable in terms of protection and safety, considering the very low radiological significance of the releases and the possibly high costs that may be associated with reducing them further.

1.4. Facilities and activities that generate controllable radioactive releases are regulated in different ways through a graded approach. In many cases, the regulation of facilities and activities generating radioactive releases during normal operation that result in very low doses to the public and for which there is no risk of an unexpected accidental release can be managed through the application of the concept of exemption or by means of notification [3]. However, some releases may result in doses with a higher level of radiological significance or the facility or activity may present potentially higher radiation risks. In such cases, it may be appropriate for the regulation of the releases from such facilities or activities to

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<sup>1</sup> The term ‘facilities and activities’ is defined in IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1], and the IAEA Safety Glossary [2]. It is a general term encompassing all nuclear facilities and uses of all sources of ionizing radiation. The recommendations of this Safety Guide apply to certain facilities and activities, as described in para. 1.13.

be managed by means of an authorization (registration or licensing, as relevant) that establishes stringent technical and regulatory conditions, including for the adequate management and control of these effluents and their radiological consequences. For a practice that is justified, the decision to authorize such releases should take into account the radiation protection principles of optimization and dose limitation, and other relevant safety principles.

1.5. Dose limits and dose constraints are established for the doses received by the public due to the authorized releases of effluents [3]. In accordance with IAEA Safety Standards Series No. SF-1, Fundamental Safety Principles [1], and the requirements established in IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [3], effluents are required to be properly managed by the licensee in order to ensure the optimized protection of the public and the environment.

1.6. A ‘discharge’ is a planned and controlled release of gaseous, aerosol or liquid radioactive substances to the environment and, as such, the term does not include releases to the environment in an accident. Strictly, the term ‘discharge’ refers to the act or process of releasing material to the environment, but it is also used in this Safety Guide to describe the material being released or to be released [2].

1.7. This Safety Guide provides recommendations on the application of the safety requirements established in GSR Part 3 [3] to the regulatory control of discharges and takes account of the recommendations provided in a number of relevant Safety Guides [4–10] and the experience of Member States. This Safety Guide supersedes IAEA Safety Standards Series No. WS-G-2.3, Regulatory Control of Radioactive Discharges to the Environment<sup>2</sup>.

## OBJECTIVE

1.8. The objective of this Safety Guide is to provide governments, regulatory bodies, applicants and operating organizations with a structured approach to controlling radiation exposures of the public resulting from discharges from normal operations of facilities and activities, and for the optimization of

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<sup>2</sup> INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. WS-G-2.3, IAEA, Vienna (2000).

protection and safety. Guidance is provided on authorizations for discharges, demonstrating compliance with the authorization and enforcing the authorization.

1.9. This Safety Guide is for use by those applying for an authorization for discharges to the environment and by those reviewing applications and authorizing discharges as part of an authorization process [3]. It may also be relevant for other interested parties.

## SCOPE

1.10. The scope of this Safety Guide is limited to discharges to the atmosphere of airborne effluents and to surface aquatic media of liquid effluents from facilities and activities during normal operation in planned exposure situations [3]. The disposal of solid radioactive waste, releases of radioactive substances in the post-closure period of a waste disposal facility, the migration of liquids containing radionuclides into underground water and releases to the environment due to accidents are not addressed in this Safety Guide; relevant guidance is provided in other Safety Guides [11–14].

1.11. This Safety Guide provides guidance on the regulatory control of discharges in connection with an authorization process.<sup>3</sup> More specifically, this Safety Guide addresses authorizations for discharges from new and modified facilities and activities, and the review of established authorizations for discharges.

1.12. This Safety Guide addresses the derivation of operational limits and conditions for discharges, the demonstration of compliance with the authorization and the need for a radiation monitoring programme. An important initial input into the process of controlling discharges is the prospective assessment of the protection of the public and the environment from harmful effects of ionizing radiation. A separate Safety Guide provides recommendations on such prospective radiological impact assessments for protection of both the public and the environment [7]. Only limited reference is made in this Safety Guide to the

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<sup>3</sup> Requirements for the authorization process for facilities and activities, as it relates to the system of protection and safety, are established in GSR Part 3 [3].

methodology used in dose assessments and the models and data that may be used in the derivation of authorized limits, such as those described in Ref. [15].<sup>4</sup>

1.13. This Safety Guide applies to different types of facilities and activities that discharge liquid and gaseous effluents containing radionuclides that may give rise to radiation risks to the public. Such facilities and activities range from nuclear installations<sup>5</sup> to applications of radioisotopes in industry, medicine and research. This Safety Guide also covers the controllable releases during normal operation to the atmosphere and to surface waters that may result from the mining and processing of ores for the extraction of uranium or thorium as part of the nuclear fuel cycle. Consideration is also given to discharges of naturally occurring radioactive material<sup>6</sup> in non-nuclear industries.

1.14. This Safety Guide focuses on setting discharge limits for the protection of the public; the radiation protection of workers is considered only as part of the optimization of protection and safety, especially in connection with the on-site management of radioactive waste and effluents. Recommendations on the assessment and control of occupational exposures are provided in IAEA Safety Standards Series No. GSG-7, Occupational Radiation Protection [16].

## STRUCTURE

1.15. Section 2 sets out the principles of radiation protection applicable to the control of discharges. Section 3 presents the safety objectives, requirements and concepts relevant to the control of discharges, including the general responsibilities of the government, the regulatory body, the operating organization and other relevant parties. Section 4 provides guidance on the decision making process for establishing the need for an authorization for discharges. Section 5 provides

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<sup>4</sup> A revision of Safety Reports Series No. 19 [15] is in preparation and will cover screening assessments of public exposure, generic models and parameters for use in assessing the impact of radioactive discharges, and generic models and parameters for assessing exposures of flora and fauna due to radioactive discharges from facilities and activities.

<sup>5</sup> The term ‘nuclear installation’ includes nuclear power plants, research reactors (including subcritical and critical assemblies) and any adjoining radioisotope production facilities, spent fuel storage facilities, facilities for the enrichment of uranium, nuclear fuel fabrication facilities, conversion facilities, facilities for the reprocessing of spent fuel, facilities for the predisposal management of radioactive waste arising from nuclear fuel cycle facilities, and nuclear fuel cycle related research and development facilities [2].

<sup>6</sup> ‘Naturally occurring radioactive material’ is radioactive material containing no significant amounts of radionuclides other than naturally occurring radionuclides [2].

recommendations on the process for authorization for discharges, including the development of an authorization for discharges and the setting of discharge limits, the establishment and use of dose constraints, the characterization of discharges and the exposure scenarios used in specifying discharge limits, the consideration of optimization of protection and safety, the assessment of doses to the public, the operational limits and conditions associated with the authorization, the demonstration of compliance, inspection and enforcement, and the involvement of interested parties. Section 6 covers discharges of naturally occurring radionuclides. In Section 7, the aspects relating to the control of discharges during decommissioning are presented. Finally, Section 8 provides recommendations on the regulation of discharges from previously unregulated practices. The Annex provides practical considerations that can be taken into account when setting authorizations for discharges.

## **2. THE PRINCIPLES OF RADIATION PROTECTION FOR CONTROL OF DISCHARGES**

2.1. The radiation protection and safety principles established in the IAEA safety standards (see Refs [1, 3]), on the basis of the recommendations of the International Commission on Radiological Protection [17], relevant for the control of radioactive discharges to the environment from a facility or activity in planned exposure situations are the principles of justification, optimization and dose limitation.

### **JUSTIFICATION OF FACILITIES AND ACTIVITIES**

2.2. For a facility or activity to be authorized, it is required to be demonstrated that the introduction of that practice will produce a positive net benefit (i.e. the expected benefits to individuals and to society from the practice outweigh the harm, including radiation detriment) [3]. Decisions regarding justification should be taken at a sufficiently high governmental level to enable all the considerations that may be related to the benefits and detriments to be taken into account [6]. Any decision on justification should always involve consideration of the radiation doses expected either to be incurred or to be averted or reduced, according to the circumstances. The radiation dose to the public is only one of the factors involved in the justification process. Many other factors, well beyond radiation

protection considerations, will need to be considered in determining whether a practice is justified.

2.3. Justification applies to the overall practice and not to individual aspects of the practice, such as discharges, which can be authorized or exempted from the requirement for an authorization only if the practice as a whole is already regarded as justified.

## OPTIMIZATION OF PROTECTION

2.4. The principle of optimization of protection and safety should be applied when setting discharge limits. Optimization of protection and safety is defined in GSR Part 3 [3] as:

“The process of determining what level of protection and safety would result in the magnitude of individual doses, the number of individuals (workers and members of the public) subject to exposure and the likelihood of exposure being ‘as low as reasonably achievable, economic and social factors being taken into account’ (ALARA).”

2.5. The protection and safety measures should provide the highest level of safety that can reasonably be achieved throughout the lifetime of the facility or activity without unduly limiting the operation of the facility or activity. The optimization of protection and safety involves the balancing of all costs, not just financial costs, associated with achieving a particular level of protection and safety, against the benefit in terms of reduction in dose. Further guidance on the optimization process relating to the control of discharges is provided in Section 5, and additional information is provided in the Annex to this Safety Guide.

## APPLICATION OF DOSE LIMITS

2.6. For planned exposure situations, exposures and risks are subject to control to ensure that the specified dose limits are not exceeded and that optimization is applied to attain the desired level of protection and safety [3].

2.7. The dose limits that are relevant for members of the public in connection with discharges during normal operation are [3]:

- (a) An effective dose of 1 mSv in a year;
- (b) In special circumstances<sup>7</sup>, a higher value of effective dose in a single year could apply, provided that the average effective dose over five consecutive years does not exceed 1 mSv per year.

These dose limits represent the maximum acceptable dose to any member of the public from all authorized radiation sources to which he or she is exposed in planned exposure situations.<sup>8</sup> The use of dose limits to set discharge limits for a specific source is described in Section 5 and the Annex.

### **3. SAFETY OBJECTIVES AND REQUIREMENTS RELEVANT TO THE CONTROL OF RADIOACTIVE DISCHARGES**

#### GENERAL

3.1. SF-1 [1] establishes principles to be applied to achieve the fundamental safety objective of protecting the public and the environment, now and in the future, from harmful effects of ionizing radiation. This safety objective has to be achieved without unduly limiting the operation of facilities and the conduct of activities that give rise to radiation risks.

3.2. The requirements for a governmental, legal and regulatory framework for safety are established in IAEA Safety Standards Series No. GSR Part 1 (Rev. 1), Governmental, Legal and Regulatory Framework for Safety [18].

3.3. GSR Part 3 [3] describes the concepts and establishes requirements for the protection of people and the environment from harmful effects of ionizing radiation and for the safety of radiation sources. GSR Part 3 also establishes requirements relevant to the various interested parties (e.g. the government, the regulatory body, the operating organization) for the control of discharges.

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<sup>7</sup> For example, in authorized, justified and planned operating conditions that lead to transitory increases in exposures.

<sup>8</sup> GSR Part 3 [3] also establishes dose limits for the public for the equivalent dose to the lens of the eye and to the skin. Because of the conditions in which such exposures would typically occur, these dose limits are not relevant for discharges to the environment during normal operation.

3.4. Paragraph 1.6 of GSR Part 3 [3] specifies that the system of protection and safety aims to “assess, manage and control exposure to radiation so that radiation risks, including risks of health effects and risks to the environment, are reduced to the extent reasonably achievable.” For planned exposure situations, para. 1.17 of GSR Part 3 [3] states that “exposures and risks are subject to control to ensure that the specified dose limits...for public exposure are not exceeded, and optimization is applied to attain the desired level of protection and safety.”

3.5. Although the system of protection and safety required by the IAEA safety standards is founded primarily on considerations of the radiation protection of humans, it also aims to provide for appropriate protection of the environment from harmful effects of ionizing radiation [3].

3.6. The establishment of discharge limits for facilities and activities, as described in this Safety Guide, is primarily for optimization of the protection of members of the public (i.e. the objective of the assessment to determine discharge limits is control of the effective dose to the representative person<sup>9</sup>, with appropriate consideration given to the radiation protection of workers at the discharging facility). This approach is based on the conclusion that the environment is protected by means of the conditions under which the practice is authorized.<sup>10</sup>

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<sup>9</sup> The representative person is defined for the purposes of radiation protection as “An individual receiving a *dose* that is representative of the *doses* to the more highly exposed individuals in the population” (italic denotes a term in the IAEA Safety Glossary) [2]. The representative person will generally be a hypothetical construct and not an actual member of the population. The representative person can be considered to be the same concept as the critical group, and similar methods can be used for assessing doses to the representative person as have been used previously for assessing doses to the critical group [15].

<sup>10</sup> Some States consider that, in addition to the optimization of the protection of the public, there may be a need to assess and verify more explicitly the protection of the environment, including, for instance, estimating the impact of radiation exposure on populations of flora and fauna. IAEA Safety Standards Series No. GSG-10, Prospective Radiological Environmental Impact Assessment for Facilities and Activities [7], provides guidance on prospective radiological environmental impact assessment that includes, as an example in an annex, a methodology for assessing exposures of flora and fauna and the relevant criteria. Usually, explicit consideration of the exposure of flora and fauna will not influence the setting of discharge limits.

## JUSTIFICATION

3.7. Paragraph 2.8 of GSR Part 3 [3] states that “For planned exposure situations, each party with responsibilities for protection and safety shall ensure, when relevant requirements apply to that party, that no practice is undertaken unless it is justified.”

3.8. Requirement 10 of GSR Part 3 [3] states that “**The government or the regulatory body shall ensure that only justified practices are authorized.**”

## OPTIMIZATION OF PROTECTION AND SAFETY

3.9. Requirement 31 of GSR Part 3 [3] on radioactive waste and discharges states that “**Relevant parties shall ensure that radioactive waste and discharges of radioactive material to the environment are managed in accordance with the authorization.**”

3.10. GSR Part 3 [3] establishes a number of requirements for the management of radioactive waste, notably including in para. 3.131(a) the requirement to ensure that “radioactive waste generated is kept to the minimum practicable in terms of both activity and volume”. The need to meet these requirements on waste management will have a direct impact on the volume of the waste generated and the radionuclides and their quantities in the waste and in the effluents resulting from the normal operation of a facility or conduct of an activity.

