IAEA Safety Standards
for protecting people and the environment

Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency

Jointly sponsored by the
FAO, IAEA, ILO, PAHO, WHO

IAEA

WHO

General Safety Guide
No. GSG-2

IAEA
International Atomic Energy Agency

IAEA SAFETY RELATED PUBLICATIONS

IAEA SAFETY STANDARDS

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

The publications by means of which the IAEA establishes standards are issued in the **IAEA Safety Standards Series**. This series covers nuclear safety, radiation safety, transport safety and waste safety. The publication categories in the series are **Safety Fundamentals**, **Safety Requirements** and **Safety Guides**.

Information on the IAEA's safety standards programme is available at 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 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.

OTHER SAFETY 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 and protection 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 **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**.

CRITERIA FOR USE IN
PREPAREDNESS AND
RESPONSE FOR A
NUCLEAR OR RADIOLOGICAL
EMERGENCY

IAEA SAFETY STANDARDS SERIES No. GSG-2

CRITERIA FOR USE IN PREPAREDNESS AND RESPONSE FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

GENERAL SAFETY GUIDE

JOINTLY SPONSORED BY THE
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS,
INTERNATIONAL ATOMIC ENERGY AGENCY,
INTERNATIONAL LABOUR OFFICE,
PAN AMERICAN HEALTH ORGANIZATION
AND WORLD HEALTH ORGANIZATION

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2011

Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

Printed by the IAEA in Austria
February 2011
STI/PUB/1467

IAEA Library Cataloguing in Publication Data

Criteria for use in preparedness and response for a nuclear or radiological emergency : general safety guide / jointly sponsored by the Food and Agriculture Organization of the United Nations … [et al.]. — Vienna : International Atomic Energy Agency, 2011.

p. ; 24 cm. — (IAEA safety standards series, ISSN 1020–525X ; no. GSG-2)
STI/PUB/1467
ISBN 978–92–0–107410–2
Includes bibliographical references.

1. Nuclear facilities — Safety measures. 2. Nuclear accidents. 3. Assistance in emergencies. 4. Emergency plans. 5. Safety standards. 6. Radiation dosimetry. I. International Atomic Energy Agency. II. Series.

IAEAL 11–00669

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

In March 2002, the IAEA's Board of Governors approved a Safety Requirements publication, Preparedness and Response for a Nuclear or Radiological Emergency (IAEA Safety Standards Series No. GS-R-2), jointly sponsored by seven international organizations, which establishes the requirements for an adequate level of preparedness for and response to a nuclear or radiological emergency in any State. The IAEA General Conference, in resolution GC(46)/RES/9, encouraged Member States "to implement, if necessary, instruments for improving their own preparedness and response capabilities for nuclear and radiological incidents and accidents, including their arrangements for responding to acts involving the malicious use of nuclear or radioactive material and to threats of such acts", and further encouraged them to "implement the Safety Requirements for Preparedness and Response to a Nuclear or Radiological Emergency".

The Convention on Early Notification of a Nuclear Accident ('the Early Notification Convention') and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency ('the Assistance Convention') (IAEA Legal Series No. 14), adopted in 1986, place specific obligations on the Parties and on the IAEA. Under Article 5a(ii) of the Assistance Convention, one function of the IAEA is to collect and disseminate to States Parties and Member States information concerning methodologies, techniques and available results of research relating to response to such emergencies.

This Safety Guide is intended to assist Member States in the application of the Safety Requirements publication on Preparedness and Response for a Nuclear or Radiological Emergency (IAEA Safety Standards Series No. GS-R-2), and to help in the fulfilment of the IAEA's obligations under the Assistance Convention. It provides generic criteria for protective actions and other response actions in the case of a nuclear or radiological emergency, including numerical values of these criteria. It also presents operational criteria derived from specific generic criteria.

The Food and Agriculture Organization of the United Nations (FAO), the International Labour Office (ILO), the Pan American Health Organization (PAHO) and the World Health Organization (WHO) are joint sponsors of this Safety Guide.

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[1] have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

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

Safety Fundamentals

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

Safety Requirements

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

Safety Guides

Safety Guides provide recommendations and guidance on how to comply with the safety requirements, indicating an international consensus that it is necessary to take the measures recommended (or equivalent alternative measures). The Safety Guides present international good practices, and increasingly they reflect best

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

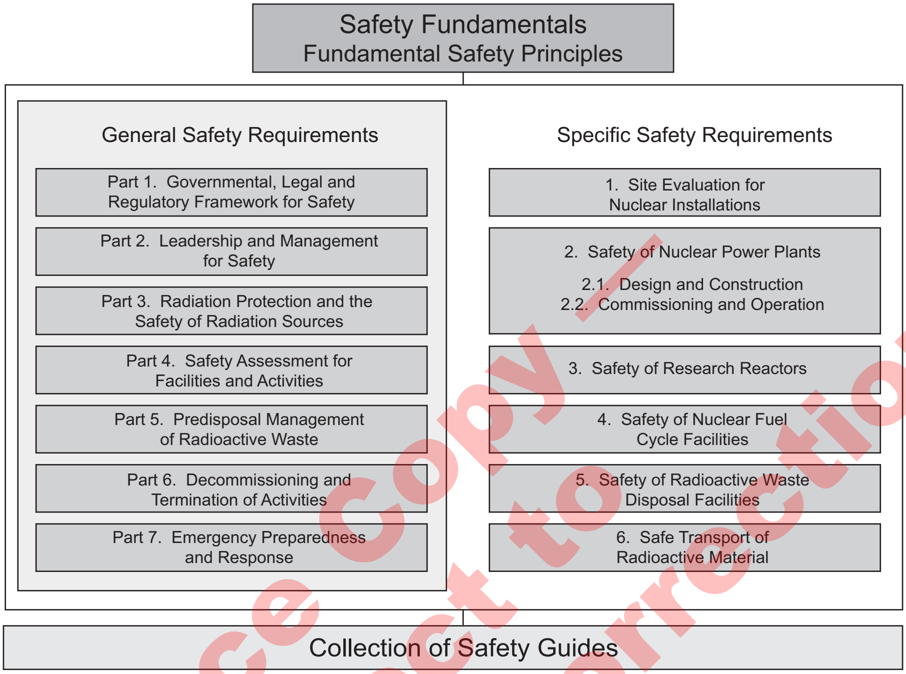

FIG. 1. The long term structure of the IAEA Safety Standards Series.

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 four safety standards committees, for nuclear safety (NUSSC), radiation safety (RASSC), the safety of radioactive waste (WASSC) and the safe transport of radioactive material (TRANSSC), and a Commission on Safety Standards (CSS) which oversees the IAEA safety standards programme (see Fig. 2).

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

A management system has been established for the processes of planning, developing, reviewing, revising and establishing the IAEA safety standards. It articulates the mandate of the IAEA, the vision for the future application of the

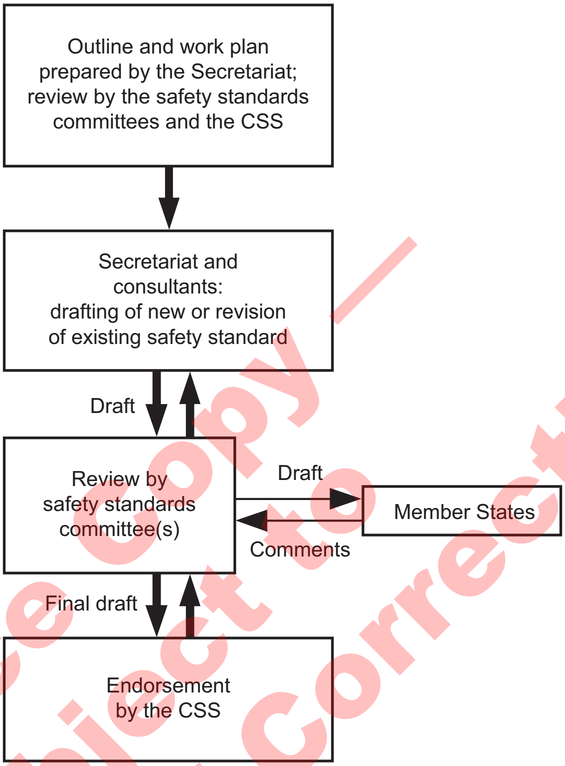

FIG. 2. The process for developing a new safety standard or revising an existing standard.

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.

CONTENTS

1. INTRODUCTION

BACKGROUND

1.1. Under Article 5a(ii) of the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency ('the Assistance Convention') [1], one function of the IAEA is to "collect and disseminate to States Parties and Member States information concerning … methodologies, techniques and available results of research relating to response to nuclear accidents or radiological emergencies".

1.2. In March 2002, the IAEA's Board of Governors approved a Safety Requirements publication, Preparedness and Response for a Nuclear or Radiological Emergency, which establishes the requirements for an adequate level of preparedness for and response to a nuclear or radiological emergency in any State. This was jointly sponsored by seven international organizations and was issued as IAEA Safety Standards Series No. GS-R-2 [2].

1.3. A rigorous assessment of experience in Member States has shown that there is a need for additional consistent international guidance on taking protective actions and other response actions[1], and for placing this guidance in a context that is comprehensive for decision makers and that can be explained to the public. In 2005, the IAEA issued a publication, jointly sponsored by the World Health Organization (WHO) [3], that presents numerical values for generic criteria for emergency response and provides additional guidance. The criteria are described and needs for their development on the basis of lessons learned from experience and related scientific knowledge are explained. The framework proposed in Ref. [3] was used as the starting point for developing revised international guidance on emergency preparedness and response.

1.4. Principle 9 of the Fundamental Safety Principles establishes that arrangements for emergency preparedness and response include "[c]riteria set in advance for use in determining when to take different protective actions" (Ref. [4], para. 3.36). The present Safety Guide provides recommendations on such criteria.

---

[1] Examples of other response actions include the provision of public information, medical treatment and long term health monitoring.

1.5. Safety related terms used in this Safety Guide are to be understood as defined in the IAEA Safety Glossary [5].

OBJECTIVE

1.6. The primary objective of this Safety Guide is:

— To present a coherent set of generic criteria (expressed numerically in terms of radiation dose) that form a basis for developing the operational levels needed for decision making concerning protective actions and other response actions necessary to meet the emergency response objectives. The set of generic criteria:
  - Addresses the requirements of Ref. [2] for emergency preparedness and response;
  - Addresses lessons learned from responses to past emergencies;
  - Provides an internally consistent foundation for the application of principles of and insights into radiation protection for the conceivable range of protective actions and other response actions, and of emergency conditions.

— To propose a basis for a plain language explanation of the criteria for the public and for public officials that addresses the risks to human health of radiation exposure and provides a basis for a response that is commensurate with the risks.

1.7. This Safety Guide should be used in conjunction with Ref. [2], which it supports. It provides recommendations on meeting the requirements of Ref. [2] by providing generic criteria, and numerical values for these criteria, for protective actions and other response actions in the event of a nuclear or radiological emergency. This Safety Guide also presents operational criteria derived from specific generic criteria and as such represents the revision of Ref. [6].

SCOPE

1.8. The recommendations presented in this Safety Guide concern the values of the generic criteria needed to develop operational criteria for implementing protective actions and other response actions to protect emergency workers and the public in the event of a nuclear or radiological emergency.

1.9. Examples of default operational criteria for implementing protective actions and other response actions are also provided. The method used for the development of operational criteria is described only in general terms.[2]

1.10. This Safety Guide addresses the criteria for initiating protective actions and other response actions and criteria to support decision making in an emergency.

1.11. This Safety Guide excludes recommendations for actions that might be required in an existing exposure situation.

1.12. This Safety Guide does not provide detailed guidance on the arrangements necessary for developing and maintaining an effective emergency response capability. Detailed recommendations on developing and maintaining an effective emergency response capability are provided in Refs [7–9].

1.13. This Safety Guide cannot take into account all factors that are site specific, local, State specific or specific to a particular type of emergency. Emergency planners should remain flexible in their use of the guidance and should work with interested parties to adapt the recommendations so as to take account of local, social, political, economic, environmental, demographic and other factors.

1.14. Protective actions and other response actions are not based on attributes relating to radiation protection alone. Decision makers should consider various social, economic, environmental and psychological factors before making any final decision on actions to be taken in response to an emergency. However, the recommendations on generic and operational criteria presented in this Safety Guide relate solely to that input into the decision making process that is based on considerations of radiation protection.

1.15. Decision makers in an emergency and the public may have only a limited or no understanding of the principles of radiation protection, the risks associated with radiation exposure and the appropriate actions that can be taken to reduce these risks. This Safety Guide therefore also provides a plain language explanation of the operational criteria, to assist in the communication of the purpose of each of the criteria and the associated protective actions and other response actions.

[2] A manual for assessment of field data in a nuclear or radiological emergency is in preparation.

STRUCTURE

1.16. This Safety Guide has five sections. Section 2 provides a discussion of the basic considerations used in the development of the recommendations. Sections 3 and 4 provide recommendations on emergency response criteria for protective actions and other response actions for protecting the public and on guidance values for emergency workers, respectively. Section 5 discusses operational criteria. The four appendices provide further elaboration on and clarification of the recommendations provided in the main text.

2. BASIC CONSIDERATIONS

2.1. Experience has clearly shown that an internationally endorsed, fully integrated system of guidance is necessary for taking consistent protective actions and other response actions in an emergency that will best ensure public safety. This system should build on existing international guidance and experience, should be based on international consensus and should subsequently be implemented at the national level. Implementing compatible systems at the national level in different States will allow the objectives of emergency response to be met and will contribute towards establishing a harmonized system for emergency preparedness and response worldwide.

2.2. The framework of generic criteria for emergency response presented in this Safety Guide was developed on the understanding that it should be simple and consistent.

2.3. This Safety Guide was developed with due consideration of the relevant international guidance that provides recommendations for the response to a nuclear or radiological emergency [2, 6, 10–15].

2.4. The recommendations presented in the Safety Guide address health consequences due to external exposure and internal exposure of specific target organs, for which the generic criteria were developed. For the recommendations on how to meet the requirements of Ref. [2], thresholds for severe deterministic effects[3] for both external exposure and internal exposure were developed that could be directly related to the full range of important radionuclides.

---

[3] A deterministic effect is considered to be a severe deterministic effect if it is fatal or life threatening or if it results in a permanent injury that reduces quality of life [2, 5].

2.5. Generic criteria are based on current knowledge of deterministic and stochastic effects (see Ref. [3] for the basis for the numerical values of the criteria addressing deterministic and stochastic effects).

3. FRAMEWORK FOR EMERGENCY RESPONSE CRITERIA

SYSTEM OF PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS

3.1. The system of protective actions and other response actions in an emergency (see Table 1) includes numerical values of generic criteria as well as of the corresponding operational criteria that form the basis for decision making in an emergency.

TABLE 1. SYSTEM OF PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS IN AN EMERGENCY

Types of possible health consequences of exposure	Basis for implementation of protective actions and other response actions	
	Projected dose	Dose received
Severe deterministic effects[a]	Implementation of precautionary urgent protective actions, even under adverse conditions, to prevent severe deterministic effects	Other response actions[b] for treatment and management of severe deterministic effects
Increase in stochastic effects	Implementation of urgent protective actions and initiation of early protective actions[c] to reduce the risk of stochastic effects as far as reasonably possible	Other response actions[d] for early detection and effective management of stochastic effects

[a] Generic criteria are established at levels of dose that are approaching the thresholds for severe deterministic effects.

[b] Such actions include immediate medical examination, consultation and treatment as indicated, contamination control, decorporation where applicable, registration for long term health monitoring, and comprehensive psychological counselling.

[c] Such actions include relocation and long term restriction of consumption of contaminated food.

[d] Such actions include screening based on individual doses to specific organs, to consider the need for registration for medical follow-up and counselling to allow informed decisions to be made in individual circumstances.

3.2. The following considerations form the basis of this system:

— The following possible outcomes should be considered during the planning and implementation of protective actions and other response actions in an emergency:
  - Development of severe deterministic effects[4];
  - Increase in stochastic effects;
  - Adverse effects on the environment and property;
  - Other adverse effects (e.g. psychological effects, social disorder, economic disruption).

— The following types of exposure should be taken into account in the planning and implementation of protective actions and other response actions in an emergency:
  - The projected dose that could be prevented or reduced by means of precautionary urgent protective actions;
  - The dose that has been received, the detriment due to which may be minimized by, for example, medical actions, as required, and may be addressed by public reassurance or counselling.

— Precautionary urgent protective actions should be implemented before the event (on the basis of a substantial risk of a release or exposure) under any circumstances, in order to prevent the development of severe deterministic effects for very high levels of dose (generic criteria are presented in Table 2).

— If the risk of stochastic effects is the main concern and the risk of the development of severe deterministic effects is negligible, urgent and early protective actions and other response actions, all of which are justified and optimized, should be implemented to reduce the risk of stochastic effects (generic criteria are presented in Table 3).

— If the dose exceeds a particular generic criterion identified in Table 2 or 3, individuals should be provided with appropriate medical attention, including medical treatment[5], long term health monitoring and psychological counselling.

[4] See Appendix I.

[5] Medical actions should be initiated and performed on the basis of medical symptoms and observations. However, dosimetric information (e.g. based on radiation survey data, dose measurements or dose calculations) can provide a valuable input for determining the medical treatment.

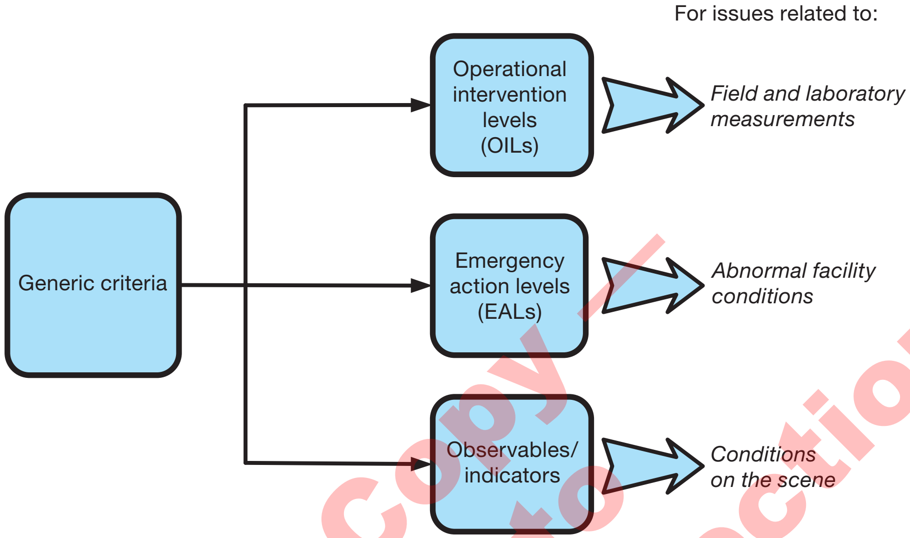

FIG. 1. System of generic criteria and operational criteria.

— For all levels of dose that may result in an emergency exposure situation, a plain language explanation of the risks should be provided to decision makers and the public to allow them to make informed decisions about what actions they will take.

3.3. Table 1 summarizes, for different types of possible health consequences of exposure, the basis for implementation of protective actions and other response actions. A summary of the dose concepts and the dosimetric quantities is provided in Appendix I.

3.4. The system of generic criteria and operational criteria is illustrated in Fig. 1. Generic criteria are provided in terms of dose that can be projected or dose that has already been received. The operational criteria[6] are values of measurable quantities or observables that include operational intervention levels (OILs), emergency action levels (EALs), specific observables and other indicators of conditions on the scene that should be used in decision making during an

[6] These operational criteria are used as 'triggers' at the early stage of an emergency, and in some publications the term 'trigger' is used.

emergency. The operational criteria can be used immediately and directly to determine the need for appropriate protective actions and other response actions.

3.5. Generic criteria have been established on the basis of generic optimization in consideration of the range of conditions that prevail in an emergency. Generic criteria are established for urgent protective actions and early protective actions, as well as for other response actions that may be required in an emergency. Urgent protective actions (e.g. evacuation) should be taken promptly (e.g. within hours) to be effective, because their effectiveness will be reduced by delay [6]. Early protective actions should be implemented within days or weeks to be effective. They can be long lasting, even after the emergency (e.g. temporary relocation). In no case should urgent protective actions and early protective actions based on the generic criteria cause more detriment than they avert. Event specific conditions may warrant modification of the generic criteria.

3.6. The generic criteria replace the system of generic intervention levels (GILs) and generic action levels (GALs) that have been described in previous standards [6, 10]. This use of generic criteria meets the need for a common term for the system of values that would be used as the basis for the implementation of protective actions (e.g. evacuation or food replacement) and other response actions (e.g. medical follow-up).

3.7. A protection strategy, comprising specific protective actions and other response actions, should be developed. It should include, but should not be limited to, the following aspects:

- Generic criteria for implementing precautionary urgent protective actions to prevent severe deterministic effects should be established (see Table 2).
- A reference level should be set, typically an effective dose of between 20 and 100 mSv, expressed in terms of residual dose, which includes dose contributions via all exposure pathways. The protection strategy should be optimized to reduce exposures below the reference level.
- On the basis of the outcome of the optimization of the protection strategy, and by using the reference level, generic criteria for particular protective actions and other response actions, expressed in terms of projected dose or dose that has been received, should be developed. If the numerical values of the generic criteria are expected to be exceeded, those actions, either individually or in combination, should be implemented. Table 3 provides a set of generic criteria for use in the protection strategy that are compatible with reference levels within a range of 20–100 mSv, as well as further details for specific actions in different time frames. The implementation of

protective actions and other response actions, given in Table 3, would prevent a significant amount of dose.