3.11. Paragraph 3.119 of GSR Part 3 [3] specifies that “The government or the regulatory body shall establish and enforce requirements for the optimization of protection and safety for situations in which individuals are or could be subject to public exposure.” Paragraph 3.120 of GSR Part 3 [3] states that “The government or the regulatory body shall establish or approve constraints on dose and constraints on risk to be used in the optimization of protection and safety for members of the public.”

3.12. Paragraph 3.22(c) of GSR Part 3 [3] states that “The government or the regulatory body:...Shall establish or approve constraints...on dose...or shall establish or approve a process for establishing such constraints, to be used in the optimization of protection and safety.”

3.13. Requirement 11 of GSR Part 3 [3] states that “**The government or the regulatory body shall establish and enforce requirements for the**

**optimization of protection and safety, and registrants and licensees shall ensure that protection and safety is optimized.”**

3.14. Paragraph 3.126 of GSR Part 3 [3] specifies that in applying the principle of optimization of protection and safety in relation to public exposure:

“Registrants and licensees...shall take into account:

- (a) Possible changes in any conditions that could affect exposure of members of the public, such as changes in the characteristics and use of the source, changes in environmental dispersion conditions, changes in exposure pathways or changes in values of parameters used for the determination of the representative person;
- (b) Good practice in the operation of similar sources or the conduct of similar practices;
- (c) Possible buildup and accumulation in the environment of radioactive substances from discharges during the lifetime of the source;
- (d) Uncertainties in the assessment of doses, especially uncertainties in contributions to doses if the source and the representative person are separated in space or in time.”

## AUTHORIZATION

3.15. Paragraph 3.132 of GSR Part 3 [3] establishes requirements regarding discharges that underpin the recommendations provided in this Safety Guide and states that:

“Registrants and licensees, in cooperation with suppliers, in applying for an authorization for discharges, as appropriate:

- (a) Shall determine the characteristics and activity of the material to be discharged, and the possible points and methods of discharge;
- (b) Shall determine by an appropriate pre-operational study all significant exposure pathways by which discharged radionuclides could give rise to exposure of members of the public;
- (c) Shall assess the doses to the representative person due to the planned discharges;
- (d) Shall consider the radiological environmental impacts in an integrated manner with features of the system of protection and safety, as required by the regulatory body;

- (e) Shall submit to the regulatory body the findings of (a)–(d) above as an input to the establishment by the regulatory body, in accordance with para. 3.123, of authorized limits on discharges and conditions for their implementation.”

3.16. Paragraph 3.123 of GSR Part 3 [3] establishes the following requirements relating to the control of discharges:

“The regulatory body shall establish or approve operational limits and conditions relating to public exposure, including authorized limits for discharges. These operational limits and conditions:

- (a) Shall be used by registrants and licensees as the criteria for demonstration of compliance after the commencement of operation of a source;
- (b) Shall correspond to doses below the dose limits with account taken of the results of optimization of protection and safety;
- (c) Shall reflect good practice in the operation of similar facilities or activities;
- (d) Shall allow for operational flexibility;
- (e) Shall take into account the results of the prospective assessment for radiological environmental impacts that is undertaken in accordance with requirements of the regulatory body”.

## DOSE LIMITATION

3.17. Requirement 12 of GSR Part 3 [3] states that “**The government or the regulatory body shall establish dose limits for...public exposure, and registrants and licensees shall apply these limits.**” Paragraph 3.26 of GSR Part 3 [3] goes on to state that “The government or the regulatory body... shall enforce compliance with the dose limits...[for] public exposures in planned exposure situations.”

## TRANSBOUNDARY IMPACTS

3.18. Paragraph 3.124 of GSR Part 3 [3] establishes requirements for the assessment of radiological impacts and the control of discharges when a source within a practice could cause public exposure outside the territory or other area

under the jurisdiction of control of the State in which the source is located. In such situations:

“the government or the regulatory body:

- (a) Shall ensure that the assessment for radiological impacts includes those impacts outside the territory or other area under the jurisdiction or control of the State;

.....

- (c) Shall arrange with the affected State the means for the exchange of information and consultations, as appropriate.”

## PERIODIC REVIEW

3.19. Paragraph 3.134 of GSR Part 3 [3] establishes requirements for registrants and licensees (operating organizations) to:

“review and modify their discharge control measures...taking into account:

- (a) Operating experience<sup>[11]</sup>;
- (b) Any changes in exposure pathways or in the characteristics of the representative person that could affect the assessment of doses due to the discharges.”

## SOURCE MONITORING AND ENVIRONMENTAL MONITORING

3.20. Requirement 32 and para. 3.135 of GSR Part 3 [3] require the regulatory body and relevant parties to ensure that programmes for source monitoring and environmental monitoring are in place.<sup>12</sup> The programmes are required to be sufficient to verify compliance with the requirements for the control of public exposures. These requirements include “Making provision for maintaining records of discharges, results of monitoring programmes and results of assessments of

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<sup>11</sup> For example, changes in the characteristics of the source term.

<sup>12</sup> Guidance on source monitoring and environmental monitoring for use in defining the monitoring programmes relating to public exposure control is provided in IAEA Safety Standards Series No. RS-G-1.8, Environmental and Source Monitoring for Purposes of Radiation Protection [9].

public exposure” (para. 3.135(e) of GSR Part 3 [3]). Similar requirements are also placed on registrants and licensees (operating organizations), including the requirement to “Verify the adequacy of the assumptions made for the assessment of public exposure and the assessment for radiological environmental impacts” (para. 3.137(g) of GSR Part 3 [3]).

3.21. Registrants and licensees (operating organizations) are required by para. 3.137(a) of GSR Part 3 [3] to:

“Establish and implement monitoring programmes to ensure that public exposure due to sources under their responsibility is adequately assessed and that the assessment is sufficient to verify and demonstrate compliance with the authorization.”

## GRADED APPROACH

3.22. The specific requirements relating to a graded approach are established in GSR Part 1 (Rev. 1) [18], GSR Part 3 [3] and IAEA Safety Standards Series No. GSR Part 4 (Rev. 1), Safety Assessment for Facilities and Activities [19]. In relation to the control of discharges, the graded approach should be reflected in the application of Requirement 6 of GSR Part 3 [3] for planned exposure situations, that is the resources devoted to assessing and controlling discharges and the scope and stringency of the regulations are required to be commensurate with the magnitude of the radiation risk and the extent to which the exposure is amenable to control.

## **4. ESTABLISHING THE NEED FOR AN AUTHORIZATION FOR DISCHARGES**

4.1. Figure 1 illustrates a scheme for deciding whether an authorization for discharges is necessary. Radioactive discharges can be considered for authorization only if the overall practice is justified. In order to decide whether an authorization for discharges is necessary, a key factor is whether the exposures due to the discharges are excluded from regulatory control or whether the discharges can be exempted from the requirement for an authorization.

4.2. Authorization for discharges is not necessary for (a) practices that are excluded from regulatory control because they result in exposures of the public

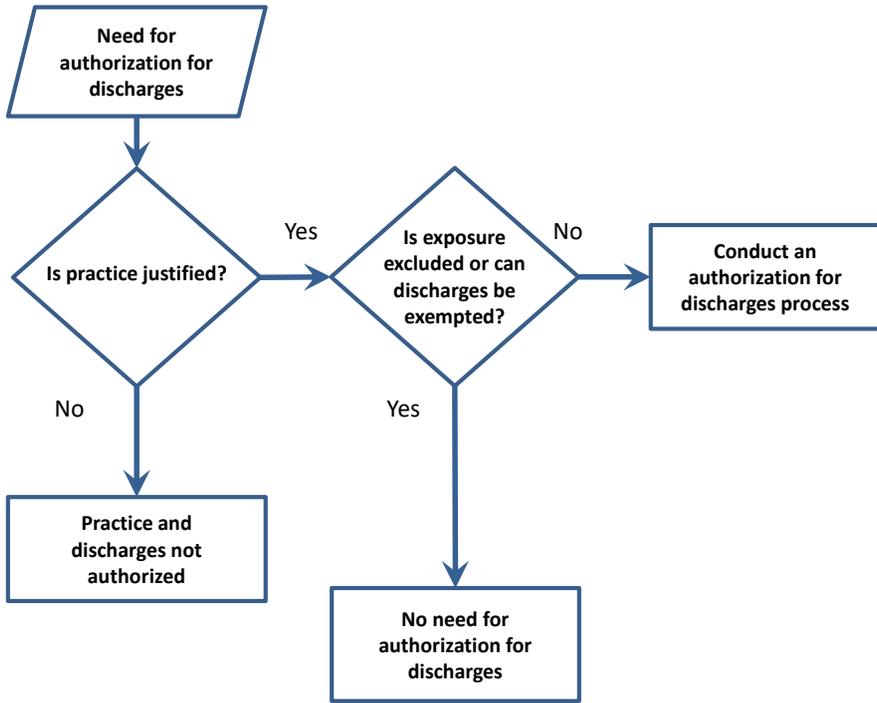


FIG. 1. Decision process to determine the need for an authorization for discharges.

that are deemed to be not amenable to control or (b) situations where the criteria for exemption are fulfilled. The regulatory body should specify when the radiation exposures due to discharges are excluded from regulatory control<sup>13</sup> or when the discharges are exempted from the requirement for an authorization, in accordance with the definitions and criteria established in schedule I of GSR Part 3 [3]<sup>14</sup>.

4.3. Exemption from the requirement for an authorization for discharges may be granted generically for certain types of practice (e.g. certain uses of short lived radionuclides in medicine for diagnosis or as radiotracers in small research

<sup>13</sup> The regulatory body should consider, on the basis of the actual characteristics of the radiological impact on the public, whether those practices that have historically been excluded from regulatory control should indeed be incorporated into the regulatory system.

<sup>14</sup> Schedule I of GSR Part 3 [3] also provides information on levels of activity and activity concentration for a large number of radionuclides to assist with determining whether moderate amounts of materials and bulk amounts of solid materials can be exempted from the requirements. However, those levels are not intended for and should not be applied to the control of discharges. Further information is provided in IAEA Safety Standards Series No. RS-G-1.7, Application of the Concepts of Exclusion, Exemption and Clearance [20].

laboratories) or on a case by case basis. If exemption is to be granted generically, the regulatory body should specify the conditions under which the exemption of discharges is warranted for the particular practice. Exemption is a decision made within the regulatory system, and the provisions for exemption may be amended by the regulatory body. In cases in which exemption is granted, no authorization for discharges is necessary and the regulatory body may decide to verify by simple checks that the conditions for granting exemption to the discharges still apply, for example from records on acquisitions of radionuclides that permit the activity released to the environment to be estimated.

4.4. In some cases, the regulatory body could decide that a practice and the associated discharges need only notification (and not authorization). Notification alone should be used only when the doses to the public expected from normal operation are low (e.g. a small fraction of the relevant dose constraint), the likelihood and magnitude of potential exposures are negligible and the regulatory body does not consider exemption to be appropriate. This can usually be determined on the basis of previous experience or by means of a preliminary qualitative assessment. Notification makes the regulatory body aware of the discharges and provides an opportunity for the regulatory body to keep the discharges under review. If notification is to be used, the regulatory body should consider developing clear criteria based on, for example, the radionuclides involved or the maximum activities that are permitted to be acquired in a given time period.

## **5. THE PROCESS FOR AUTHORIZATION FOR DISCHARGES**

5.1. ‘Authorization’ is defined in GSR Part 3 [3] as “The granting by a regulatory body or other governmental body of written permission for a person or organization...to conduct specified activities.” The control of discharges is one important aspect that should be addressed within the authorization process for a facility or activity and at different stages throughout the lifetime of the facility or activity. Authorization applies to practices for which exemption cannot be granted and notification is not sufficient.

5.2. The regulatory body should establish the authorization process for facilities and activities, including provisions for discharges, using the concept of a graded

approach, in accordance with the expected radiological impact on the public and the environment.<sup>15</sup>

5.3. An authorization can be granted by means of registration or licensing. Depending on national arrangements, the choice should depend on the level of exposure associated with the facility or activity and the likelihood and possible consequences of an accidental release of radioactive material to the environment.

5.4. Authorization by means of registration should be used for facilities and activities for which:

- (a) Safety can largely be ensured by the design of the facility and the equipment;
- (b) The operating procedures are simple to follow and operations do not vary significantly;
- (c) The need for training on safety is minimal;
- (d) Past experience has shown that there are few problems with safety in such types of operation [3].

Registrations are usually expressed in generic terms but may have specific conditions or limits attached. Registration is best suited to those practices for which the risk of exposure is very low and for which operations do not vary significantly. Examples of practices for which registration may be adequate are those in which small quantities of short lived radionuclides are used for standardized bioassays (e.g. radioimmunoassay). The regulatory body should specify the practices that may be authorized through registration.

5.5. Authorization by means of licensing should be applied in all other cases, with the stringency of the associated operational limits and conditions graded in accordance with the expected exposure of the public during normal operation and the likelihood and magnitude of potential exposures, evaluated on the basis of a prospective assessment. The regulatory body should establish the level of stringency of the operational limits and conditions attached to the authorization for discharges, taking into account (a) the likelihood and expected magnitude of exposures; (b) the characteristics of the facility or activity; and (c) a number of additional factors, such as the characteristics of the source term, the level of

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<sup>15</sup> GSG-10 [7] provides guidance on determining whether a simple or complex radiological environmental impact assessment is appropriate for a particular facility or activity; table 1 of GSG-10 [7] sets out relevant factors. The same factors could also be used in applying a graded approach to determining the necessary level of detail in the provisions for discharges to be included in the authorization for a facility or activity.

expected exposures, the safety characteristics of the activity or facility (e.g. the types of safety barriers and engineering features present in the design), and the characteristics of the location.