— Once the protection strategy has been optimized and a set of generic criteria has been developed, default triggers for initiating the different parts of an emergency response plan, primarily for the early phase, should be derived from the generic criteria. Default triggers, such as conditions on the scene, OILs and EALs, should be expressed in terms of parameters or observable conditions. Arrangements should be established in advance to revise these triggers, as appropriate, in an emergency exposure situation, with account taken of the prevailing conditions as they evolve.

3.8. Table 2 presents generic criteria (expressed in terms of the dose that is projected or dose that has been received) for taking precautionary urgent protective actions under any circumstances to prevent severe deterministic effects.

3.9. Table 3 provides a set of generic criteria expressed in terms of the dose that has been projected or the dose that has been received. The set of generic criteria expressed in terms of the projected dose compatible with reference levels within a range of 20–100 mSv. Taking protective actions at this level of dose will allow the occurrence of all deterministic effects to be avoided and the risk of stochastic effects to be reduced to acceptable levels. If a protective action is implemented effectively, the majority of the projected dose can be averted. The concept of averted dose is therefore useful for the assessment of the efficiency of individual protective actions or their combination. The concept of averted dose represents an important component of the optimization of emergency response planning [15]. In the application of generic criteria for individual protective actions, the process of optimization of emergency response planning should be applied.

3.10. The generic criterion provided in Table 3 for iodine thyroid blocking is applied for an urgent protective action: (a) if exposure due to radioactive iodine is involved, (b) before or shortly after a release of radioactive iodine, and (c) within only a short period after the intake of radioactive iodine. Less disruptive protective actions such as sheltering could be implemented for lower doses.

3.11. In the absence of national guidance, the generic criteria presented in Tables 2 and 3 could be used as a basis for the development of criteria at the national level. If a reference level different from 20–100 mSv is chosen, appropriate scaling of the values of the generic criteria in Table 3 should be carried out, with account taken of the time frame (acute or annual) of the

TABLE 2. GENERIC CRITERIA FOR ACUTE DOSES FOR WHICH PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS ARE EXPECTED TO BE TAKEN UNDER ANY CIRCUMSTANCES TO AVOID OR TO MINIMIZE SEVERE DETERMINISTIC EFFECTS

Generic criteria		Examples of protective actions and other response actions
External acute exposure (<10 hours)		If the dose is projected:
$AD_{\text{Red marrow}}$[a]	1 Gy	— Take precautionary urgent protective actions immediately (even under difficult conditions) to keep doses below the generic criteria
AD_{Fetus}	0.1 Gy	— Provide public information and warnings
AD_{Tissue}[b]	25 Gy at 0.5 cm	— Carry out urgent decontamination
AD_{Skin}[c]	10 Gy to 100 cm^2	
Internal exposure from acute intake (Δ = 30 days)[d]		If the dose has been received:
$AD(\Delta)_{\text{Red marrow}}$	0.2 Gy for radionuclides with $Z \geq 90$[e] 2 Gy for radionuclides with $Z \leq 89$[e]	— Perform immediate medical examination, consultation and indicated medical treatment
$AD(\Delta)_{\text{Thyroid}}$	2 Gy	— Carry out contamination control
$AD(\Delta)_{\text{Lung}}$[g]	30 Gy	— Carry out immediate decorporation[f] (if applicable)
$AD(\Delta)_{\text{Colon}}$	20 Gy	— Carry out registration for long term health monitoring (medical follow-up)
$AD(\Delta')_{\text{Fetus}}$[h]	0.1 Gy	— Provide comprehensive psychological counselling

[a] $AD_{\text{Red marrow}}$ represents the average RBE weighted absorbed dose to internal tissues or organs (e.g. red marrow, lung, small intestine, gonads, thyroid) and to the lens of the eye from exposure in a uniform field of strongly penetrating radiation.

[b] Dose delivered to 100 cm^2 at a depth of 0.5 cm under the body surface in tissue due to close contact with a radioactive source (e.g. source carried in the hand or pocket).

[c] The dose is to the 100 cm^2 dermis (skin structures at a depth of 40 mg/cm^2 (or 0.4 mm) below the body surface).

[d] $AD(\Delta)$ is the RBE weighted absorbed dose delivered over the period of time Δ by the intake (I_{05}) that will result in a severe deterministic effect in 5% of exposed individuals.

[e] Different criteria are used to take account of the significant difference in the radionuclide specific intake threshold values for the radionuclides in these groups [3].

[f] The generic criterion for decorporation is based on the projected dose without decorporation. Decorporation is the biological processes, facilitated by a chemical or biological agent, by which incorporated radionuclides are removed from the human body.

[g] For the purposes of these generic criteria, ‘lung’ means the alveolar-interstitial region of the respiratory tract.

[h] For this particular case, Δ' means the period of in utero development.

TABLE 3. GENERIC CRITERIA FOR PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS IN EMERGENCY EXPOSURE SITUATIONS TO REDUCE THE RISK OF STOCHASTIC EFFECTS

Generic criteria		Examples of protective actions and other response actions
Projected dose that exceeds the following generic criteria: Take urgent protective actions and other response actions		
$H_{Thyroid}$	50 mSv in the first 7 days	Iodine thyroid blocking
E	100 mSv in the first 7 days	Sheltering; evacuation; decontamination; restriction of consumption of food, milk and water; contamination control; public reassurance
H_{Fetus}	100 mSv in the first 7 days	
Projected dose that exceeds the following generic criteria: Take protective actions and other response actions early in the response		
E	100 mSv per annum	Temporary relocation; decontamination; replacement of food, milk and water; public reassurance
H_{Fetus}	100 mSv for the full period of in utero development	
Dose that has been received and that exceeds the following generic criteria: Take longer term medical actions to detect and to effectively treat radiation induced health effects		
E	100 mSv in a month	Screening based on equivalent doses to specific radiosensitive organs (as a basis for medical follow-up), counselling
H_{Fetus}	100 mSv for the full period of in utero development	Counselling to allow informed decisions to be made in individual circumstances

Note: H_T — equivalent dose in an organ or tissue T; E — effective dose.

reference level. In exceptional circumstances, higher values of the generic criteria may be necessary.

3.12. Examples of when such higher values of generic criteria in exceptional circumstances may be warranted include cases in which replacement food or water is not available, cases of extreme weather conditions, natural disasters, the rapid progression of a situation and cases of malicious acts. Generic criteria used in such cases should not exceed those presented in Table 3 by a factor of more than 2–3.

SUBSTANTIAL RISK AS A BASIS FOR OPERATIONAL CRITERIA

3.13. The risk associated with a radioactive release or exposure is considered to be a 'substantial risk' if the release or exposure could result in early deaths or other severe deterministic effects.

3.14. The term 'substantial risk' is the basis for operational criteria for decision makers to take actions to prevent severe deterministic effects by keeping doses below those approaching the generic criteria set out in Table 2. These precautionary urgent protective actions are warranted under any circumstances [2].

3.15. Emergencies can result in early deaths or other severe deterministic effects unless urgent protective actions are taken. Examples include a nuclear emergency in a facility in threat category I [2], such as severe core damage at a nuclear power plant, a criticality accident or a radiological emergency in threat category IV involving a lost or stolen source or the malicious use of radioactive material [16]. For such emergencies, observed conditions indicating a substantial risk associated with a release or exposure that could result in severe deterministic effects should warrant precautionary urgent protective actions.

3.16. Reference [2] addresses this issue by stating that facilities in threat categories I, II and III[7] shall have appropriate arrangements in place for promptly detecting, classifying and responding to emergencies for which precautionary urgent protective actions should be taken to protect workers and the public from severe deterministic effects. Generic criteria, based on projected dose, for precautionary urgent protective actions to prevent severe deterministic effects, as provided in Table 2, should be used as the dosimetric criteria in defining those emergencies that have the potential to result in such health effects.

3.17. For emergencies in threat category IV [2] involving dangerous sources[8], precautionary urgent protective actions should also be undertaken before or shortly after the start of a release or exposure. These include transport and other authorized activities involving dangerous sources such as industrial radiography

---

[7] Threat categories I, II and III represent decreasing levels of threat at facilities and of the corresponding stringency of requirements for emergency preparedness and response arrangements. See para. 3.6 and table I of Ref. [2] for more details.

[8] A dangerous source is a source that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects. This categorization is used for determining the need for emergency response arrangements and is not to be confused with categorization of sources for other purposes.

sources, nuclear powered satellites or radiothermal generators, as well as events involving possible unauthorized activities. Reference [2] establishes that the operator of a practice using a dangerous source shall make arrangements to respond promptly to an emergency involving the source in order to mitigate any consequences (Ref. [2], para. 4.37). The generic criteria in Table 2 are used as the dosimetric criteria in defining those sources that are considered dangerous [8, 17]. In addition, local officials should develop predetermined criteria for initiating precautionary urgent protective actions upon identifying a situation that could result in severe deterministic effects if no action were taken [18].

PROJECTED DOSE AS A BASIS FOR OPERATIONAL CRITERIA

3.18. The projected dose is the basis for operational criteria for decision makers to take actions that meet the following three objectives [2]:

— To prevent severe deterministic effects by keeping the dose below levels approaching the generic criteria in Table 2 at which urgent protective actions are warranted under any circumstances;
— To take effective protective actions and other response actions to reasonably reduce the risk of stochastic effects by keeping the dose below levels approaching the generic criteria in Table 3;
— To ensure the safety of emergency workers in the tasks being undertaken through the use of the guidance values in Table 4.

3.19. Urgent protective actions should always be introduced to avoid doses approaching levels at which, if received, severe deterministic effects could occur. It should be recognized that the doses received before implementation of the protective action could contribute to the induction of deterministic effects.

3.20. When assessing projected doses, the dose distribution should be considered together with the uncertainty in the dose distribution in the population under consideration. When exposure is being assessed for members of the public, the possibility of the presence of children and pregnant women should be considered.

3.21. The generic criteria in Table 2 are given separately for intake of radioactive material and for external exposure. For external exposure, the threshold for the development of deterministic effects depends on the dose, the dose rate and the relative biological effectiveness (RBE) of the radiation. For internal exposure, the threshold depends on many factors, such as intake activity, half-life, route of intake, the radionuclide emitted and the metabolism of the radionuclide. In order to take all of these factors into account, the threshold for the development of specific deterministic effects following intake is best established in terms of intake activity [3]. However, the thresholds in terms of intake range over six orders of magnitude [3]. Establishing threshold values in terms of the 30 day committed RBE weighted dose relative to the intake thresholds leads to a decrease in the range of threshold values from six orders of magnitude (for the intake) down to a factor of three (for the dose). Therefore, in the case of inhalation or ingestion of radioactive material, a value of the 30 day committed RBE weighted absorbed dose is used to specify the threshold for the possible onset of severe deterministic effects in the organ concerned.

3.22. The RBE weighted averaged absorbed dose in an organ or tissue (RBE weighted absorbed dose) is defined as the product of the averaged absorbed dose in an organ or tissue and the RBE. The unit used to express the RBE weighted absorbed dose is the gray (Gy). For details see Appendix I.

3.23. In the case of combined internal and external exposure, the sum of the RBE weighted absorbed doses for intake of radioactive material and for external exposure may be used as a basis for calculation of OILs for decision making purposes, as discussed in detail in para. II.5 of appendix II of Ref. [3].

3.24. The generic criteria in Table 2 should be used to derive OILs for taking precautionary urgent protective actions and other response actions to prevent severe deterministic effects. For the purpose of taking actions to reduce the risk of stochastic effects, the principles of both justification and optimization require consideration of the benefit that would be achieved by the protective actions and other response actions and of the harm, in its broadest sense, that would result from them. Actions to prevent doses approaching those in Table 2 are always justified.

3.25. Table 3 provides the generic criteria that should be used to derive OILs for taking urgent and early protective actions and other response actions. The protection provided by applying these generic criteria has been optimized on a generic basis for the general population, assuming that other hazardous conditions do not prevail at the time the actions are implemented. The proposed values do not need to be adjusted to take account of any particular members of the population (e.g. children or pregnant women) because protective action taken to avert these doses will satisfy the basic principle for the whole population.

DOSE THAT HAS BEEN RECEIVED AS A BASIS FOR OPERATIONAL CRITERIA

3.26. In describing the dose that has been received, there is a need to distinguish between the planning stage and an actual situation. In the planning stage, the hypothetical dose that will be received falls under the definition of residual dose (the dose expected to be incurred in the future after protective actions have been terminated or a decision has been taken not to implement protective actions). In an actual situation, the dose that has been received is the actual dose received via all exposure pathways.

3.27. The dose that has been received is the basis for operational criteria to support the following actions:

— To provide medical care, as required, when the dose received exceeds the levels in Table 2 (see footnote 3 on page 4);
— To consider the need for medical follow-up for early detection and effective treatment of radiation induced cancers if the dose received exceeds the levels in Table 3;
— To provide counselling to those exposed, including pregnant women, so that they can make informed decisions concerning the further course of their treatment if the dose received exceeds the levels in Tables 2 and 3;
— To provide a basis for reassuring those who were not exposed above the levels specified in Tables 2 and 3 that there is no need for concern.

3.28. The dose that has been received supports decisions for urgent and longer term medical actions. Examples of urgent actions are medical triage on the scene of an emergency and specialized treatment in hospital shortly after an emergency. These actions are initiated and performed on the basis of medical symptoms and observations. However, in the performance of medical triage on the scene, observables (e.g. radiation signs and placards) and radiation survey data should be taken into account when they become available. Decisions on the implementation of medical actions in the hospital (e.g. the extent of exposed tissue to be excised during surgical treatment for local radiation injury and the efficiency of decorporation for internal contamination) are strongly supported by the dosimetric information. Long term health monitoring of exposed persons starts early during the response and continues for an extended period of time.

3.29. Medical records made during an emergency (especially on the site) should be focused on clinical symptoms and other observed facts, without including assumptions of causal association with radiation exposure. Such assumptions might lead to anxiety and unjustified medical examination. Determining the cause of the symptoms requires analysis by experts.

3.30. There are different reasons to perform long term health monitoring of the persons affected, such as to provide advanced medical care, to reduce their concern with regard to their health status and to advance scientific knowledge. The reason for follow-up studies should be carefully explained to those involved.

3.31. Long term medical follow-up is justified to detect and treat late deterministic effects and their complications as well as radiation induced cancers. Long term health monitoring should be justified on the basis of one of the following levels of exposure:

— Long term health monitoring is always justified at levels of dose above the thresholds for deterministic effects [3].
— Justification of long term health monitoring at levels of dose below the thresholds for deterministic effects requires proper identification of populations at higher risk of developing radiation induced cancers. Medical follow-up should always result in more benefit than harm in terms of public health. One reason for establishing a registry and providing medical follow-up is for the early detection of disease. This is on the basis of the assumption that earlier diagnosis of cancer will result in more efficient treatment and thus in reduced morbidity and mortality. The level of exposure of radiosensitive organs expressed in equivalent dose and the possibility of detecting cancer among the exposed population should be taken into account when establishing the registry.

3.32. Current epidemiological data show that radiation induced cancers (the excess number of cancer cases above background cancer cases) could be statistically detected in large populations exposed at doses above 0.1 Sv delivered at high dose rates. These data are based on epidemiological studies of well defined populations (e.g. the survivors of the atomic bombings in Japan and patients undergoing radiological medical procedures). Epidemiological studies have not demonstrated such effects in individuals exposed at low doses (less than 0.1 Sv) delivered over a period of many years [19]. The inclusion in long term health monitoring programmes of persons who have received very low doses may cause unnecessary anxiety. Moreover, it is not cost effective in terms of public health care.

3.33. Assessment of long term follow-up after the Chernobyl accident in 1986 revealed that medical follow-up of persons receiving doses below 1 Gy may not be justified, except in the case of absorbed doses to the thyroid. As cited in the WHO Report on Health Effects of the Chernobyl Accident and Special Health Care Programmes [20], cancer screening tests for asymptomatic persons have not been beneficial in terms of improving either survival or quality of life, except screening for breast cancer and cervical cancer through mammography and Pap[9] tests, respectively. Thyroid cancer screening following emergencies involving the release of radioactive isotopes of iodine has proved very effective for earlier diagnosis and treatment of children exposed following the Chernobyl accident.

3.34. Exposed persons should be provided with adequate information about the long term risk due to their radiation exposure, including assurance of no further actions being required.

4. GUIDANCE VALUES FOR EMERGENCY WORKERS

4.1. An emergency worker is a person having specified duties as a worker in response to an emergency, who might be exposed while taking actions in response to the emergency. Emergency workers may include those employed by registrants and licensees as well as personnel from response organizations, such as police officers, firefighters, medical personnel, and drivers and crews of evacuation vehicles.

4.2. Reference [2], para. 4.60, states that

> "National guidance that is in accordance with international standards…shall be adopted for managing, controlling and recording the doses received by emergency workers. This guidance shall include default operational levels of dose for emergency workers for different types of response activities, which are set in quantities that can be directly monitored during the performance of these activities (such as the integrated dose from external penetrating radiation). In setting the default operational levels of dose for emergency workers the contribution to doses via all exposure pathways shall be taken into account."

[9] The Papanicolaou test.

4.3. Table 4 recommends guidance values to be used for the protection of emergency workers responding to an emergency.

4.4. Life saving actions resulting in doses that approach or exceed the threshold for severe deterministic effects should be considered only if (a) the expected benefit to others would clearly outweigh the emergency worker's own risk and (b) the emergency worker volunteers to take the action, and understands and accepts this risk.

4.5. Emergency workers who undertake actions in which the doses received might exceed 50 mSv do so voluntarily and should have been clearly and comprehensively informed in advance of the associated health risks, as well as of available protective measures, and should be trained, to the extent possible, in the actions that they may be required to take. The voluntary basis for response actions by emergency workers is usually covered in the emergency response arrangements.

4.6. Emergency workers should receive medical attention appropriate for the dose they may have received (actions according to Tables 2 and 3). The doses received and information concerning the consequent health risks should be communicated to the workers. Female workers who are aware that they are pregnant should be encouraged to notify the appropriate authority and would typically be excluded from emergency duties.

4.7. In almost all emergencies, at best only the dose from external penetrating radiation will be measured continuously. Consequently, the operational guidance provided to emergency workers should be based on measurements of penetrating radiation (e.g. as displayed on an active or self-reading dosimeter). The dose from intake or skin contamination should be limited by means of the use of protective equipment, the use of stable iodine prophylaxis and the provision of instructions concerning operations in potentially hazardous radiological conditions[10]. Available information about radiation conditions on the site should be used in aiding decisions on the appropriate protection of emergency workers.

---

[10] Instructions will cover the application of time, distance and shielding principles, the prevention of ingestion of radioactive material and the use of respiratory protection.

TABLE 4. GUIDANCE VALUES FOR RESTRICTING EXPOSURE OF EMERGENCY WORKERS

Tasks	Guidance value[a]
Life saving actions	$H_P(10)$[b] <500 mSv This value may be exceeded under circumstances in which the expected benefits to others clearly outweigh the emergency worker's own health risks, and the emergency worker volunteers to take the action and understands and accepts this health risk
Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment	$H_P(10)$ <500 mSv
Actions to avert a large collective dose	$H_P(10)$ <100 mSv

[a] These values apply only for the dose from exposure to external penetrating radiation. Doses from exposure to non-penetrating external radiation and from intake or skin contamination need to be prevented by all possible means. If this is not feasible, the effective dose and the equivalent dose to an organ that are received have to be limited to minimize the health risk to the individual in line with the risk associated with the guidance values given here.

[b] $H_P(10)$ is the personal dose equivalent $H_P(d)$ where d = 10 mm.

5. OPERATIONAL CRITERIA

5.1. Projected dose and dose that has been received are not measurable quantities and cannot be used as a basis for quick actions in an emergency. There is a need to establish — in advance — operational criteria (values of measurable default quantities or observables) as a surrogate for the generic criteria for undertaking different protective actions and other response actions. Precautionary urgent protective actions and, as applicable, urgent protective actions should be taken on the basis of precalculated default operational criteria. The majority of urgent protective actions and early protective actions are also implemented on the basis of precalculated default operational criteria. However, if the characteristics of an emergency differ from those assumed in the calculations of default operational criteria, the criteria should be recalculated. Methods for the recalculation to address prevailing conditions in an actual emergency should be established during the planning phase.

5.2. The operational criteria[11] are the EALs, OILs, observables and indicators of conditions on the scene.

5.3. The EALs are the specific, predetermined, observable operational criteria used to detect, recognize and determine the emergency class of an event at facilities in threat categories I, II and III [2]. The EALs are used for classification and for decisions on the implementation of precautionary urgent protective actions corresponding to the emergency class. These criteria should be predefined as stated in Ref. [2] and implemented as described in Refs [7, 8]. Appendix III provides a discussion of the EAL development process and gives examples of EALs for the classification of emergencies at a light water reactor nuclear power plant.

5.4. For emergencies in threat category IV [2], the operational criteria for implementing urgent protective actions should be predetermined on the basis of information that will be observable on the scene. Usually observations that indicate a radiation hazard will be made by first responders or operators on the scene (e.g. upon seeing a placard on a vehicle that has been involved in an accident). References [7, 8, 18] provide guidance on the approximate radius of the inner cordoned area in which urgent protective actions would initially be taken on the basis of information observable by responders upon their arrival on the scene. The size of the cordoned area may be expanded on the basis of dose rate OILs and other environmental measurement OILs (see Appendix II) when these data become available. Reference [18] provides a list of observables that can be used by responders to identify a dangerous source, together with the actions to be taken to protect responders and the public. Reference [17] provides guidance on the activity of a radionuclide that, if not controlled, should be considered to constitute a dangerous source.