5.6. For simple facilities or activities, such as those with limited amounts of radionuclides with the potential to cause a significant radiological impact on the public and the environment, the authorization process should normally consist of a single stage. The regulatory body could provide generic guidance identifying the necessary elements to be included in the process to determine the discharge limits and, when possible, should provide the methodology for the necessary assessments.

5.7. For complex facilities such as nuclear installations, there may be multiple stages in the full authorization process, associated with the different stages in the lifetime of the facility, from siting and site evaluation to decommissioning and release from regulatory control. Figure 2, which is adapted from figure 1 of IAEA Safety Standards Series No. SSG-12, Licensing Process for Nuclear Installations [4], describes schematically the stages in the lifetime of a complex facility, such as a nuclear installation, and the points at which the control of discharges should be considered. The horizontal arrow indicates the evolution of time. The solid vertical arrows indicate the stages at which the control of

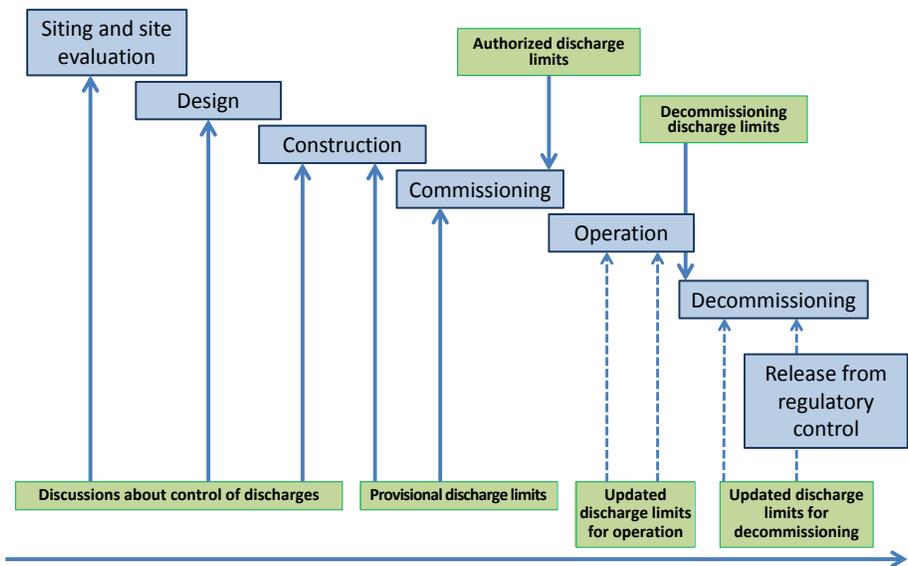


FIG. 2. Example of stages in the lifetime of a facility and the points at which the control of discharges should be considered.

discharges can be part of the preliminary discussions with the regulatory body and illustrate when, prior to operation, the discharge limits are set by the regulatory body. The dashed vertical arrows indicate when a review of the discharge limits can be considered as a result of operating experience if significant changes have occurred during the operational stage. In some cases, the regulatory body may consider a generic design proposed by a designer of the facility (e.g. the nuclear power plant vendor) to set generic provisional discharge limits prior to identification of a specific site. This would help to make a subsequent site specific authorization process more efficient, especially if the same type of facility is to be built on a number of sites.

5.8. During the siting, design and construction stages of a complex facility, the applicant should provide the regulatory body with information relevant to the optimization of protection of the public, such as information on (a) possible discharges to the atmosphere and to surface water bodies and the radiological impact of those discharges on the public and the environment; (b) the generation of waste; and (c) waste management on the site and its impact on workers. This information should be sufficient to allow the regulatory body to form an opinion about the suitability of the optimization procedure.

5.9. GSR Part 3 [3] states that, for setting discharge limits, the results of a prospective radiological environmental impact assessment conducted in accordance with the requirements of the regulatory body are required to be considered. Guidance on prospective radiological environmental impact assessments for facilities and activities that should be conducted during or prior to the siting, design and construction stages is presented in IAEA Safety Standards Series No. GSG-10, Prospective Radiological Environmental Impact Assessment for Facilities and Activities [7].

5.10. The authorization for discharges should be reviewed during the operation stage, for example as part of a periodic safety review of the facility or activity [3]. Significant changes in any condition that could affect public exposure should be taken into account during the review of an existing authorization. Such significant changes could include changes in the characteristics and operation of the facility, changes in the characteristics of the discharges, changes in the parameters that are input into the models used to calculate doses, changes in the habits or location of the population or changes in the environmental dispersion conditions.

5.11. A new or revised authorization for discharges may be required when the operational stage ends, in order to take into account the likely changes to the discharges during the decommissioning process. New discharge limits should be

established prior to the start of the decommissioning activities. In some situations, operation and decommissioning activities may overlap; due consideration should be given to this eventuality when relevant discharge limits are set.

5.12. The release of a facility from regulatory control after decommissioning depends, in part, on whether an authorization for discharges is still necessary. For some practices (e.g. uranium mining or processing), some form of control of public exposures may be necessary after decommissioning, because exposure to residual discharges to the environment may still occur. For such situations, the regulatory body should specify the control measures necessary after decommissioning to minimize public exposure and, when relevant and on a case by case basis, the necessary environmental monitoring programme.

## DEVELOPMENT OF AN AUTHORIZATION FOR DISCHARGES

5.13. The regulatory body should establish the process to be followed by an applicant seeking an authorization for discharges once the need for an authorization for discharges has been established. The steps of the authorization process may be as follows:

- (a) The regulatory body should specify the relevant dose constraint for the facility or activity under consideration (see paras 5.15–5.19 and the Annex).
- (b) The applicant should characterize the discharges and the main exposure pathways identified, in order to assess adequately the exposure of the representative person.
- (c) The applicant should present the measures to be used for the optimization of protection and safety of the public, having given consideration to measures for keeping the exposures due to discharges as low as reasonably achievable and having taken into account all relevant factors.
- (d) The applicant should assess the doses to the representative person. This may involve a number of iterations, starting with a simple, cautious generic assessment and, if necessary, a more detailed, site specific study.
- (e) The applicant should submit the results of the assessment to the regulatory body. The regulatory body should evaluate whether the models and assumptions used by the applicant are appropriate, should compare the results of the assessment with dose limits and dose constraints, and should evaluate whether the assessed doses are in accordance with the need to provide optimized protection of the public.

- (f) The regulatory body should set the discharge limits and should establish conditions by which compliance during operation is to be demonstrated, including by means of source monitoring and environmental monitoring systems and programmes.
- (g) The regulatory body should issue an authorization for discharges upon its satisfaction that the models and assumptions are valid and that the doses will not be higher than the optimized levels.

Figure 3 illustrates the process for setting discharge limits in accordance with the steps described above. The various elements in the process are described in the following subsections.

5.14. The process illustrated in Fig. 3 identifies actions of the regulatory body and actions of the applicant. In setting the discharge limits, there should be regular engagement and discussion between the applicant and the regulatory body with regard to the validity of the assumptions made to estimate doses, the optimization

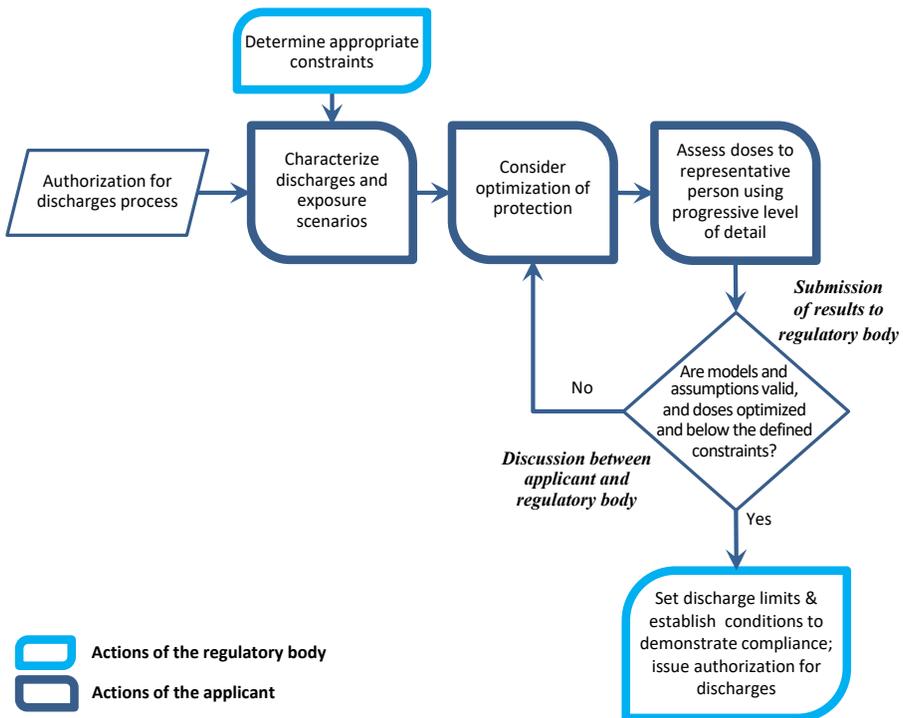


FIG. 3. Steps in setting discharge limits, indicating those responsible.

process and the implications that the discharge limits and the operational limits and conditions under discussion may have for the operation of the facility or the conduct of the activity. The safety implications of the storage of any liquid or gaseous radioactive waste that is not discharged to the environment and the associated doses to workers should also be considered. This process should be conducted in an iterative manner in order to reach an acceptable optimal solution from the point of view of safety and radiation protection.

## ESTABLISHMENT OF A DOSE CONSTRAINT FOR THE CONTROL OF DISCHARGES

5.15. The government or regulatory body is responsible for establishing or approving the source related dose constraints to be used in the optimization of the protection of the public during normal operation. The dose constraint for each particular source is intended, among other things, to ensure that the sum of doses from planned operations of that source and of all the authorized sources that may contribute to the exposure of the public remains within the dose limit. In specifying the dose constraint, the contribution to exposure due to local sources and regional sources may be considered.

5.16. The dose constraint, set for a single source, should be expressed in terms of the annual effective dose; the dose constraint should be below the limit set for the effective dose to the public in planned exposure situations from all regulated sources (i.e. 1 mSv in a year, as required by GSR Part 3 [3]) and higher than a dose of the order of 10  $\mu$ Sv in a year. Therefore, in practical terms, dose constraints should be selected within the range of 0.1 to <1 mSv in a year<sup>16</sup> [7].

5.17. Dose constraints should be used in planning measures for protection and safety as part of a prospective assessment and should not be used as alternative dose limits to be applied during facility operation. More specifically, exceeding a dose constraint should not represent a regulatory infraction, as would be the case if the dose limit were to be exceeded.

5.18. In setting a dose constraint, the government or the regulatory body should take the following into account:

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<sup>16</sup> The regulatory body may determine what additional restrictions, if considered necessary, are required to ensure that the dose limits specified in GSR Part 3 [3] for the public in planned exposure situations are not exceeded through possible combinations of doses from exposures due to different authorized practices.

- (a) The characteristics of the location that are of relevance for the level of public exposure, for example exposure pathways, habit data and time occupation factors;
- (b) The possible contribution to the dose from other authorized facilities and activities or foreseeable future facilities and activities.

5.19. Although dose constraints should be set at a value that depends on the specific facility or activity and the expected exposure conditions at its location, national authorities may choose to develop generic dose constraints for facilities or activities of a similar design or with similar characteristics (e.g. nuclear installations, uranium mining and processing, industrial and medical applications). The specification and use of generic and specific dose constraints in the process of optimization of the protection of the public is described further in the Annex.

## CHARACTERIZATION OF DISCHARGES AND EXPOSURE SCENARIOS

5.20. A pre-operational analysis should be carried out to identify the inventories of radionuclides that would result in discharges during the operation of a facility or the conduct of an activity, the possible discharge routes, the amounts that would be discharged to the environment and the radiation exposure pathways, and other relevant data that could be used to estimate doses to members of the public. This pre-operational analysis could be based on specific analysis for the practice under consideration or on experience in similar practices.

5.21. The need for a detailed characterization of the discharges should depend on the expected magnitude of the dose to members of the public, in accordance with a graded approach. For small facilities or activities using unsealed radioactive material, such as research laboratories or nuclear medicine departments in hospitals, consideration should be given to whether the discharges can be assessed on the basis of the estimated throughput, with allowance made for radioactive decay. For nuclear fuel cycle facilities, estimates of discharges should be made from consideration of the design, proposed operating characteristics and efficiency of the techniques used to reduce the discharges. Information from similar facilities or activities already in operation elsewhere could also be used [21].

5.22. The relative importance of different exposure pathways is dependent on the nature and route of the discharges and the physical and chemical characteristics of

the radionuclides. The characterization of the radiation exposure pathways should take into account whether discharges are to the air or to water, and in the case of liquid discharges, whether the discharge is to a marine, estuarine or freshwater environment. In the case of discharges to the atmosphere, consideration should be given to the meteorological data for the site and its surroundings and the possible deposition of radioactive substances on land and subsequent transfer to crops and animals. In the case of discharges to water, consideration should be given to the uses of the water, such as consumption, fisheries and production of aquatic food, irrigation, and recreation. Some facilities, such as hospitals and small research laboratories, may discharge radionuclides to sewerage systems, which could lead to exposures of individuals through their occupation (e.g. sewage treatment plant workers<sup>17</sup>) or through the use of treated sewage sludge for landfill or agricultural purposes. Guidance on the selection of exposure pathways, the use of meteorological and hydrological data and environmental transfer, and the estimation of doses can be found in GSG-10 [7].

5.23. Pre-operational studies should also be carried out to determine the existing levels of background radiation in the area surrounding the facility prior to its operation and should include a determination of the external radiation levels as well as the concentrations of radionuclides in the environment (e.g. water, soil, plants, crops, food). These studies should be used to establish a baseline above which the actual impact of the discharges can be determined. This baseline can vary from site to site because of variations in natural background radiation and possible residual contamination from past practices, accidents or global fallout after nuclear weapon tests. The establishment of a baseline is particularly important for practices that discharge naturally occurring radionuclides (see Section 6). Detailed guidance on undertaking pre-operational surveys is given in IAEA Safety Standards Series No. RS-G-1.8, Environmental and Source Monitoring for Purposes of Radiation Protection [9], and Ref. [22].

5.24. If a discharge could cause significant public exposure outside the territory or other area under the jurisdiction or control of the State in which the discharge takes place, the operating organization should make an assessment of the radiological impacts of the discharges on the public and the environment in these areas. Such an assessment is particularly important when the individuals likely to receive the highest doses could live in a neighbouring State, for example if a facility is to be constructed close to a national border or on an international waterway.

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<sup>17</sup> Such workers are subject to the same dose limits as for members of the public; see para. 3.78 of GSR Part 3 [3].

## CONSIDERATION OF OPTIMIZATION OF PROTECTION AND SAFETY

5.25. Optimization of protection and safety is the key process in establishing an authorization for discharges, and it involves a number of different aspects. In relation to a discharging facility that may cause public exposure, optimization should be part of the design and planning process and should also be kept under review throughout the lifetime of a facility. Optimization in relation to discharges forms part of the optimization of protection and safety for the practice as a whole.

5.26. Optimization of protection with respect to radioactive discharges is not simply a matter of considering the balance between the radiation risks associated with the discharges during normal operation and the costs of making any reductions. The impact of waste management decisions on the exposure of workers and on the safety of the facility as a whole should also be considered. For example, a reduction in discharges may lead to an increase in radioactive waste stored on the site, with related increases in occupational exposures; therefore, such a reduction might not be the optimal solution. Guidance on the optimization of the design of a facility or an activity with respect to the management of radioactive waste can be found in IAEA Safety Standards Series No. GSG-3, The Safety Case and Safety Assessment for the Predisposal Management of Radioactive Waste [23].

5.27. Optimization should involve examining the available options for reducing discharges and all aspects of the impact of these options. Much can be achieved at the early stages of siting and design, when account can be taken of good techniques and practices applied in other facilities and activities. In the case of liquid and gaseous radioactive waste that might be generated during operation, consideration should be given to keeping the waste to a minimum and to the subsequent treatment of the radioactive effluents.

5.28. The main types of treatment of radioactive effluents are either storage, so that, for example, short lived radionuclides present in liquid and gaseous forms can decay before they are released to the environment, or abatement techniques that remove radionuclides from the effluent stream (e.g. ion exchange resins, HEPA filters). Within these two broad categories, there may be a number of different options available; these options should be identified, and their advantages and disadvantages should be examined.

5.29. The optimization of protection and safety should be conducted in consideration of the dose constraints and the range of available protection

options. An iterative analysis should be performed of the impact on the doses to the public and to the workers of each selected protection option.

5.30. There are generally a number of trade-offs between various options, and other factors, that should be considered in the optimization process. These include the following:

- (a) A trade-off between doses from discharges and future doses associated with the disposal of solid waste, if a decision was made to solidify the residues;
- (b) A trade-off between public exposure and occupational exposure (i.e. the reduction in public exposure at the expense of an increase in occupational exposure due to an improved effluent treatment system);
- (c) Choices between options whose characteristics are known with different degrees of certainty;
- (d) Non-radiological impacts and conventional health and safety;
- (e) An increased risk of accidental releases (e.g. if a large storage tank leaks).

5.31. Irrespective of the approach used in determining the optimal option, it should be recognized that judgements regarding the relative significance of the factors involved are necessary. Making those judgements should involve dialogue between the regulatory body and the operating organization. The discussions on optimization could also involve different authorities, such as authorities responsible for nuclear safety, the protection of workers, the protection of the public and the protection of the environment.

5.32. When the projected doses to members of the public are of the order of 10  $\mu\text{Sv}$  per year or below, a process for optimization should not normally be required, on the basis that the efforts for further dose reduction would generally not fulfil the requirement for optimization.

### **Optimization of protection and regulatory control of specific radionuclides**

5.33. While the requirements for the optimization of protection and regulatory control must be applied to all types of facilities, activities and radionuclides, in carrying out the optimization of protection, particular consideration should be given to the special characteristics of certain effluents containing radionuclides used in some practices. These characteristics include the technical difficulties in managing radioactive waste from applications of radioisotopes in medicine or from the operation of certain facilities or the conduct of certain activities. Examples are the use of unsealed sources in nuclear medicine, which are administered to patients as part of medical treatment, or the management of large

volumes of gaseous or liquid effluents containing very low levels of activity concentration of certain radionuclides resulting from, for example, neutron activation in the coolant system of nuclear power plants.

5.34. For such practices, the discharge of some specific radionuclides may require special consideration by the operating organization and the regulatory body at the time of specifying and agreeing the optimal solution in terms of protection and safety. This consideration may also result in the need for an adapted approach for the regulatory control of these discharges. Examples of such radionuclides are tritium and  $^{14}\text{C}$  discharged from some nuclear installations and  $^{131}\text{I}$  used in hospitals for nuclear medicine therapy.

5.35. For these particular practices and radionuclides, the operating organization should specify, in discussion with the regulatory body, the optimal option for discharges, taking into account the following:

- (a) Technical characteristics relating to the control of discharges of these radionuclides, such as the availability of abatement techniques on a scale consistent with the needs of the particular practice (in particular for large volumes of liquid or gaseous effluents with low concentrations of radionuclides);
- (b) Economic characteristics, such as the cost of the waste abatement techniques, which might be excessive and unjustified in the framework of the general optimization of protection and safety for the type of practice;
- (c) Societal considerations, such as public acceptance of the type of practice under consideration, as well as individual and societal benefits derived from the type of facility or activity;
- (d) Environmental and efficiency considerations, such as the effects of any releases of hazardous chemical substances or high energy consumption entailed by the waste abatement techniques;
- (e) Safety considerations, such as those relating to the safe storage of large amounts of solid, liquid or gaseous radioactive material for long times, as well as the risk of accidental releases;
- (f) Issues relating to the management of radioactive waste, such as issues relating to the transport and storage of large quantities of low level waste<sup>18</sup>;

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<sup>18</sup> 'Low level waste' is waste that is above clearance levels but that has limited amounts of long lived radionuclides (see IAEA Safety Standards Series No. GSG-1, Classification of Radioactive Waste [24]).

- (g) Radiation protection considerations, such as individual doses and collective doses received by workers in connection with the abatement process and with the storage of waste.

5.36. The regulatory body and the operating organization should take into account that, for the above mentioned specific practices and radionuclides, the optimal management option from a radiation protection perspective might not result in the application of costly waste abatement techniques, but in the application of more stringent measures for the verification of compliance by the operating organization and the regulatory body, as relevant. The optimal management option and the justification of the selection of this option should be presented by the operating organization and endorsed, if acceptable, by the regulatory body. Examples of more stringent measures for verification of compliance for complex facilities, including nuclear installations, are a radionuclide specific source monitoring and environmental monitoring programme; more detailed assessment of the dose to the representative person, including the identification of relevant exposure pathways; and more frequent reporting of discharges to the regulatory body.

### **Decision aiding techniques**

5.37. Depending on the circumstances, the process of optimization of the protection of the public can include the use of a variety of quantitative and qualitative techniques. Formal decision aiding techniques should be used as appropriate in the optimization process. The advantage of formal decision aiding techniques is that they allow each of the elements involved in making a decision to be explicitly identified. If the doses to the representative person are assessed to be very low (e.g. of the order of 10  $\mu$ Sv or less in a year), a formal analysis of the optimization of protection will generally not be necessary.

5.38. Various analytical techniques have been proposed to assist in determining the optimized level of protection, and these techniques may be applied for discharges [25]. Decision aiding techniques include cost–benefit analysis and multicriteria methods. The main limitation of cost–benefit analysis is that it requires explicit valuation of all factors in monetary terms. This tends to restrict the range of factors that can be included in the optimization process. Multicriteria methods do not necessarily require such explicit valuation and are potentially more flexible decision aiding techniques because they allow additional factors to be considered. For example, equity in time and space, risk perception of the public and the potential for an accidental release are additional factors that can be

taken into account by means of multicriteria methods. The distributions over time of investments and operating costs can also be considered.

### **Best available techniques**

5.39. In optimizing the protection of the public, the measures used in the management of radioactive waste and effluents and the way those measures are applied should be considered and compared with other possible options. Concepts such as ‘best available techniques’ are applied in some States [26] and under certain international frameworks [27, 28], and in other industries for controlling pollutants generally. The use of best available techniques corresponds to optimization if the techniques are verified and their use is not simply a matter of considering what techniques are or could be available for reducing discharges, but rather considering the situation as a whole to determine the optimal level of protection, including the availability of the options and the costs involved. The application of the concept of best available techniques to particular processes, facilities or methods of operation to reduce discharges of radionuclides to the environment is described in more detail in the Annex in the framework of the optimization of protection.

### **Use of collective dose**

5.40. The estimation of collective doses to members of the public resulting from alternative options for managing discharges, and the comparison of those options, is another approach that could be included in the optimization process.

5.41. The collective dose is the total radiation dose from a source incurred by a given group of the population [3], and it can be obtained by multiplying the average dose to the exposed group by the number of individuals in the group [25, 29]. When estimating the collective dose to the public, care should be taken to avoid inappropriate aggregation of, for example, very low individual doses over extended time periods and wide geographical regions (i.e. truncating conditions should be set) [25]. Collective dose should be used only in the comparison of options, and any truncation applied to the calculations has to be consistent for the comparisons to be meaningful.

5.42. Use has been made of collective dose in different ways to assist in the selection of an optimal level of protection of the public, for instance to assign a monetary cost to the radiation detriment and to compare this with the cost of each option to reduce discharges. This Safety Guide does not provide detailed guidance on the use of collective dose; however, with adequate consideration and care,

the use of collective dose could be a practical means of applying optimization by comparing the protection outcome of different technologies. Collective dose must not be used to predict health effects [30]. International Commission on Radiological Protection Publication 101 [25] describes optimization and the use of collective dose in more detail.

## ASSESSMENT OF THE DOSE TO THE REPRESENTATIVE PERSON

5.43. The establishment of an authorization for discharges should take into account the results of an assessment of the radiological environmental impacts commensurate with the radiation risk associated with the facility or activity [3, 7]. To set the discharge limits, prospective estimates of the dose to members of the public should be used to determine acceptable optimized discharge levels that meet the established radiological criteria.

5.44. The estimate of the effective dose that may be incurred by members of the public depends on a number of factors, such as the characteristics of the source term, the behaviour of radionuclides in the environment and their transfer to people, the duration of exposure and other relevant factors. These factors cause a wide variation in the effective dose among the exposed population. For the purpose of setting discharge limits, the dose to an individual receiving a dose that is representative of the doses to the more highly exposed individuals in the population (i.e. the representative person) should be assessed. The dose to the representative person “is the equivalent of, and replaces, the mean dose in the ‘critical group’” [25].

5.45. Before starting the estimation of doses to the representative person, a judgement should be made by the applicant regarding the scope and level of detail and the resources that should be allocated to the assessment. These matters should be discussed with and subject to the agreement of the regulatory body.

5.46. The level of detail of the assessment model should depend on the type of facility under consideration, the nature of the discharges and the availability of information, and should be consistent with a graded approach. In order to make effective use of assessment resources, a structured iterative approach for assessing doses to the representative person may be useful. Such an approach should start with a simple assessment based on very cautious (conservative) assumptions and should be refined with each iteration, using progressively more complex models with more realistic assumptions and site specific data, as necessary.

5.47. Consistent with a graded approach, the use of generic assessments should be limited to assessing the impacts from small and simple facilities or activities with standardized practices that result in foreseeable low to very low discharges. GSG-10 [7] provides guidance on conducting assessments at different levels of detail and realism. Depending on its characteristics, the facility or activity can have discontinuous discharges that can lead to the exposure of members of the public within its premises (e.g. hospitals using  $^{131}\text{I}$  for diagnosis and therapy) or to the exposure of workers who are not normally subject to monitoring for occupational exposure (e.g. workers in external plants treating the effluents from the facility or activity); such situations should be considered carefully in the assessments.

5.48. To estimate doses to the representative person, a generic approach may also be used at the early stages in the lifetime of a complex nuclear installation (see Fig. 2), such as during initial discussions about the control of discharges or the setting of provisional discharge limits. This generic approach should be followed by a more site specific, realistic assessment once more information becomes available during the authorization process. GSG-10 [7] provides guidance on the level of detail and the type of information needed to conduct a prospective radiological environmental impact assessment for different facilities and activities during the process of authorization, which also applies to the assessments used to establish discharge limits.

5.49. When estimated doses to the representative person are above the dose constraint, the reduction of projected discharges or a change in their characteristics (e.g. a change in the location of the point of discharge) should be considered. Otherwise, a more detailed assessment (using site specific data or more realistic models) should be conducted. In any case, if a generic cautious assessment is used, then it should be ensured that its use does not unduly affect the optimization process. Adopting cautious assumptions in the calculations that are likely to significantly overestimate the doses could lead to decisions that do not meet the radiation protection principle of optimization.

5.50. The habits (e.g. consumption of foodstuffs, indoor or outdoor occupation factors, consumption of locally produced foods) adopted to characterize the representative person should be typical habits or characteristics of a small number of individuals representative of those more highly exposed. The highest percentiles (e.g. the 95th percentile) in the distribution of the habit data of certain exposure pathways, such as the consumption of milk and crops, should be used to characterize the representative person. However, not all extreme habits should be used to represent a single member of the population, so as to avoid

overestimation. Extreme or unusual habits should not dictate the characteristics of the representative person considered [25].

5.51. In assessing doses to the representative person from discharges to the environment, the following three main exposure pathways should be considered:

- (a) External exposure from radionuclides present in the environmental media;
- (b) Internal exposure from the inhalation of radionuclides present in air;
- (c) Internal exposure from the ingestion of radionuclides incorporated in water and foods.