5.5. The OIL is a calculated quantity that corresponds to one of the generic criteria. The OILs are used with the other operational criteria (EALs and observables) to determine appropriate protective actions and other response actions. If the OILs are exceeded, the appropriate protective action should be promptly invoked. The OILs are typically expressed in terms of dose rates or activity of radioactive material released, time integrated air concentrations, ground or surface concentrations, or activity concentration of radionuclides in the environment, in food, in water or in biological samples. OILs can be measured by

[11] These operational criteria are used as triggers at the early stage of an emergency; in some publications the term ‘trigger’ is used.

means of instruments in the field or can be determined by means of laboratory analysis or assessment.

5.6. Reference [2], in para. 4.71, states that "arrangements shall be made for promptly assessing the results of environmental monitoring and monitoring for contamination on people in order to decide on or to adapt urgent protective actions to protect workers and the public, including the application of operational intervention levels (OILs) with arrangements to revise the OILs as appropriate to take into account the conditions prevailing during the emergency." In addition, para. 4.89 of Ref. [2] states that default OILs shall be established together with the means to revise the OILs for "environmental measurements (such as dose rates due to deposition and deposition densities) and food concentrations; the means to revise the OILs; timely monitoring...for ground contamination in the field; the sampling and analysis of food and water; and the means to enforce agricultural countermeasures."

5.7. Every effort should be made to keep the system simple by keeping the number of OILs to a minimum. In principle, the default OILs should be a minimum set for each operational quantity (e.g. dose rate due to skin contamination) that, with due consideration of the uncertainties, reasonably encompasses the protective action (e.g. urgent decontamination), applicable generic criteria and associated assumptions (e.g. the type of emergency or the characteristics of the radiological hazard).

5.8. It is possible that, during an emergency, individuals might receive doses that give rise to a high risk of incurring radiation induced cancers. Although it is unlikely, there might be a detectable increase in the incidence of cancers among the population group that has been exposed, owing to radiation induced cases of cancer. Emergencies have occurred for which no criteria for long term health monitoring and treatment had been pre-established. Criteria that have been established after emergencies have occurred have often been set at too low a level of dose received or have not been set on the basis of radiation dose criteria at all. This has led to the designation of groups for follow-up for which it would have been impossible, because of the inherent limitations of epidemiological studies, to detect any increase in the incidence of cancers, owing to the relatively small number of cases of radiation induced cancer to be expected. Default operational criteria are therefore needed for determining whether a person should be considered for long term health monitoring and treatment.

5.9. Reference [2] states a requirement for guidelines relating to the diagnosis and treatment of radiation injuries. These guidelines should include operational criteria used in the dosimetric support of medical management of the patient [21].

5.10. The dosimetric models for developing the OILs should be established during the planning phase. These models should include a full set of parameters important for the purposes of decision making for dose assessment. For internal dose assessment and the development of corresponding OILs, the application of computer codes is necessary.

5.11. The dosimetric models and data should provide reliable assurance that all members of the public, including those that are most sensitive to radiation (e.g. pregnant women), are considered. In the development of the default operational criteria, the public needs to be assured that all groups (e.g. children playing outdoors) have been considered. Consequently, the OILs must be accompanied by a plain language explanation of the situation to which they apply (see Appendix II), the way in which they address a safety or health concern and what their application means in terms of the risk to individuals.

5.12. These default OILs should be developed on the basis of assumptions regarding the emergency, the affected population and the prevailing conditions; these assumptions, however, may not accurately reflect the emergency in question. Consequently, Ref. [2] requires that means be established to revise the default OILs to take into account prevailing emergency conditions. However, revising the OILs during an emergency may be disruptive, and they should therefore only be revised if the situation is well understood and there are compelling reasons to do so. The public should be informed of the reasons for any change in the OILs applied in an actual emergency.

5.13. Appendix II provides selected examples of default OILs for deposition, levels of individual contamination, and contamination levels for food, milk and water, together with a plain language explanation of the OILs.

Appendix I

DOSE CONCEPTS AND DOSIMETRIC QUANTITIES

I.1. There are different dose concepts that are relevant to preparedness for and response to an emergency: projected dose, residual dose and averted dose [5].

I.2. The dosimetric quantities of effective dose, equivalent dose and RBE weighted absorbed dose are used in evaluating radiation induced consequences of a nuclear or radiological emergency. They are listed in Table 5 and illustrated in Fig. 2, and are discussed in the following.

I.3. The RBE weighted averaged absorbed dose in an organ or tissue (RBE weighted absorbed dose, AD_T) is defined as the product of averaged absorbed dose ($D_{R,T}$) of radiation (R) in an organ or tissue (T) and the relative biological effectiveness ($RBE_{R,T}$):

$$AD_{R,T} = \sum_{R} D_{R,T} \times RBE_{R,T} \tag{1}$$

TABLE 5. DOSIMETRIC QUANTITIES USED IN EMERGENCY EXPOSURE SITUATIONS

Dosimetric quantity	Symbol	Purpose
		Radiation protection quantities
RBE weighted absorbed dose	AD_T	For evaluating deterministic effects induced as a result of exposure of an organ or tissue
Equivalent dose	H_T	For evaluating stochastic effects induced as a result of exposure of an organ or tissue
Effective dose	E	For evaluating detriment related to the occurrence of stochastic effects in an exposed population
		Operational quantities
Personal dose equivalent	$H_P(d)$	For monitoring external exposure of an individual
Ambient dose equivalent	$H^*(d)$	For monitoring a radiation field at the site of an emergency

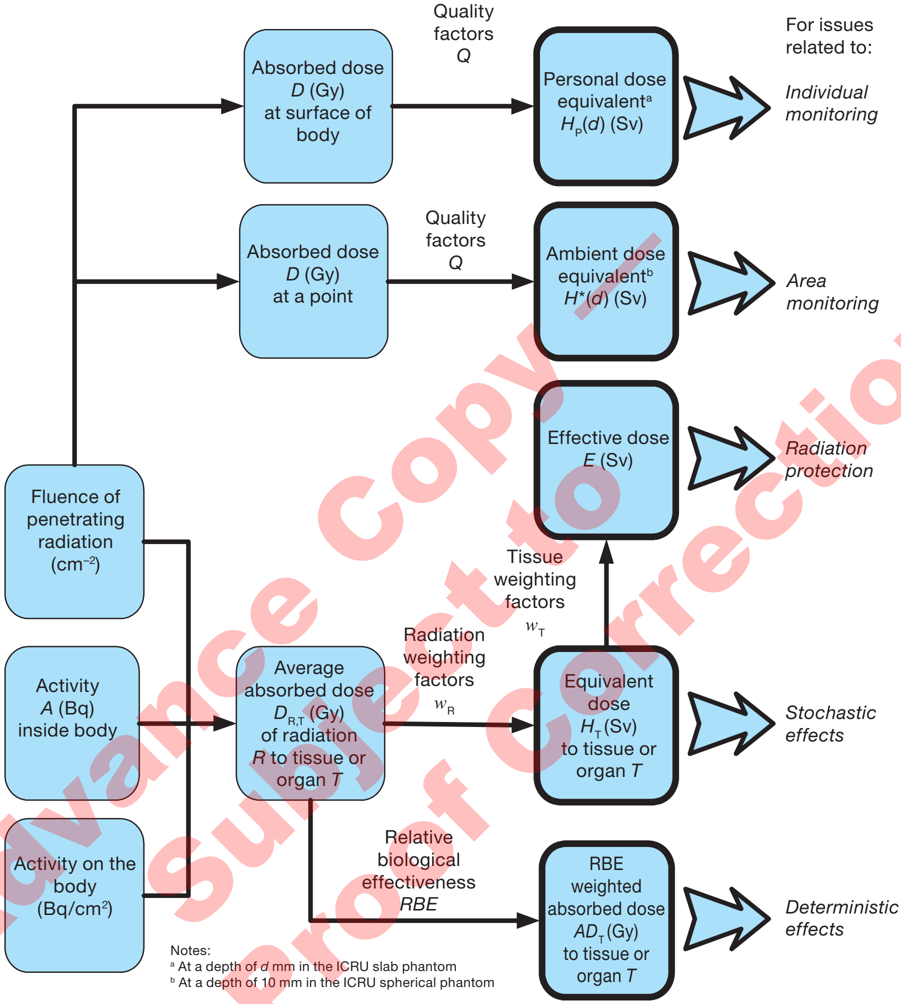

FIG. 2. Dosimetric quantities and their application in emergency exposure situations.

I.4. The value of RBE should be selected with account taken of the type of radiation, the dose and the health effects of concern, as shown in Table 6.

I.5. The International System of Units (SI) unit used to express the RBE weighted absorbed dose is $J{\cdot}kg^{-1}$, which is called the gray (Gy) [14, 22, 23].

TABLE 6. TISSUE SPECIFIC AND RADIATION SPECIFIC VALUES OF RBE FOR THE DEVELOPMENT OF SELECTED SEVERE DETERMINISTIC EFFECTS [3, 17]

Health effect	Critical organ	Exposure[a]	$RBE_{T,R}$
Haematopoietic syndrome	Red bone marrow	External and internal γ	1
		External and internal *n*	3
		Internal β	1
		Internal α	2
Pneumonitis	Lung[b]	External and internal γ	1
		External and internal *n*	3
		Internal β	1
		Internal α	7
Gastrointestinal syndrome	Colon	External and internal γ	1
		External and internal *n*	3
		Internal β	1
		Internal α	0[c]
Necrosis	Soft tissue[d]	External β, γ	1
		External *n*	3
Moist desquamation	Skin[e]	External β, γ	1
		External *n*	3
Hypothyroidism	Thyroid	Intake of iodine isotopes[f]	0.2
		Other thyroid seekers	1

[a] External β, γ exposure includes exposure due to bremsstrahlung produced within the material of the source.
[b] Tissue of the alveolar-interstitial region of the respiratory tract.
[c] For alpha emitters uniformly distributed in the contents of the colon, it is assumed that irradiation of the walls of the intestine is negligible.
[d] Tissue at a depth of 5 mm below the skin surface over an area of more than 100 cm^2.
[e] Tissue at a depth of 0.5 mm below the skin surface over an area of more than 100 cm^2.
[f] Uniform irradiation of the tissue of the thyroid gland is considered to be five times more likely to produce deterministic effects than internal exposure due to low energy beta emitting isotopes of iodine, such as ^{131}I, ^{129}I, ^{125}I, ^{124}I and ^{123}I. Thyroid seeking radionuclides have a heterogeneous distribution in thyroid tissue. The isotope ^{131}I emits low energy beta particles, which leads to a reduced effectiveness of irradiation of critical thyroid tissue owing to the dissipation of the energy of the particles within other tissues.