External exposure may be caused by radioactive substances suspended in the air or deposited on the ground or other surfaces. For the assessment of doses resulting from internal exposure, the committed dose<sup>19</sup> should be considered. More details on the exposure pathways relevant for the assessment of doses to the representative person are provided in Refs [7, 15].

5.52. In some facilities or activities, radiation sources can contribute to the external exposure of members of the public located in the immediate vicinity, through direct gamma irradiation and, in some cases, sky scattered gamma ray radiation (sky shine). Examples are sources of radiation stored at the facility (e.g. spent fuel, radioactive waste), sources used in the facility or activity (e.g. industrial irradiators) and components of the facility (e.g. nuclear reactors, coolant systems, steam systems). When direct irradiation influences the exposure conditions of the representative person, the resulting doses should be estimated and taken into account when setting discharge limits, so that the established dose constraint is not exceeded.

5.53. Given that the initial authorization for discharges from a facility or activity is based on a prospective assessment, mathematical environmental models should be used to assess the activity concentrations in the air or water. Subsequently, environmental transfer models and parameters should be used to assess the activity concentrations in other environmental media relevant for the estimation of doses (e.g. sediments or food products). Dispersion and transfer parameters are given in Ref. [15]. The possible accumulation or buildup of long lived

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<sup>19</sup> The committed dose is the lifetime dose expected to result from an intake. Further information is provided in previous IAEA guidance: INTERNATIONAL ATOMIC ENERGY AGENCY, Principles for Limiting Releases of Radioactive Effluents into the Environment, IAEA Safety Series No. 77, IAEA, Vienna (1986).

radionuclides and the ingrowth of radioactive progeny in environmental media should be taken into account.

5.54. Models for the assessment of dispersion and transfer in the environment should be adequate for the situation in which they are being applied to ensure that the assessment methodologies are suitable for demonstrating that there is a high likelihood that all compliance requirements can be met under all reasonably foreseeable conditions. Models should be verified. Where possible, the selected models should be validated through comparison of the results with data for similar exposure scenarios or, at least, by means of benchmarking procedures against other adequate models. Different methods, including different calculation tools and input data, can be used to carry out an assessment [15]. The regulatory body should decide, in discussion with the applicant and other interested parties, which methodology is best suited to carrying out a particular assessment and should agree that the methodology adopted is adequate for its proposed purpose. GSG-10 [7] provides more information on the assessment methodologies and the characteristics of models and data to be used in the assessment of discharges during normal operation.

5.55. Different age groups should be considered when determining the exposure of the representative person. It is generally sufficient to consider the exposures of three age groups (1 year old infants, 10 year old children and adults). Exposure of the embryo or fetus and of breastfed infants may also need to be considered in some limited circumstances [25], for example when, owing to the radionuclides to be discharged, the exposure of the embryo or fetus and of breastfed infants may be more significant (e.g. discharges of radioiodine).

5.56. When identifying the representative person, it should be ensured that the groups of individuals closest to the facility or activity are not the only groups considered. Population groups at more distant locations which could be more exposed owing to their specific living habits should be considered. For example, this could be a group of individuals who live in a town at some distance from the plant but who eat fish from a catchment area close to the discharge point.

5.57. The location and lifestyle habits of the representative person should be specified with regard to present and, as far as is reasonably foreseeable, future environmental conditions, land use, spatial distribution of population, food production, distribution and consumption, and other relevant factors, with account taken of the projected lifetime of the facility or activity.

5.58. When determining the location and lifestyle habits of the representative person for remote sites with only a small local population or no local population, consideration should be given to developing a theoretical representative person on the basis of a reasonable exposure scenario that captures land use practices such as fishing, hunting or other seasonal or periodic land use practices that may be associated with a nearby community.

#### AUTHORIZATION FOR DISCHARGES AND OPERATIONAL LIMITS AND CONDITIONS

5.59. The authorization for discharges should take the form of written permission from the regulatory body. The regulatory body may grant an authorization for discharges on a justified basis or may impose additional conditions or operational limitations that it deems appropriate for the purposes of protection and safety.

5.60. The regulatory body should record formally the basis for its decision on an authorization for discharges, or on the amendment, renewal, suspension or revocation of the authorization for discharges, and should inform the applicant, in a timely manner, of its decision, including the reasons and justification.

5.61. In granting an authorization for discharges, the regulatory body should establish or approve authorized limits for discharges. These limits should take into account the results of the optimization of protection and safety and should be set in accordance with a graded approach.

5.62. Large complex facilities such as nuclear installations are subject to an extensive authorization process, which should include provisions for discharges and establish in detail the relevant operational limits and conditions. Operational limits and conditions associated with the authorization for discharges for such facilities should be expressed in terms that the operating organization can reasonably be expected to control, for example in terms of measured discharges (total activity or activity concentrations and gaseous or liquid volume discharged) rather than doses to the public, which can only be estimated. The operational limits and conditions associated with the authorization for discharges for simpler facilities, such as hospitals with small nuclear medicine departments, industrial applications or small laboratories, should be less onerous. The choice of discharge limits expressed in terms of dose versus discharge limits expressed in terms of activity amounts is described further in the Annex.

5.63. Discharge limits should be attached or incorporated into the authorization granted to the facility or activity so that they become regulatory limits with which the operating organization or licensee should comply.

5.64. The period of validity of the discharge limits should be specified in the authorization for discharges or in another related regulatory document, with a provision for their review whenever deemed appropriate by the regulatory body, but at least once every ten years. The period of validity of discharge limits for complex facilities, such as nuclear power plants, nuclear fuel reprocessing facilities and radioisotope production facilities, should be the same as the period of validity of the authorization for the facility, subject to a periodic review.

5.65. A review of the authorization for discharges should be conducted whenever modification of the facility or of the operational limits and conditions attached to the authorization is expected to affect significantly the characteristics of the discharges. Nuclear facilities and other complex installations have periodic safety reviews, typically after intervals of ten years, that should include the review of the authorization for discharges. Simpler facilities, such as facilities or activities using limited amounts of radioisotopes, should be reviewed periodically but at longer intervals. The discharge limits for a new practice for which experience is limited should be reviewed by the regulatory body after an adequate time, when sufficient operational experience has been gathered, for instance within the first three years.

5.66. The operational limits and conditions in an authorization for discharges should include, as appropriate, some or all of the following:

- (a) Restrictions relating to different operational states of the facility (e.g. separate authorized limits for maintenance and for normal operation), different seasonal conditions and different environmental dispersion conditions. For example, a restriction may be specified for facilities discharging into a river when the river is prone to flooding or when the water level is low because of very dry weather in a particular season. Similarly, in the case of discharges to a tidal marine environment, the regulatory body may specify the period of the tidal cycle at which the discharge should take place to ensure maximum dispersion.
- (b) Limits on the activities or activity concentrations of radionuclides or groups of radionuclides that can be discharged in a given time period (e.g. monthly, quarterly, annually).

- (c) Requirements for source monitoring and environmental monitoring programmes and systems and the frequency for reporting of results to the regulatory body (the regulatory body should specify the form and the required content of the reports).
- (d) Requirements for the maintenance of the appropriate records.
- (e) Requirements for the reporting to the regulatory body of proposed modifications and of any revisions to the radiological environmental impact assessment.
- (f) Actions to be taken in the event of exceeding authorized discharge limits or breaching operational limits and conditions.
- (g) Period of validity of the authorization for discharges for the facility or activity and interval for the periodic review.

5.67. The discharge limits should include a margin for flexibility to provide for operational variability and for anticipated operational occurrences. How much operational flexibility should be permitted is a matter of judgement on the part of the regulatory body, but as a minimum it should allow for discharges that are anticipated for normal operation, such as an increase in the throughput of patients in a nuclear medicine department or an increase in atmospheric discharges from a nuclear power plant during maintenance. Previous experience from similar facilities can provide useful information on the minimum allowance for flexibility that should be permitted [31]. The need for operational flexibility should be considered in setting the discharge limits as part of the optimization process.

5.68. Discharge limits should be specified for different radionuclides, or groups of radionuclides, depending on:

- (a) The feasibility of measurement of the individual radionuclides;
- (b) The significance of the radionuclides in terms of dose to the representative person;
- (c) The relevance of the measurement of the individual radionuclides as an indicator of the performance of the facility or activity.

5.69. In addition to the discharge limits for groups of radionuclides, discharge limits could be specified for particular radionuclides. These radionuclides should be identified on the basis of their special significance, for instance their radiological importance (e.g.  $^{137}\text{Cs}$ ,  $^{60}\text{Co}$ ) or other aspects, such as the involvement of large volumes of liquid or gaseous waste with very low levels of activity concentration (e.g.  $^{14}\text{C}$ , tritium; see paras 5.33–5.36). In some cases, the regulatory body may also impose limits on specific radionuclides that have low radiological significance but that provide early indications of important changes

in the operational or safety status of the facility (e.g. tritium and noble gases from purges in the coolant systems or steam systems in nuclear reactors).

5.70. Discharge limits for groups of radionuclides rather than for individual radionuclides may be appropriate when the radionuclides share relevant characteristics so that they can be measured with gross counting techniques. The use of scaling factors for relating one measured radionuclide to others should be applied for radionuclides that cannot be promptly analysed as part of routine measurements at a nuclear installation (e.g.  $^{63}\text{Ni}$ ,  $^{55}\text{Fe}$ ,  $^{90}\text{Sr}$ ). Scaling factors should be derived from a sufficient number of detailed measurements to determine the characteristic radionuclide composition in the effluents, using adequate methods and taking into account detection limits. The scaling factors should be reviewed periodically.

5.71. The grouping of radionuclides should take into account not only the different ways of sampling and quantifying the discharges but also dosimetric considerations. For example, airborne discharges from nuclear installations are often grouped as noble gases, halogens or iodine radioisotopes, and particulates. This grouping reflects that noble gases result in external exposure of the whole body, that iodine radioisotopes result in thyroid doses and that particulates usually present a potential hazard from inhalation or ingestion to all the organs and tissues of the body.

5.72. The grouping may also be extended to include gross alpha and gross beta activities. When limits are specified for groups of radionuclides measured by gross alpha or gross beta counting, the discharge limit for the group should be set on the basis of the characteristics of the radionuclide that gives the highest dose per unit activity discharged. In the case of uranium discharges, a limit expressed as a mass in kilograms per year, with consideration of the contribution of each uranium isotope, may be more appropriate than a limit on gross alpha activity.

5.73. The regulatory body should include in the authorization for discharges, or in other regulatory documents, conditions and anomalies to be reported, such as:

- (a) Any levels exceeding the operational limits and conditions relating to public exposure, including authorized limits on discharges, in accordance with reporting criteria established by the regulatory body;
- (b) Any significant increase in dose rate or concentrations of radionuclides in the environment that could be attributed to the authorized practice, in accordance with reporting criteria established by the regulatory body.

Further recommendations on records and reporting are provided in paras 5.88–5.91.

5.74. The operating organization should make available, on request, results from source monitoring. This request may be incorporated within the operational limits and conditions of the authorization or specified in other regulatory documents. The Annex provides further information on the possible forms of an authorization for discharges.

## DEMONSTRATION OF COMPLIANCE

5.75. In order to demonstrate that discharges are in compliance with the limits and in order to check the assumptions used to evaluate doses to the representative person, monitoring programmes should be established [9]. Two general types of monitoring are appropriate in the context of the control of discharges and the related public exposure:

- (a) Monitoring of the source, which involves measuring activity concentrations or dose rates at the discharge point or within the activity or facility (i.e. at the stack or the discharging pipelines or at the reservoirs prior to discharge);
- (b) Monitoring of the environment, which involves the measurement of radionuclide concentrations in environmental media (including foodstuffs and drinking water) and of doses or dose rates due to sources in the environment.

5.76. The requirements for source monitoring and environmental monitoring should be specified in the authorization for discharges by the regulatory body. The necessity for and frequency of monitoring should be determined by the assessed level of risk of radiological impact.

5.77. Monitoring programmes should be developed and conducted in line with a graded approach. For example, routine environmental monitoring is unlikely to be necessary in the case of discharges from a hospital with a nuclear medicine department or from a small research laboratory using short lived radionuclides [9]. Rather, a single monitoring campaign, close to the facility prior to and at the beginning of operations may be considered by the regulatory body as sufficient to verify compliance. However, even for such simpler facilities, changes in operational procedures can lead to increased discharges and as such may necessitate a review of the need for monitoring.

5.78. Source monitoring and environmental monitoring should normally be undertaken for facilities in the nuclear fuel cycle [9].

5.79. For complex facilities, such as nuclear power plants or reprocessing facilities, monitoring programmes should also provide an additional means of checking the operating conditions of the facility and provide a warning of unusual or unforeseen conditions that might result in unexpected releases.

### **Monitoring by the operating organization**

5.80. The operating organization should establish and use the monitoring programme to verify and demonstrate compliance with the authorization and to enable adequate assessment of public exposures due to sources for which the operating organization is responsible. The monitoring programmes developed by operating organizations should be subject to approval by the regulatory body. RS-G-1.8 [9] provides comprehensive guidance on source monitoring and environmental monitoring applicable to the control of discharges. Additional technical information on programmes and systems for source monitoring and environmental monitoring is available in Ref. [22].

5.81. Some secondary objectives, which should usually be fulfilled by a monitoring programme, are to provide information for the public, to maintain a record of the impacts of a facility or an activity on radionuclide levels in the environment, and to check the predictions of environmental models in order to reduce uncertainties in the dose assessment [9]. In accordance with these objectives, the monitoring programme should also include the collection of relevant supporting information, such as meteorological and hydrological data when this is considered necessary, in accordance with the radiation risk presented by the level of discharges.

5.82. The operating organization should establish an appropriate quality assurance programme covering the control of discharges and the monitoring programme. The programme should set out the corrective actions that should be taken in the event that deficiencies in control and monitoring are identified. It should cover both sample collection and measurement.