I.6. The weighted averaged absorbed dose (equivalent dose, H_T) is defined as the product of the averaged absorbed dose in the organ or tissue (D) and the radiation weighting factor w_R [11, 24]:

$$H_T = \sum_R D_{R,T} \times w_R \tag{2}$$

I.7. The weighted averaged absorbed dose (equivalent dose, H_T) is expressed in sieverts (Sv) [22, 24]. It is an organ specific quantity that may be used for assessment of the risk of incurring any radiation induced cancer in an organ.

I.8. The effective dose is widely used in justifying and optimizing protective actions [10]. Its unit is the sievert (Sv) [22]. The total effective dose (E) includes the doses due to external penetrating radiation and due to intake:

$$E = \sum_T H_T \times w_T \tag{3}$$

I.9. The quantities used for radiation monitoring are:

— Ambient dose equivalent ($H^*(d)$); that is, the dose equivalent that would be produced by the corresponding aligned and expanded field in the International Commission on Radiation Units and Measurements (ICRU) sphere at a depth d on the radius opposing the direction of the aligned field;
— Personal dose equivalent ($H_P(d)$); that is, the dose equivalent in soft tissue below a specified point on the body at an appropriate depth d.

The SI unit for these quantities is $J \cdot kg^{-1}$, and they are expressed in Sv.

I.10. Ambient dose equivalent and personal dose equivalent are the operational quantities based on the quantity of dose equivalent. The dose equivalent is the product of the absorbed dose at a point in the tissue or organ and the appropriate quality factor (Q_R) for the type of radiation giving rise to the dose [25]:

$$H = \sum_R D_R \times Q_R \tag{4}$$

TABLE 7. CRITICAL RADIATION INDUCED HEALTH EFFECTS IN A NUCLEAR OR RADIOLOGICAL EMERGENCY [3]

Health effect	Target organ or entity
	Deterministic effects
Fatal	
Haematopoietic syndrome	Red marrow[a]
Gastrointestinal syndrome	Small intestine for external exposure[a] Colon for internal exposure[b]
Pneumonitis	Lung[a,c]
Death of embryo/fetus	Embryo/fetus in all periods of gestation
Non-fatal	
Moist desquamation	Skin[d]
Necrosis	Soft tissue[e]
Cataract	Lens of the eye[a,f]
Acute radiation thyroiditis	Thyroid[a]
Hypothyroidism	Thyroid[a]
Permanently suppressed ovulation	Ovaries[a]
Permanently suppressed sperm count	Testes[a]
Severe mental retardation	Embryo/fetus 8–25 weeks of gestation
Verifiable reduction in intelligence quotient (IQ)	Embryo/fetus 8–25 weeks of gestation
Malformation	Embryo/fetus 3–25 weeks of gestation [26]
Growth retardation	Embryo/fetus 3–25 weeks of gestation [26]
	Stochastic effects
Thyroid cancer	Thyroid
All stochastic effects	All organs taken into account in definition of effective dose

[a] External exposure to the red bone marrow, lung, small intestine, gonads, thyroid and lens of the eye as irradiation in a uniform field of strongly penetrating radiation is addressed by $AD_{\text{Red marrow}}$.

[b] Different targets for gastrointestinal syndrome are proposed because of the difference in the dose formation in the small intestine and colon in the case of internal exposure. This is due to differences in the kinetics of ingested material in the gastrointestinal tract, which lead to much higher doses in the colon than in the small intestine after intake.

[c] For the alveolar-interstitial region of the respiratory system.

[d] Skin structures at a depth of 50 mg/cm^2 (or 0.5 mm) below the surface and over an area of 100 cm^2.

[e] To a depth of 5 mm in tissue.

[f] Lens structures at a depth of 300 mg/cm^2 (or 3 mm) below the surface.

I.11. Table 7 presents a list of radiation induced health effects that would be critical during an emergency. Experience and research indicate that evaluation of the dose to the target organs as presented in the table should provide a basis for selecting operational criteria for making decisions that will address the full range of possible health effects.

Appendix II

EXAMPLES OF DEFAULT OILs FOR DEPOSITION, INDIVIDUAL CONTAMINATION AND CONTAMINATION OF FOOD, MILK AND WATER

GENERAL

II.1. In this appendix, examples of default OILs are provided for use in responding to an emergency that results in contamination, together with a plain language explanation of these OILs and guidance on the use of the OILs (see Tables 8–10). The following example default OILs are provided[12,13]:

(1) OIL1 is a measured value of ground contamination calling for:
- — Urgent protective actions (e.g. evacuation) to keep the dose to any person living in a contaminated area below the generic criteria for urgent protective actions provided in Table 3;
- — Medical actions, as required, because the dose received by evacuees may be above the generic criteria for medical actions provided in Table 3.

(2) OIL2 is a measured value of ground contamination calling for early protective actions to keep the dose for one year to any person living in the area below the generic criteria for taking actions to reasonably reduce the risk of stochastic effects provided in Table 3.

[12] OILs for rates or air concentrations in a plume resulting from an ongoing release are not provided because the example criteria are intended to be very general and practical. OILs for air doses or air concentrations from a plume are not included because: (a) in many cases the significant release will be over by the time results of environmental measurements are available; (b) it is difficult to take and analyse air concentrations in a sample in a timely manner; (c) there is a great variation in time and location of the plume concentrations at any location during a release; and (d) OILs of these types are highly dependent on the nature of the release, which makes it very difficult to develop OILs that apply to the full range of possible releases. During the period of significant release, therefore, protective actions (e.g. evacuation or sheltering, to a predetermined distance) are best taken on the basis of observable criteria. Operating organizations of facilities at which there could be emergencies that result in airborne releases of long duration should develop EALs and possibly facility specific OILs for measurements taken in a plume, for possible airborne releases from the facilities. Examples of OILs for dose rates in a release from a light water reactor resulting from core melt are provided in Ref. [27].

[13] OILs for air concentrations arising from resuspension are not provided because doses arising from resuspension have been considered in the deposition OILs.

(3) OIL3 is a measured value of ground contamination calling for immediate restrictions on the consumption of leaf vegetables, milk from animals grazing in the area and rainwater collected for drinking to keep the dose to any person below the generic criteria for taking the urgent protective actions provided in Table 3.

(4) OIL4 is a measured value of skin contamination calling for performing decontamination or providing instructions for self-decontamination and for limiting inadvertent ingestion so as:
- To keep the dose due to skin contamination to any person below the generic criteria for taking urgent protective action provided in Table 3;
- To initiate medical treatment or screening, as required, because the dose received by any person may exceed the generic criteria for medical actions provided in Table 3.

(5) OIL5 and OIL6 are measured values of concentrations in food, milk or water that warrant the consideration of restrictions on consumption so as to keep the effective dose to any person below 10 mSv per annum.

II.2. For the purposes of describing the use of the OILs, nuclear or radiological emergencies resulting in contamination can be thought of as being of three types:

(1) A nuclear or radiological emergency resulting in contamination of a large area (hundreds of square kilometres) with the possible involvement of a large number of people; that is, contamination of an area so large that, in order to be effective, implementation of urgent protective actions and early protective actions should be performed in two phases: first, urgent protective actions (e.g. evacuation) are taken, followed by early protective actions (e.g. relocation). An emergency of this type could occur at nuclear facilities such as nuclear power plants that are in threat category I or II [2].

(2) A nuclear or radiological emergency resulting in contamination of a moderate area (tens of square kilometres) with the possible involvement of a large number of people; that is, contamination of an area small enough that urgent protective actions and early protective actions can be effectively performed at the same time without the need for a phased response. An emergency of this type could be the result of the explosion of a radiological dispersal device or could be caused by a damaged dangerous radioactive source [28].

(3) A nuclear or radiological emergency resulting in contamination of small areas and/or with the possible involvement of a small number of people; that is, contamination of small areas that can easily and quickly be isolated, with the involvement of a small number of people who can all be decontaminated and medically assessed by using available resources,

without causing any major disruptions. This type of emergency includes those confined to a single room or a single spill. For this type of emergency, the response involves isolating the potentially contaminated area and decontaminating all those involved without necessarily using the OILs.

RESPONDING TO A NUCLEAR OR RADIOLOGICAL EMERGENCY THAT RESULTS IN CONTAMINATION OF A LARGE AREA

II.3. The process of assessing and responding to an emergency of this type through the implementation of protective actions is shown in Fig. 3. First protective actions should be taken on the basis of conditions observed on the scene [7, 18] or on the basis of an emergency classification (see Appendix III, and appendix IV of Ref. [7]) before data from radiological monitoring become available.

II.4. Within hours, areas where ground deposition levels exceed or are likely to exceed OIL1, the default OIL, should be identified and the appropriate urgent protective actions should be taken, such as evacuation, stopping the consumption of local produce, and medical evaluation of evacuees.

II.5. Within hours, actions should also be taken to reduce the consequences of contamination for those people who were in the area where OIL1 was exceeded. If OIL4 is exceeded, the evacuees should be monitored and decontaminated (if these actions can be carried out promptly). If monitoring and decontamination are not immediately possible, the evacuees should be released and instructed to take actions to reduce inadvertent ingestion, and to shower and change their clothing as soon as possible. OIL4 levels may be very difficult to detect under emergency conditions. Therefore, any person who may have been contaminated, including those who were monitored and had contamination levels below OIL4, should take actions to reduce inadvertent ingestion, and should shower and change their clothing as soon as possible. The dose to evacuees should also be evaluated and the medical actions called for in Tables 2 and 3 should be taken, as appropriate.

II.6. Within a day, the areas where ground deposition levels exceed default OIL2 should be identified and early protective actions should be taken, such as stopping the consumption of locally produced vegetables and milk and commencing the process of implementing temporary relocation. Relocation should be accomplished within a week.