5.83. Measures to satisfy the following specific conditions should be incorporated into the quality assurance programmes, as relevant:

- (a) Requirements relating to source monitoring and environmental monitoring and to the collection of representative samples, including the identification of the environmental media and the associated sampling frequency;
- (b) Requirements relating to the accreditation or qualification of analytical laboratories;<sup>20</sup>
- (c) Procedures for the calibration and performance testing of measurement equipment;
- (d) A programme for the intercomparison of measurements;
- (e) A record keeping system;
- (f) A reporting procedure that is in compliance with requirements of the regulatory body.

### **Independent monitoring by the regulatory body**

5.84. The regulatory body should make provision for independent monitoring. The characteristics of independent monitoring and the resources devoted to independent monitoring should be based on a graded approach and should incorporate best practices and scientifically sound analytical methods. Such monitoring may be undertaken by the regulatory body or on behalf of the regulatory body by another organization that is independent of the operating organization.

5.85. The purpose of such independent monitoring may be one or more of the following:

- (a) To verify the quality of the results provided by the operating organization;
- (b) To verify the assessment of doses to the representative person;
- (c) To determine the consequences of any unforeseen release of radioactive material;
- (d) To undertake research into exposure pathways, including the contributions to dose from other sources of exposure;
- (e) To provide public reassurance.

### **Retrospective assessment**

5.86. An additional means of demonstrating compliance is to carry out a retrospective assessment of the radiological impact of the discharges. This should include the assessment of doses to the representative person from measurements

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<sup>20</sup> If accreditation is used as a means to demonstrate qualification, the related requisites should be made available to the laboratory concerned.

taken as part of the source monitoring or environmental monitoring programmes and should consider the relevance of the exposure pathways and related information that were assumed in the prospective assessment of the possible discharges when setting the limits originally.

5.87. The results of retrospective assessments using environmental monitoring data should only be compared with the doses used to derive the discharge limits with careful consideration. Because of the cautious nature of models for environmental dispersion and transfer used in prospective dose assessments, the doses to the representative person determined retrospectively using environmental monitoring data will, in general, be lower than those calculated using data from source monitoring. Measurements in the environment may also be below limits of detection; may include contributions from other installations, past accidental releases or global fallout from past nuclear weapon tests; or might not be representative because of the characteristics in the frequency and spatial coverage of the environmental sampling techniques (which result in data that are limited in time and space).

### **Records and reporting**

5.88. Records of the results of source monitoring and environmental monitoring and verification of compliance, including retrospective assessment of the radiological impact of the discharges, should be retained by the operating organization [9]. The regulatory body should establish the content and the frequency of the reporting of such results.

5.89. Reports from the discharge monitoring programmes should include the main operational and discharge data in the period covered by the report and a conclusion on trends observed from a comparison with previous results. Such reports should indicate whether the discharges are within the authorized limits established by the regulatory body or as approved for particular operating conditions. Results of audits and inspections, as well as documents relating to the quality assurance or quality control of laboratory analytical procedures and data, should be included in the reports, as relevant.

5.90. The operating organization should make provisions to report promptly to the regulatory body any releases exceeding specified reporting levels or authorized discharge limits, in accordance with criteria specified in the authorization for discharges or in other applicable documents issued by the regulatory body.

5.91. The operating organization should also report any significant abnormal increase in dose rate or concentrations of radionuclides in the environment that could be attributed to the facility or activity.

## INSPECTION AND ENFORCEMENT

5.92. The regulatory body should verify compliance with the regulatory requirements and the operational limits and conditions of the authorization for discharges. This should involve, as appropriate, auditing of the operating organization's records (including those setting out the results of discharge monitoring and environmental monitoring), review of the periodic reports on the results of the radiological environmental impact assessment review, of the results of the independent monitoring programmes, and inspection.

5.93. The regulatory body should establish a process for identifying and managing any identified non-compliance with the regulatory requirements on discharges. When a regulatory requirement, including a condition of the authorization, has not been met, the operating organization should, as appropriate:

- (a) Investigate the breach and its causes, circumstances and consequences;
- (b) Take appropriate action to remedy the circumstances that led to the breach and to prevent a recurrence of similar breaches;
- (c) Promptly communicate to the regulatory body the causes of the breach and the corrective or preventive actions taken or to be taken;
- (d) Take whatever other actions are required by the regulatory body.

5.94. The actions to be taken by the regulatory body in response to non-compliance should be graded in accordance with the seriousness of the failure. Depending on the national legal and regulatory system, such actions may range from a simple warning, to legal procedures (including prosecution) and the imposition of fines, through to the suspension or withdrawal of the authorization.

5.95. The setting of discharge limits takes into account the relevant dose constraints and the process of optimization, so any breach of discharge limits will generally not result in a breach of the dose limit. However, any breach of discharge limits should be reported to the regulatory body and should result in an investigation and, if necessary, follow-up actions to improve the situation.

## **Amendment, renewal, suspension or revocation of an authorization**

5.96. The regulatory body should establish procedures for any subsequent amendment, renewal, suspension or revocation of an authorization for discharges. The date of renewal should be specified in the authorization issued to the operating organization.

5.97. The results of regulatory actions, such as inspections, reviews and assessments, and feedback from operational performance (e.g. feedback on the exceeding of operational limits and conditions or on incidents) should be taken into account in making decisions on the amendment, renewal, suspension or revocation of an authorization.

5.98. The approval of the regulatory body should be obtained before any changes that may significantly affect doses or the safety of operations are made. When such changes may affect the discharges from the facility, the regulatory body should review the authorization for discharges and revise it as necessary. Any changes to authorized discharge limits should be communicated to all interested parties.

## **INVOLVEMENT OF INTERESTED PARTIES**

5.99. Because the regulatory control of radioactive discharges takes into account both operational and societal aspects, such as radioactive waste management in the facility and the optimization of the level of protection of the public, there are a number of different interested parties whose views should be considered, as appropriate. A process resulting in the granting of an authorization for discharges is likely to necessitate an exchange of information between the regulatory body, the applicant and other interested parties<sup>21</sup>. Some interested parties may be located in other States, especially in neighbouring States.

5.100. Any exchange of information relating to the control of discharges may form part of other decision making processes, for example a governmental

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<sup>21</sup> In the context of this Safety Guide, ‘interested parties’ typically include individuals or organizations representing members of the public; industry; government agencies or departments whose responsibilities cover public health, nuclear energy and the environment; scientific bodies; the news media; environmental groups [2, 3]; and groups in the population with particular habits that may be affected significantly by the discharges, such as local producers and indigenous peoples living in the vicinity of the facility or activity under consideration.

decision making process on a major undertaking, such as the construction of a large nuclear installation.<sup>22</sup> Such exchange of information should include consideration of societal aspects, for example public concern over the risks associated with radiation exposure, and consideration of the doses to the public that might result from discharges during operation.

5.101. In some cases, there may be specific requirements for the exchange of information with interested parties before the authorization for discharges has been finalized. One means of doing this is through the establishment of a group reflecting local public concerns for liaison with both the operating organization and the regulatory body. Among other things, the results of the prospective radiological environmental impact assessment [7] should be a focal point of the discussions.

5.102. Paragraph 3.124 of GSR Part 3 [3] establishes a requirement to exchange information with other States when a discharge could cause public exposures in these States, for example if a facility will discharge into an international waterway or when the representative person is located in a neighbouring State.<sup>23</sup>

## **6. CONSIDERATION OF EFFLUENTS CONTAINING RADIONUCLIDES OF NATURAL ORIGIN IN DIFFERENT INDUSTRIES**

6.1. In general, for facilities and activities authorized in accordance with the requirements established in GSR Part 3 [3], there is no distinction in the general approach for controlling the release of effluents containing radionuclides of artificial origin or radionuclides of natural origin, for example discharges from nuclear installations and from uranium and thorium mining and processing facilities within the nuclear fuel cycle. This same general approach involves the use of dose limits, dose assessment, dose constraints and optimization of the

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<sup>22</sup> GSG-10 [7] addresses the information relevant for different interested parties, in the framework of governmental decision making and authorization processes relating to facilities and activities.

<sup>23</sup> Information exchange and, in some cases, consultation with the public and other interested parties are policy requirements for environmental decisions in some States, for example for parties to the Aarhus Convention [32].

protection and safety — or best available techniques as relevant — in accordance with the national regulations.

6.2. Some non-nuclear industries may release effluents containing radionuclides of natural origin. In some States, some of these industries involving naturally occurring radioactive material are controlled by national authorities other than the regulatory body; therefore, discharges might not be subject to regulatory control with respect to radioactive substances. When necessary, the regulatory body should cooperate with other national authorities with responsibilities for the regulation of those industries and should coordinate actions regarding the control of releases to ensure that radiation protection is taken into account in the management of any effluents.<sup>24</sup>

6.3. Non-nuclear industries that could generate controlled releases of effluents containing radionuclides of natural origin include onshore and offshore facilities for oil and gas extraction, surface and underground mineral mines, mills and processing facilities outside the nuclear fuel cycle, and the production of rare earth metals, fertilizers, phosphogypsum, thorium, titanium and ceramics using zircon sands. Effluents from the extraction processes used for heavy metals usually also contain naturally occurring radionuclides. Most of the radionuclides of natural origin associated with these industries are found in products, by-products and solid waste. For example, in the phosphate industry, fertilizers contain enhanced levels of uranium, while phosphogypsum waste usually contains enhanced levels of radium. During the production of rare earth elements, radionuclides from the uranium and thorium series are enhanced in the residues.

6.4. Within non-nuclear industries involving naturally occurring radioactive material, atmospheric or liquid releases should be controlled in accordance with the requirements for discharges from planned exposure situations if the activity concentration in the material of any radionuclide in the uranium decay chain or the thorium decay chain is greater than 1 Bq/g or if the activity concentration of <sup>40</sup>K is greater than 10 Bq/g [3]. In cases in which the activity concentrations are below 1 Bq/g or 10 Bq/g, as relevant, the regulatory body may still require an assessment of the doses delivered based on actual exposure scenarios.

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<sup>24</sup> Safety Reports and a Technical Report have been issued on radiation protection and radioactive waste management in industrial activities involving naturally occurring radioactive material (see Refs [33–39]).

6.5. Paragraph I.4 of schedule I of GSR Part 3 [3] states:

“For radionuclides of natural origin, exemption of bulk amounts of material is necessarily considered on a case by case basis...by using a dose criterion of the order of 1 mSv in a year, commensurate with typical doses due to natural background levels of radiation.”

It should be taken into account that the criterion used for the exemption of bulk amounts of material containing radionuclides of natural origin is higher than the criterion normally adopted in IAEA Safety Standards Series No. GSG-8, Radiation Protection of the Public and the Environment [6], and in this Safety Guide, for defining the possible range of values of dose constraints for public exposure (i.e. below the dose limit for an effective dose of 1 mSv in a year and higher than a dose of the order of 10  $\mu$ Sv in a year). This higher criterion for radionuclides of natural origin should be taken into account when dose constraints are specified for these situations, as appropriate. The specification and use of dose constraints is described in the Annex.

6.6. Some important differences that should be taken into account in specifying the operational limits and conditions associated with an authorization for discharges for facilities and activities discharging radionuclides of natural origin or for non-nuclear industries releasing naturally occurring radioactive material to the environment, as relevant, are the following:

- (a) The releases are not always from a point source and often originate from large surface areas of stored material. This means that the determination of source terms and dispersion in the environment may be quite difficult and uncertain. For existing facilities, surveys should therefore be conducted to determine the geometry and characteristics of the release (point source versus area source). Alternatively, use may be made of appropriate models for assessing the impact of area sources.
- (b) Greater reliance may need to be placed on environmental monitoring in assessing and verifying doses to the representative person. However, in regions with a relatively high level of natural background radiation, any increment in environmental levels of radiation caused by the discharge may be masked by the natural variability in natural background levels of radiation.
- (c) Specific assessments should be carried out to identify media to be included in the environmental monitoring programme so that any increment in environmental levels of radiation may be followed in time.

- (d) Doses from radon may need to be assessed where large quantities of materials containing uranium or radium are handled or stored, including waste piles. Radioactive dust may be released through ventilation systems or resuspended from waste piles. In this case, monitoring of radon and dust near venting stacks and waste piles should be performed.
- (e) The cleaning of tanks and pipes (such as those used within some oil and gas industries) that contained residues with elevated levels of radium may result in liquid, aerosol or solid radioactive waste; the need for regulation of such waste should be considered.
- (f) Seasonal variation in rainfall may affect the radioactive releases and the radiological impact of liquid effluents from mining and processing facilities or activities (e.g. when the storage or processing of minerals in open pits is part of the process). For example, in the dry season, the dilution of the releases may be lower and the releases of aerosols and gases such as radon may be higher. Furthermore, sedimentation in periods of low water flow may be followed by remobilization of deposited sediments in periods of high rainfall.
- (g) The hazard associated with the non-radioactive components of the discharge may be more significant than the hazard associated with the radioactive components; in these cases the non-radioactive components of the discharge will normally determine the stringency of the controls to be exercised over the discharge.

The discharge of radionuclides from facilities involving large amounts of naturally occurring radioactive material is the result of a complex interaction of geological, climatic and technological factors. Radiation exposure of members of the public resulting from such discharges involves many exposure pathways, and the level of exposure per unit discharge rate depends on quite a number of site specific conditions. Such site specific conditions can result in very large differences in the dose per unit discharge rate between different sites. Consequently, no simple and general relationship exists between the discharge rate and the effective dose to members of the public. However, a detailed site specific analysis is not warranted when, on the basis of a generalized and cautious (conservative) approach, it can be concluded that the discharges are of no radiological significance.<sup>25</sup>

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<sup>25</sup> Reference [40] provides information on the use of reference discharge situations for effluents from industries involving naturally occurring radioactive material.

## 7. CONTROL OF DISCHARGES DURING DECOMMISSIONING

7.1. Decommissioning is a post-operational situation that should be considered as a different practice subject to authorization, requiring specific regulatory provisions [41], including for discharges. In general, two main options for decommissioning should be considered:

- (a) Permanent shutdown of the facility, followed by its immediate dismantling;
- (b) Permanent shutdown of the facility, with dismantling deferred to a later date.

7.2. It is typical for effluent discharges to vary through the different phases of decommissioning. For example, as the removal of radioactive hazards progresses through decommissioning, the radioactive discharges may decrease.

7.3. Immediate dismantling of the facility increases the likelihood of mobilizing and potentially releasing radionuclides that might not otherwise have been released. Deferred dismantling will allow time for some radioactive decay to occur.

7.4. The anticipated discharge levels following permanent shutdown of a facility are usually much lower than during the operational period, since any short lived radionuclides will have decayed. Furthermore, the likelihood of large accidental releases is reduced. However, for some dismantling activities, there may be an increased likelihood of low level unplanned liquid or gaseous releases.

7.5. Whichever of the two main options is chosen, consideration should be given to the following aspects:

- (a) The possibility of additional radionuclides being discharged that were not present in routine discharges during normal operation. For example, alpha emitters, which might not have been present in the discharge during operation, might be discharged when a nuclear installation is dismantled.
- (b) The need for a survey of these additional radionuclides in the environment to determine pre-existing levels.
- (c) The possibility that any contamination on the site that resulted from incidents during operation may affect the discharges during decommissioning.

- (d) The need to revise the radiological environmental impact assessment prior to dismantling of the facility to determine, in particular, if new exposure pathways need to be included.
- (e) The need to revise the authorization for discharges, including any conditions relating to the source monitoring and environmental monitoring programmes to take account of any differences identified. The monitoring programmes should be sufficiently robust to detect abnormal or unauthorized discharges.
- (f) The need for more frequent inspections by the regulatory body, particularly while radioactive liquids remain in the facility.

7.6. The dismantling of nuclear installations usually takes place progressively over several years and is usually divided into different stages. Discharges of effluents containing radionuclides typically vary through these steps, and the regulatory control should be applied on a case by case basis. Protection and safety should be optimized at each step in the decommissioning process, with account being taken of the experience gained in the previous steps. Because unexpected difficulties and changing conditions may arise during each step, the regulatory control of discharges should reflect the prevailing conditions in each step.

## **8. PREVIOUSLY UNREGULATED PRACTICES**

8.1. The regulatory body may identify existing practices or sources that already discharge radionuclides to the environment, but not under an authorization as described in this Safety Guide or under less stringent regulations with respect to the control of public exposure. This may be the case for some facilities and activities that began operating prior to the development and full application of the national regulatory infrastructure that meets the requirements of the IAEA safety standards [18].

8.2. The regulatory body should, first, establish whether the exposure due to the practice or source may fall within the scope of regulatory control (i.e. whether it is excluded from the application of safety standards). If the exposure is not excluded, the regulatory body should determine whether the provisions for exemption of the practice can be applied.

8.3. If an authorization for discharges is necessary, as for a new practice, discharges should be adequately characterized, exposure pathways should be

identified, a prospective radiological environmental impact assessment should be carried out [7], and a process for defining discharge limits as part of the authorization for discharges should be conducted.

8.4. The applicability of dose constraints to this previously unregulated source should be established. Dose constraints for new practices should not be used without proper consideration for previously unregulated practices because, in a strict sense, dose constraints apply only prospectively. However, the regulatory body may choose also to establish dose constraints for the future operation of an existing practice.

8.5. In any case, the operating organization should be required to demonstrate that the dose in a year to the representative person from all sources is below the effective dose limit of 1 mSv. Furthermore, consideration should be given to whether protection and safety can be further optimized.

8.6. Exceptionally, if the assessed annual dose is found to be greater than 1 mSv, the regulatory body should consider setting authorized discharge limits and operational conditions to ensure that the average annual dose over a five year period is not more than 1 mSv and that the maximum annual dose is lower than 5 mSv in any single year. During this period in which the averaging of doses is applied, investigations should be carried out to determine how the discharges can be reduced so that, within a few years, the dose to the representative person is below the annual limit of 1 mSv. The authorization should be reviewed after this period, and the regulatory body should consider withdrawing the authorization for discharges or revising the limits and conditions.

8.7. The limits on effective dose to the representative person should be applied only to future discharges from the facility. They should not take into account the total dose resulting from past unregulated operations of the facility. If appropriate, the contributions to the effective dose from past operations should be addressed within a framework of remedial actions for an existing situation [3].

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## Annex

### PRACTICAL CONSIDERATIONS IN GRANTING AN AUTHORIZATION FOR DISCHARGES

#### SPECIFICATION AND USE OF CONSTRAINTS

A-1. Dose constraints for public exposure in planned exposure situations are required to be set or approved by the government or the regulatory body [A-1]. Dose constraints are set for the specific facility or activity; however, national authorities may develop generic dose constraints for facilities or activities with similar characteristics. In some cases, the applicant for an authorization for discharges proposes a dose constraint for a particular facility or activity, which needs to be defensible, discussed with the regulatory body and agreed on in a timely manner by the regulatory body.

A-2. In order to establish a generic dose constraint, the regulatory body may consider previous IAEA guidance that suggested 0.3 mSv in a year as an appropriate default value on the basis of the maximum levels of individual exposures generally used for optimization in nuclear fuel cycle facilities in various countries.<sup>1</sup> The International Commission on Radiological Protection has not explicitly recommended a dose constraint for the control of discharges to the environment but has also suggested a value of 0.3 mSv per year in relation to the disposal of radioactive waste and prolonged exposures (see Refs [A-2 to A-4] and table 8 of Ref. [A-5]). In the requirements for disposal of radioactive waste established in IAEA Safety Standards Series No. SSR-5, Disposal of Radioactive Waste [A-6], a dose constraint of 0.3 mSv per year for optimization of the protection of the public is established, to be used in the design, construction, operation and closure of a disposal facility.

A-3. When setting a specific dose constraint for a particular activity or facility, the following need to be considered:

- (a) The characteristics of the site and of the facility or activity that are relevant for public exposure;

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<sup>1</sup> INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Control of Radioactive Discharges to the Environment, IAEA Safety Standards Series No. WS-G-2.3, IAEA, Vienna (2000).

- (b) Good practices and experience in the operation of similar facilities or activities;
- (c) The location of the facility or activity;
- (d) Dose contributions from other authorized practices and foreseeable future practices;
- (e) The expected exposure conditions.

Other factors, such as economic and societal factors, as well as the views of interested parties, would also need to be taken into account.

A-4. When considering the contribution to the exposure of the public from other authorized sources of radiation, local and distant practices and existing and projected practices need to be considered. For example, for a nuclear installation, other nuclear installations collocated on the same site or discharging to the same body of water (particularly rivers and small lakes) could contribute to the exposure of the representative person under consideration; for hospitals in urban areas, other sources of radiation from other practices in the same area (e.g. industrial applications, other medical applications) can contribute to the exposure. On the other hand, in the case of practices in remote areas (e.g. uranium mining and processing), the assumption that additional local sources of radiation contribute to the dose might not be appropriate.

A-5. In the case of sites with multiple facilities or for facilities and activities in an area where more than one source is present that could contribute to the exposure of the representative person, the specific dose constraint may need to be set at an appropriately low value. On the other hand, for individual facilities or activities located in extremely remote areas (e.g. a uranium mine), it may be reasonable to assume that there are no other contributing sources and that, consequently, a higher specific dose constraint could be set.

A-6. Considering that the dose constraint is set not only to take account of other existing or planned sources of exposure to the public but also to guide the optimization of protection for each specific facility or activity, in the case of multiple facilities or activities on the same site it might not always be appropriate to apportion the generic dose constraints by dividing exactly by the number of facilities. A specific dose constraint needs to be assigned to each facility or activity on the basis of its particular contribution to the exposure of the representative person, to ensure that, once the protection is optimized with respect to each source, the resulting combination of doses does not exceed the dose limit.

A-7. In the case of a hospital discharging radionuclides to the sewerage system, the specific dose constraint value may need to be set to take account of the exposure conditions of workers at a sewage treatment works<sup>2</sup> used to collect and process liquid discharges from the hospital and from other hospitals using the same treatment facility.

A-8. As described in previous paragraphs and in Section 5, there are different aspects to be considered and different options for specifying discharge limits that can optimize the level of protection of the public; these may include using best available techniques (see para. 5.39), possibly in combination with the application of a dose constraint. States may adopt such different options for the optimization of protection subject to national regulations, as far as is consistent with the concept of ensuring that the sum of doses from planned operations for all sources under control remains within the dose limit.

A-9. A scheme illustrating the possible use of a generic dose constraint and specific dose constraints in establishing discharge limits is presented in Figs A-1 and A-2. The generic dose constraint is to be set below the dose limit of 1 mSv in a year and above a dose of the order of 10  $\mu$ Sv in a year. Figure A-1 illustrates

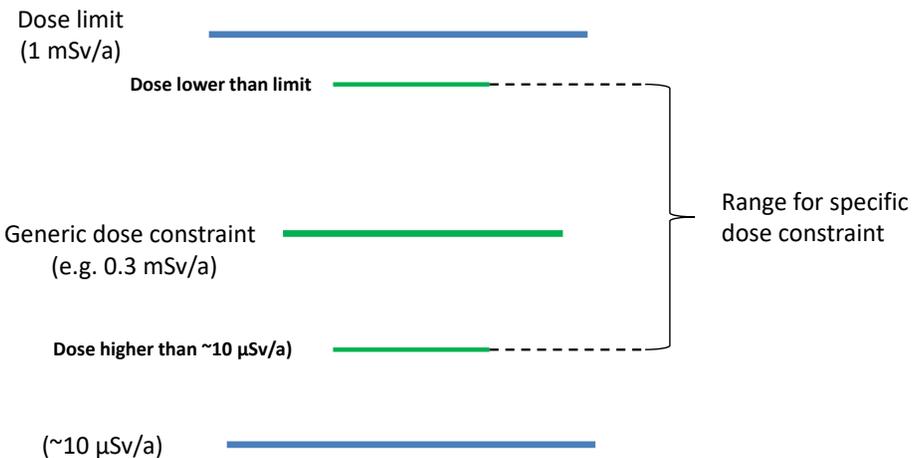


FIG. A-1. Relationship between a generic dose constraint and a specific dose constraint.

<sup>2</sup> Such workers are not normally monitored for occupational exposure and are subject to the same dose limits as for public exposure (see para. 3.78 of IAEA Safety Standards Series No. GSR Part 3, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [A-1]); the representative person may be such a worker.

that the specific dose constraint for a facility or activity could be higher or lower than the generic dose constraint, depending on different factors determining the exposure conditions at the location of the representative person, such as the presence of other sources of radiation that can contribute to the dose to the representative person, if relevant.

A-10. Figure A-2 illustrates how a specific dose constraint set for a facility or activity is used as a starting point within the process of optimization to find a level of discharges that is optimal in terms of protection of the public. A margin for operational flexibility needs to be allowed, depending on the characteristics of the activity or facility and its operational features. The dose corresponding to the discharge limit is set below the specific dose constraint and slightly above the dose to the public in accordance with which protection is considered optimized. The margin for flexibility needs to be determined on the basis of the characteristics of the facility or activity influencing the discharges and may be proposed by the applicant and is subject to approval by the regulatory body.

A-11. Figure A-2 also indicates with an arrow the region below the specific dose constraint that is considered for the optimization process, in which best available techniques could also be used to find the optimal discharge limit. Optimization and best available techniques are addressed in paras A-13 to A-21.

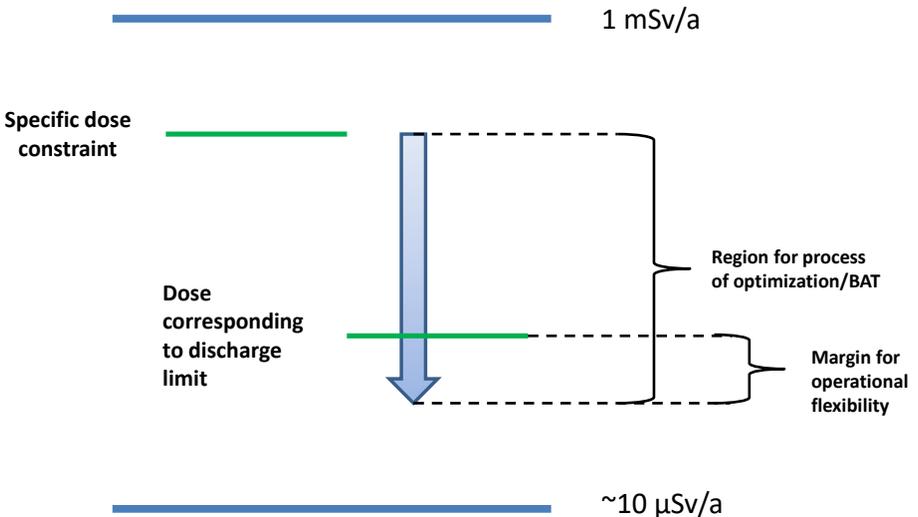


FIG. A-2. Dose to be used for setting discharge limits.

A-12. When the technical characteristics of certain facilities and activities with respect to the retention of radionuclides (e.g. high efficiency containment and filtering systems in nuclear installations such as nuclear power plants) are considered, and particularly when best available techniques for the confinement and abatement of radionuclides are used, it is possible that the estimated discharges result in assessed doses below the order of 10  $\mu$ Sv per year. In such cases, the regulatory body could consider not requiring that a formal process of optimization, as described in Section 5, be applied.

## OPTIMIZATION

A-13. The extent to which a formal process of optimization is applied depends on the operational status of the facility involved and the doses and risks that could potentially be involved. As described in Section 5, many options for minimizing discharges may lead to increased generation of solid radioactive waste and a corresponding trade-off between reduced public exposures and reduced occupational exposures. There could also be safety considerations, such as an increased risk of accidental spillages or releases from storage tanks [A-7].