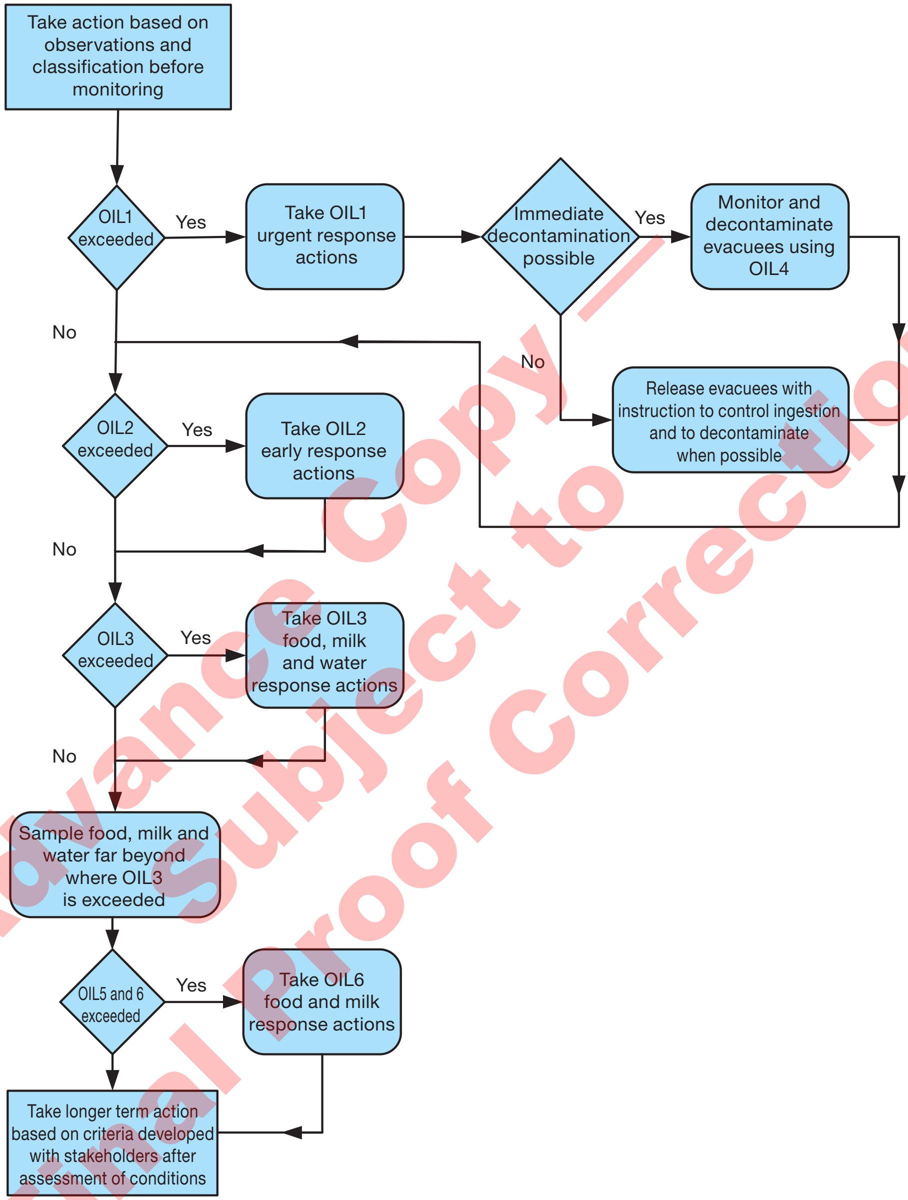

FIG. 3. Process of assessment of a nuclear or radiological emergency resulting in contamination of a large area.

II.7. Within days, the areas where ground deposition levels exceed default OIL3 should be identified and actions should be taken to stop consumption of locally produced vegetables and milk, and of rainwater collected for drinking, until they have been screened and analysed. Within a week, food, milk and water should be screened and analysed, possibly out to a distance of more than 100 km, and actions should be taken to restrict consumption of food, milk and water with concentrations of radionuclides in excess of OIL5 and OIL6.

II.8. Within days, the mixture of the radionuclides over the affected area should be determined and the OILs being used to make decisions should be revised, if warranted.

II.9. Any recommendation to the public to take any protective actions should be accompanied by a plain language explanation of the criteria.

II.10. After the emergency is over, further actions should be taken on the basis of criteria developed after careful assessment of conditions and in consultation with interested parties.

RESPONDING TO A NUCLEAR OR RADIOLOGICAL EMERGENCY RESULTING IN CONTAMINATION OF A MODERATE AREA

II.11. The process of assessing and responding to a nuclear or radiological emergency resulting in contamination of a moderate area through the implementation of protective actions is shown in Fig. 4. First protective actions are taken on the basis of conditions observed on the scene [7, 18] or on the basis of an emergency classification (see Appendix III, and appendix IV of Ref. [7]) before data from radiological monitoring become available.

II.12. Within hours, areas where ground deposition levels exceed default OIL2 should be identified, and the appropriate urgent protective actions and early protective actions should be taken where OIL2 is exceeded. The dose to evacuees should also be evaluated and the medical actions called for in Tables 2 and 3 should be taken.

II.13. Evacuees should be monitored and if OIL4 is exceeded, evacuees should be decontaminated, if this can be done promptly. If monitoring and/or decontamination are not immediately possible, the evacuees should be released

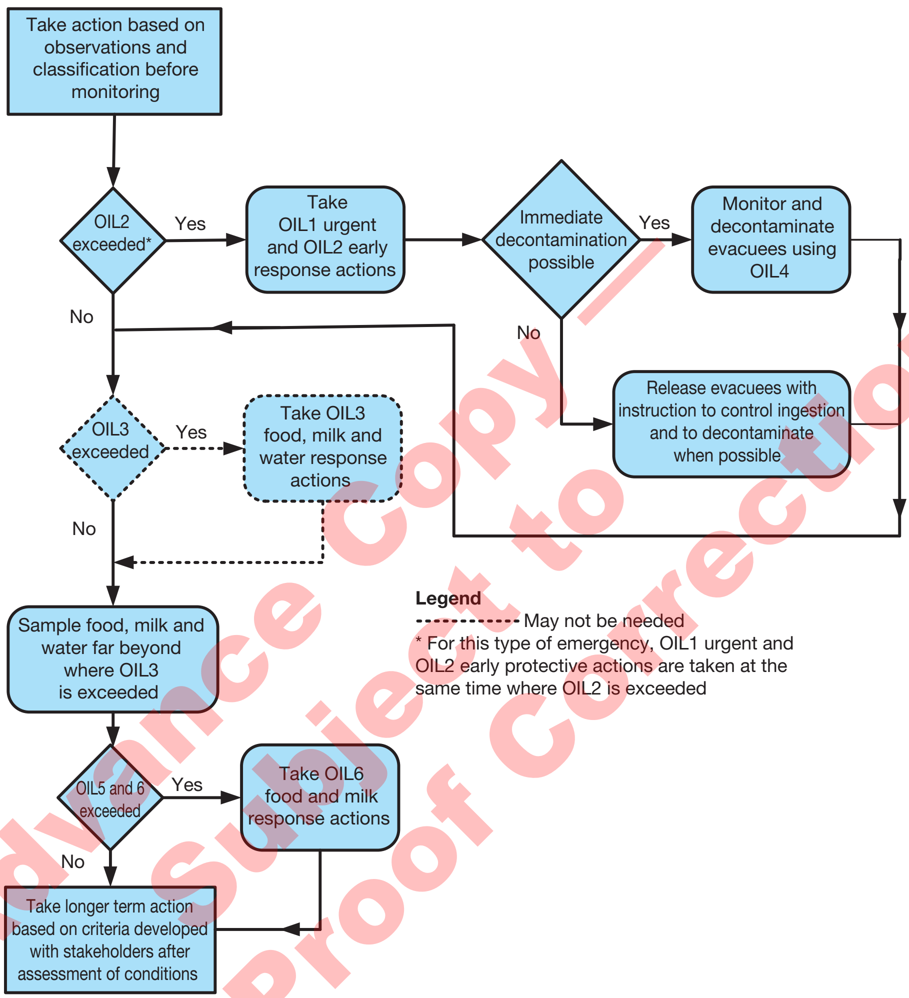

FIG. 4. Process of assessment of a nuclear or radiological emergency resulting in contamination of a moderate area.

and should be instructed to take actions to reduce inadvertent ingestion, and to shower and change their clothing as soon as possible. OIL4 levels may be very difficult to detect under emergency conditions. Any person who may have been contaminated, including those who were monitored and had contamination levels below OIL4, should therefore take actions to reduce inadvertent ingestion, and should shower and change their clothing as soon as possible.

II.14. Within days, areas where ground deposition levels exceed default OIL3 should be identified and actions should be taken to stop the consumption of rainwater and locally produced vegetables and milk until they have been screened and analysed. However, if only limited amounts of food (e.g. fruit and vegetables from local gardens) and non-essential food could have been affected, this step may be omitted, and instead restrictions should be placed on the consumption of all the food that could be contaminated until it can be screened and analysed. Finally, food, milk and rainwater should be screened and analysed, out to a distance of several kilometres, and actions should be taken to restrict the consumption of food, milk and rainwater having concentrations of radionuclides in excess of OIL5 and OIL6.

II.15. Within days, the mixture of radionuclides over the affected area should be determined and the OILs being used to make decisions should be revised, if warranted.

II.16. Any recommendations to the public to take any protective actions should be accompanied by a plain language explanation of the criteria.

II.17. After the emergency is over, further actions should be taken on the basis of criteria developed after careful assessment of the conditions and in consultation with the interested parties.

DEFAULT OILs

II.18. Table 8 contains OILs for assessing the results of field monitoring of contamination of the ground, skin and clothing. Three types of OIL are provided in the units measured by field survey instruments: dose rate (OIL(γ)); beta counts per second (counts/s) for beta radiation (OIL(β)); and alpha counts/s for alpha radiation (OIL(α)). An OIL is exceeded if any of its types are exceeded. These OILs apply for emergencies involving all radionuclides, including fission products released by melting reactor fuel.

II.19. The OILs in Table 8 were established for implementing the protective actions and other response actions in a way consistent with the generic criteria in Tables 2 and 3. In the development of these OILs, all members of the population (including children and pregnant women) as well as all usual activities (such as children playing outdoors) were considered. The OILs were calculated to ensure that the protective actions to be taken protect against the most radiotoxic radionuclides. As a result, the OILs are overly conservative for many

TABLE 8. DEFAULT OILs FOR FIELD SURVEY MEASUREMENTS

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
		Environmental measurements
OIL1	Gamma (γ) 1000 µSv/h at 1 m from surface or a source 2000 counts/s direct beta (β) surface contamination measurement[e] 50 counts/s direct alpha (α) surface contamination measurement[f]	— Immediately evacuate or provide substantial shelter[a] — Provide for decontamination of evacuees[b] — Reduce inadvertent ingestion[c] — Stop consumption of local produce[d], rainwater and milk from animals grazing in the area — Register and provide for a medical examination of evacuees — If a person has handled a source with a dose rate equal to or exceeding 1000 µSv/h at 1 m[e], provide an immediate medical examination
OIL2	Gamma (γ) 100 µSv/h at 1 m from surface or a source 200 counts/s direct beta (β) surface contamination measurement[f] 10 counts/s direct alpha (α) surface contamination measurement[f]	— Stop consumption of local produce[d], rainwater and milk from animals grazing in the area until they have been screened and contamination levels have been assessed using OIL5 and OIL6 — Temporarily relocate those living in the area; before relocation, reduce inadvertent ingestion[c]; register and estimate the dose to those who were in the area to determine if medical screening is warranted; relocation of people from the areas with the highest potential exposure should begin within days — If a person has handled a source with a dose rate equal to or exceeding 100 µSv/h at 1 m[e], provide medical examination and evaluation; any pregnant women who have handled such a source should receive immediate medical evaluation and dose assessment
OIL3	Gamma (γ) 1 µSv/h at 1 m from surface 20 counts/s direct beta (β) surface contamination measurement[f,i] 2 counts/s direct alpha (α) surface contamination measurement[f,i]	— Stop consumption of non-essential[g] local produce[d], rainwater and milk from animals[h] grazing in the area until it has been screened and contamination levels have been assessed using OIL5 and OIL6 — Screen local produce, rainwater and milk from animals[h] grazing in the area out to at least 10 times the distance to which OIL3 is exceeded and assess samples using OIL5 and OIL6 — Consider providing iodine thyroid blocking[j] for fresh fission products[k] and for iodine contamination if replacement for essential[g] local produce or milk is not immediately available — Estimate the dose of those who may have consumed food, milk or rainwater from the area where restrictions were implemented to determine if medical screening is warranted

TABLE 8. DEFAULT OILs FOR FIELD SURVEY MEASUREMENTS (cont.)