A-14. Different considerations will also be involved in the optimization of protection and safety for proposed and existing facilities or activities. The design stage of a new facility or activity is likely to involve complex technical decisions that may require the use of formal decision aiding techniques. At this stage, there may be a broad range of possible designs and there is the potential for designing the facility such that waste and discharges arising from its operation are reduced, thereby reducing both occupational exposure and public exposure. However, during the operational stage, the options for reducing public exposures are more restricted than during design, owing to the more limited possibilities of introducing changes in the systems and processes for reducing radioactive waste and effluents. Optimization of public protection for ongoing discharges is often undertaken by considering the configurations of the available technical options and the associated procedures, based on the operational experience, in an interactive manner between the regulatory body and the operating organization [A-8].

A-15. Consideration of management options for radioactive waste and effluents includes the evaluation of requirements for design and operational features, storage and treatment (including radionuclide abatement techniques), and the prevention of spills. For new facilities, protection and safety can be optimized through the design. Before decommissioning is commenced,

protection and safety can be optimized through the selection of appropriate options for decommissioning. In the operational and decommissioning stages of the facility, there may be fewer options available to optimize protection and safety. However, during operation there may be opportunities to review options for the management of discharges. The management option may then consist of reconfiguring the storage and radionuclide abatement systems of the facility, or backfitting or upgrading the existing system features. Possible abatement techniques for the removal of radionuclides and control methods for effluents are described elsewhere [A–8].

A–16. Different decision aiding techniques may be employed to facilitate the optimization process. The most common decision aiding techniques addressed in the literature are cost–benefit analysis and multi-attribute analysis, although other techniques also exist. Information on decision aiding techniques is provided in Ref. [A–9], and further information is given in Ref. [A–8] in relation to the control of discharges.

A–17. A number of societal and economic factors may influence the decision on the optimized level of discharge. The effects on future generations, the ability to control exposures, the amount of information available for making informed decisions, and the views of interested parties may also be considered. The need to accommodate and balance the requirements of different strategies also needs to be considered (e.g. the requirements to reduce discharges, with associated requirements for waste treatment measures that will increase the generation of solid waste, and the principle of waste minimization).

A–18. Societal and economic factors that need to be considered are dependent on the characteristics of the activity or facility under consideration and on site specific attributes, as well as on the political and social pressures within a State. A list of such considerations is provided in Ref. [A–8].

A–19. An important aspect that has to be taken into account is the international obligations of the State established through binding regional and international conventions relating to the protection of people and the environment. Conventions for the prevention of marine environment pollution, such as the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) [A–10], the Convention on the Protection of the Marine Environment of the Baltic Sea Area (the Helsinki Convention) [A–11] and the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Convention) [A–12], may impose additional requirements that have to be included as part of the optimization process. For example, Contracting Parties

to the OSPAR Convention have committed to applying best available techniques and best environmental practice including, where appropriate, clean technology, in their efforts to prevent and eliminate marine pollution due to discharges from land based installations [A-13].

## USE OF BEST AVAILABLE TECHNIQUES

A-20. When properly specified, the use of best available techniques is an effective approach to optimization that focuses on techniques and technology for protection. The International Commission on Radiological Protection recognizes that for the control of radioactive emissions to the environment, best available techniques not entailing excessive cost may be used [A-7].

A-21. Within the context of European Union Directive 2008/1/EC on integrated pollution prevention and control [A-14]<sup>3</sup>, the term ‘best available techniques’ is defined as follows:

- ‘Best’, as used in relation to techniques, means the most effective in achieving a high general level of protection of the environment as a whole.
- ‘Available techniques’ means those techniques developed on a scale that allows implementation in the relevant class of activity under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced within the State, as long as they are reasonably accessible to the person carrying out the activity.
- ‘Techniques’ includes both the technology used and the way in which the installation is designed, built, managed, maintained, operated and decommissioned.

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<sup>3</sup> The European Commission has developed a series of reference documents on the application of best available techniques to specific industries, such as the reference documents under the Integrated Pollution Prevention and Control (IPPC) Directive and the Industrial Emissions Directive (IED); these documents provide information on relevant techniques, processes used, current emission levels, techniques to consider in determining best available techniques and emerging techniques. See: <http://eippcb.jrc.ec.europa.eu/reference/>.

## CHARACTERIZATION OF DISCHARGES

A-22. As outlined in paras 5.20–5.24 of this Safety Guide, once the need for an authorization has been confirmed, the applicant should characterize the nature of the discharges. For instance, this characterization could be in terms of:

- (a) The industrial process or activity and the assumptions made about the discharges it generates;
- (b) The radionuclide composition;
- (c) The chemical and physical form of the radionuclides (relating to behaviour in the environment);
- (d) Routes of discharge and discharge points, including aspects such as stack height, exit velocity, exit temperature, maximum and average discharge rates;
- (e) The total amount of the various radionuclides expected to be discharged in one year;
- (f) The expected time pattern of discharge, including the need for and likelihood of increased short term discharges if a constant release rate cannot be assumed.

A-23. For existing regulated facilities, information on the characteristics of actual discharges will already exist as a result of the monitoring programmes, and these characteristics may be considered to support the process of periodic safety review [A-8]. For new or previously unregulated facilities, it may be possible to characterize the discharges on the basis of knowledge of similar facilities elsewhere or on the basis of engineering analysis. In either case, it is generally necessary to understand the way in which particular effluents are produced to determine the relationship between the discharges and operational parameters, such as energy production figures for nuclear power plants, and the possible effect that waste treatment or waste abatement techniques might have on the amount discharged.

## FORMS OF THE AUTHORIZATION FOR DISCHARGES

A-24. Authorized discharge limits can be set in a number of ways and can be based on limiting either the dose to the representative person, the amount of radionuclides discharged or the activity concentration in the liquid and gaseous

effluents.<sup>4</sup> In most cases, the choice is a matter of preference and practicality on the part of the regulatory body, as well as the manner in which the regulatory body requires the licensee to demonstrate compliance.

A-25. Some regulatory bodies prefer to express the limit in terms of a dose, because it relates directly to the actual radiological impact and makes the objective of the system of limitation of discharges more evident. Setting limits in terms of amounts of activity or activity concentration of radionuclides to be discharged, on the other hand, is viewed by other regulatory bodies to reflect more closely the quantity that is to be controlled and measured, and is therefore more closely connected to the actions that the operating organization needs to take to control discharges.

A-26. Expressing limits in terms of a dose (i.e. in millisieverts per year) or in terms of an amount of activity or activity concentration of radionuclides discharged (e.g. becquerels per year or becquerels per litre) does not represent a fundamental difference. The use of either approach is justified, because a dose to the representative person and an amount of radionuclides (or activity concentration) are broadly proportional, and one can be converted to the other without difficulty. However, while an amount or a concentration of radionuclides is a directly measurable quantity, the dose to members of the public is always based on an assessment [A-8].

### **Grouping of radionuclides**

A-27. When discharge limits are specified in terms of the quantity of radionuclides discharged, separate limits are usually specified for different radionuclides. Exceptions are cases in which the facility discharges only a few radionuclides, such as a hospital using only iodine or <sup>99m</sup>Tc. For most facilities and activities, a mixture of radionuclides is discharged. In such cases, it is unusual to set limits for each individual radionuclide, because such an approach is considered cumbersome and unnecessary; instead, one limit for a group of radionuclides may be used. Factors influencing the choice of radionuclide groups include the feasibility of measuring one or more radionuclides within the group, their use as indicators of the performance of the facility and their contribution to the dose to the representative person.

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<sup>4</sup> If the discharge limit is set in terms of activity concentration, it has to be related to a total activity or a total volume of the effluents for a given period, usually per year.

A-28. For larger facilities that discharge a variety of radionuclides, limits are generally imposed on groups of radionuclides that share similar characteristics, although limits may also be imposed on specific radionuclides that are deemed to be of special significance. Guidance on the grouping of radionuclides is provided in paras 5.70–5.72. Tritium and  $^{14}\text{C}$  are of special significance and should be considered for specific limits and consideration (see para. 5.69).

A-29. The grouping of radionuclides is appropriate in situations in which members of some radionuclide groups are usually discharged in fairly fixed proportions and, therefore, the occurrence of one radionuclide indicates the presence of the others in the group. Such grouping has the merit of simplicity both in the formulation of the limits and in their application. The radionuclide of the group that is most easily detected at the desired sensitivity is often used in specifying the discharge limit for the group.<sup>5</sup>

A-30. In some cases, a regulatory body may include in the authorization for discharges limits on specific radionuclides that provide early indications of changes in the operational status of the facility or that make an exceptionally high contribution to the total dose to the representative person. When limits are specified for groups of radionuclides, the approach is usually to set the limit for the group on the basis of the characteristics of the most radiotoxic radionuclide of the group.

### **Site specific or facility specific limits**

A-31. Discharge limits may be specified either for the whole site, for each unit within a site, or even for each discharge point, such as a stack or a pipe. A unit in this context means an identifiable entity that generates airborne or liquid waste. For example, at a large hospital there may be a nuclear medicine facility, a waste treatment facility and an incinerator, each of which has its own discharge point and each of which could be considered as a separate and independent unit on which discharge limits may be imposed. At a nuclear power plant site, each unit may be a nuclear reactor. In general, the regulatory body will impose discharge limits for each individual unit, but in some cases the regulatory body will impose only a site limit, with no limits for individual units [A-8].

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<sup>5</sup> Periodic review may need to be undertaken if there is reason to believe that the ratio of the various radionuclides in the group might change.

## **Time interval for demonstrating compliance**

A-32. The basic interval over which compliance is expected to be shown is normally one year, usually a calendar year, although a rolling 12 month period is also used. The advantage of the latter approach is that it may permit closer supervision of the facility by the regulatory body, but it is administratively more cumbersome to implement. In some cases, the interval can be tied to operating cycles of the activity, which may be longer than one year.

A-33. Although annual discharge limits are almost always used and are considered as the primary means of regulatory control, some regulatory bodies consider the need to establish discharge limits for shorter periods (e.g. on a monthly or quarterly basis). This could be justified if there is concern that the validity of the averaging assumptions used in setting annual discharge limits (e.g. in the estimation of the dose to the representative person) is not applicable if short term increased discharges occur. For such cases, dose assessments using assumptions valid for the shorter periods need to be carried out.

A-34. Parameters used to estimate the doses that form the basis for setting discharge limits are typically chosen to be representative of annual averages. For example, the prevailing wind direction and speed, the stability category of the atmosphere, and the dietary habits assumed are usually annual averages. It is possible that a facility may discharge a significant fraction of its annual allowance over a short period or a series of short periods. Short term limits are therefore often specified in addition to annual limits. Short term limits also allow the regulatory body to more closely monitor the facility's performance and to take action if operations fail to meet the short term limits. Short term limits are generally higher than the prorated value for the applicable duration, to allow for operational flexibility [A-8].

A-35. Consideration also needs to be given to setting discharge limits for those facilities at which total discharges are generally low but at which specific events can result in short term discharges without markedly affecting the long term average discharges (e.g. replacement of the molybdenum generators in a technetium production facility or discharges from hospitals treating patients with radioiodine).

## **Operational flexibility**

A-36. Discharge limits are set by taking account of dose constraints and the need for optimization, so a breach of a discharge limit might not result in a breach

of the dose limit; indeed, the main intent of the regulatory control of discharges is to avoid the breaching of the dose limit. Exceeding discharge limits would normally initiate actions by the licensee and the regulatory body (e.g. a report, an investigation, corrective measures, inspections), even if the resulting doses to the public were assessed to be below the dose limits. To avoid frequent contraventions of regulatory requirements that would result in significant and unnecessary expenditure of resources, public misperception and frequent interference with the operation of the facility, some margin for operational flexibility may be allowed when setting discharge limits.

A-37. The margin for operational flexibility needs to allow for what would be anticipated under normal operating events [A-8]. Such events include practices or facility conditions that lead to a temporary increase in discharge levels of relatively short duration, usually hours to days, but which are not considered abnormal events. Examples are an increased number of patients in a nuclear medicine department or a temporary failure or loss of efficiency of an effluent treatment system.

A-38. Specific guidance cannot be provided to assist in determining the appropriate margin to allow for operational flexibility. Previous experience with similar facilities can provide useful information on the minimum allowance for flexibility that needs to be permitted, in accordance with the regulatory framework [A-8].

### **Period of validity of the authorization for discharges**

A-39. While in principle the authorization for discharges could have the same validity period as the authorization of the facility or activity, some regulatory bodies issue authorizations for discharges that have a shorter period of validity or specify that the discharge limits are subject to revision within the framework of a periodic safety review. In such cases, at the end of the period of validity, the authorization for discharges is reviewed, and updated as necessary, on the basis of current information relating to public exposure and operational experience. The usual period for the periodic safety review of more complex installations is ten years. The appropriate period is generally selected by the regulatory body on the basis of, for example, the likelihood of the occurrence of changes at the site and its surrounding environment that might affect the conditions according to which the authorization for discharges was initially issued. Some regulatory bodies may decide to review and update the authorizations at any time, as necessary, and do not apply a specified limit on the validity of the authorization for discharges.

A-40. Operating organizations are required to obtain approval from the regulatory body before making any changes to the operation of the facility or the conduct of the activity that may affect doses significantly or affect the safety of operations. If a number of changes are made over a period of time, there may be a change in the safety performance of the facility or activity that can only be evaluated through a complete review of the overall operation. The period of validity is also influenced by the degree of ongoing review and supervision provided by the regulatory body, and by the breadth and depth of such ongoing reviews. In some cases, such ongoing reviews are of such a depth and scope that they constitute, in themselves, a formal review of the authorization for the facility or activity.

A-41. In other cases, the period of validity of the authorization for discharges may be equal to the expected life of the facility or activity. Such practices would normally have stringent ongoing review and audit requirements imposed in their authorization, for example a requirement that a periodic safety review be carried out irrespective of whether there have been any significant changes in operation or in dose assessment factors such as the demographics or land use in the areas surrounding the facility. The ongoing reviews and audits would ensure that the assumptions used to estimate doses to the representative person, such as the source term, the location where the representative person lives, the habit data and other assumptions (e.g. the locations of dairy farms and vegetable gardens) remain valid. Any significant changes are generally required to be reported to the regulatory body, which may decide to initiate a formal review of the authorization for discharges, if relevant.

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Director General

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