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
		Skin contamination
OIL4	Gamma (γ) 1 μSv/h at 10 cm from the skin 1000 counts/s direct beta (β) skin contamination measurement[f] 50 counts/s direct alpha (α) skin contamination measurement[f]	— Provide for skin decontamination[b] and reduce inadvertent ingestion[c] — Register and provide for a medical examination

Note: The OILs should be revised as soon as it is known which radionuclides are actually involved. The OILs should also be revised, if necessary, as part of the preparedness process, to be more consistent with the instruments to be used during the response. However, the default OILs in this table can be used without revision to make a conservative assessment immediately.

[a] Inside closed halls of large multi-storey buildings or large masonry structures and away from walls or windows.

[b] If immediate decontamination is not practicable, advise evacuees to change their clothing and to shower as soon as possible. Guidance on performing decontamination can be found in Refs [18, 21].

[c] Advise evacuees not to drink, eat or smoke and to keep hands away from the mouth until hands are washed.

[d] Local produce is food that is grown in open spaces that may be directly contaminated by the release and that is consumed within weeks (e.g. vegetables).

[e] This external dose rate criterion applies only to sealed dangerous sources and does not need to be revised in an emergency.

[f] Performed using good contamination monitoring practice.

[g] Restricting essential foods could result in severe health effects (e.g. severe malnutrition), and therefore essential foods should be restricted only if replacement food is available.

[h] Use 10% of OIL3 for milk from small animals (e.g. goats) grazing in the area.

[i] Deposition by rain of short lived naturally occurring radon progeny can result in count rates of four or more times the background count rate. These rates should not be confused with the deposition rates due to the emergency. Count rates due to radon progeny will decrease rapidly after the rain stops and should be back to typical background levels within a few hours.

[j] Only for several days and only if replacement food is not available.

[k] Fission products that were produced within the last month, thus containing large amounts of iodine.

radionuclides and should be revised as soon as it is known which radionuclides are involved.

II.20. As a minimum criterion, a contamination monitoring instrument is considered suitable for applying the OIL if it will provide a response equal to or more conservative than that assumed in development of the OILs. The following procedure may be used for checking whether or not a particular instrument meets the minimum criterion and can be used in applying the operational criteria for OIL1, OIL2 and OIL4 in Table 8:

(1) Ensure that the instrument can display counts/s (or counts/min) over the ranges of the OIL values in Table 8.
(2) For a beta monitor, ensure that it can detect both high (e.g. ^{32}P) and low (e.g. ^{14}C) energy beta emitters. It is not required that very weak emitters (e.g. ^{63}Ni) be detectable.
(3) Calculate the instrument coefficients (ICs) using measured (i.e. derived from the calibration factor) or known 4π efficiencies (e.g. those provided by the manufacturer) for high energy and low energy beta emitting radionuclides and an alpha emitting radionuclide (as applicable) using the formula:

$$IC = W_{\text{monitor}} \times \theta_{\text{monitor}} \quad (5)$$

where

IC is the instrument coefficient ((counts/s × cm^2)/Bq);
W_{monitor} is the effective area of the detector window (cm^2);
θ_{monitor} is the energy dependent efficiency for 4π geometry close to the surface and under ideal conditions (counts/s × Bq^{-1}).

(4) If the calculated IC values are greater than or equal to the following, the instrument is suitable:

— For medium or high energy beta emitters (e.g. ^{36}Cl) — 1;
— For low energy beta emitters (e.g. ^{14}C) — 0.2;
— For alpha emitters — 0.5.

A beta monitor should meet both the high energy and the low energy beta criteria.

These criteria were established so that the majority of commonly available contamination monitoring instruments will give a response that is equal to or higher (i.e. more conservative) than the response assumed in developing the default OILs. However, the response of instruments that meet these minimum criteria may vary by a factor of as much as 20, primarily owing to differences in the effective area of the detector. Therefore, the OILs in Table 8 should be revised, if necessary, to be more consistent with the characteristics of the instruments to be used during the response. This should be done as part of the preparedness process.

II.21. The process of assessing radionuclide concentrations in food, milk and water is shown in Fig. 5. First the potentially contaminated food should be screened over a wide area and analysed to determine the gross alpha and beta concentrations if this can be done more promptly than assessing the concentration of individual radionuclides. If the OIL5 (see Table 9) screening levels are not exceeded, the food, milk and water are safe for consumption during the emergency phase. If an OIL5 level is exceeded, the radionuclide specific concentrations in the food, milk or water should be determined. If the OIL6 levels in Table 10 are exceeded, consumption of non-essential food, milk or water should be stopped, and essential food, milk and water should be replaced or the people should be relocated if replacements are not available. Finally, as soon as possible the guidance in Ref. [29] should be used to determine whether the food, milk or water is suitable for international trade, and national criteria or WHO guidance [30] should be used to determine whether the food, milk or water is suitable for long term consumption after the emergency phase.

II.22. Tables 9 and 10 give OILs for assessing food, milk and water (see also Table 11). These OILs apply to radionuclides in food, milk and water destined for human consumption (they are not applicable for dried food or concentrated food). The food, milk and water OILs in Tables 9 and 10 were calculated on the basis of the following conservative assumptions:

- All of the food, milk and water are initially contaminated and are consumed throughout a full year.
- The most restrictive age dependent dose conversion factors and ingestion rates (i.e. those for infants) are used.

The generic criterion of 10 mSv per year (and not 100 mSv per year, as in Table 3, at which early protective actions are to be taken) was used to ensure that those people in areas from which they were not relocated will not receive a total dose (including the dose from ingestion) greater than 100 mSv per year.

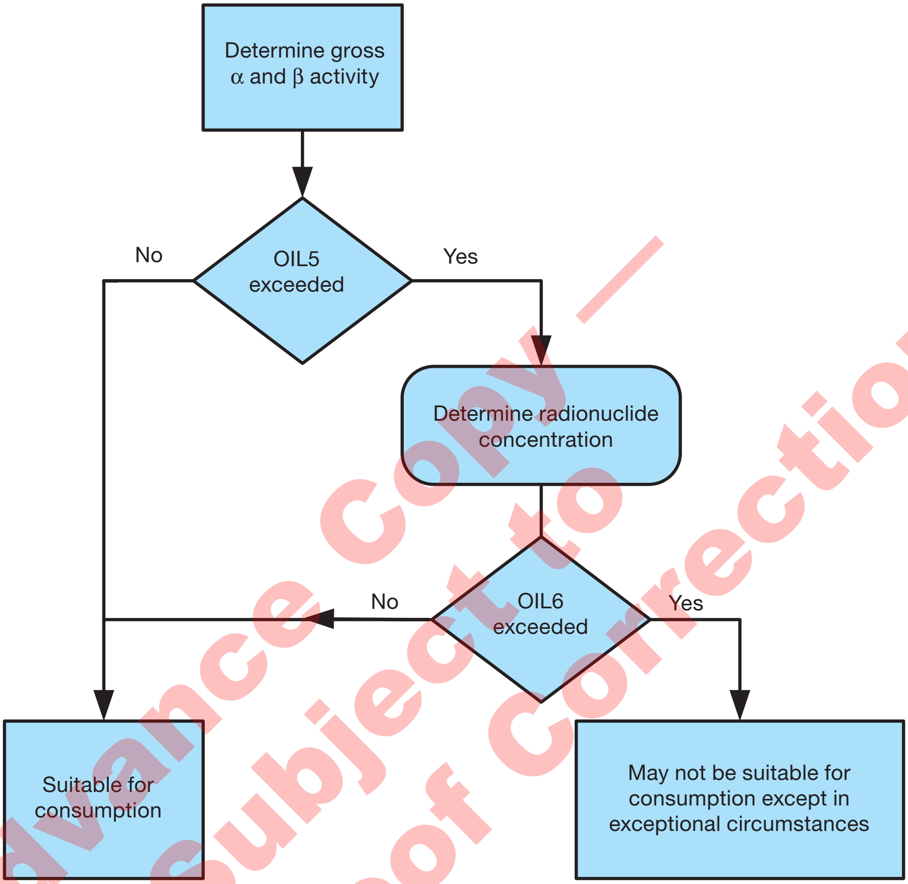

FIG. 5. Process of assessing radionuclide concentrations in food, milk and water.

II.23. Radioactive ^{40}K is commonly found in food and water. It does not accumulate in the body but is maintained at a constant level independent of intake[14] [30]. The contribution of ^{40}K should therefore be subtracted, following a separate determination of total potassium content. The beta activity of the ^{40}K included in natural potassium is 27.6 Bq/g. This is the factor that should be used to calculate the beta activity due to ^{40}K (Ref. [29], para. 9.4.2).

Text cont. on p. 49.

[14] In the response to the Chernobyl accident in 1986, in some cases ^{40}K was confused with ^{137}Cs and produce was discarded even though it contained virtually no radioactive caesium [31].

TABLE 9. DEFAULT SCREENING OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS

OIL	OIL value	Response action if the OIL is exceeded
OIL5	Gross beta (β): 100 Bq/kg or Gross alpha (α): 5 Bq/kg	Above OIL5: Assess using OIL6 Below OIL5: Safe for consumption during the emergency phase

TABLE 10. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS

Radionuclide		OIL6 (Bq/kg)	Radionuclide		OIL6 (Bq/kg)
H-3		2×10^{5}	Sc-44		1×10^{7}
Be-7		7×10^{5}	Sc-46		8×10^{3}
Be-10		3×10^{3}	Sc-47		4×10^{5}
C-11		2×10^{9}	Sc-48		3×10^{5}
C-14		1×10^{4}	Ti-44	+	6×10^{2}
F-18		2×10^{8}	V-48		3×10^{4}
Na-22		2×10^{3}	V-49		2×10^{5}
Na-24		4×10^{6}	Cr-51		8×10^{5}
Mg-28	+[a]	4×10^{5}	Mn-52		1×10^{5}
Al-26		1×10^{3}	Mn-53		9×10^{4}
Si-31		5×10^{7}	Mn-54		9×10^{3}
Si-32	+	9×10^{2}	Mn-56		3×10^{7}
P-32		2×10^{4}	Fe-52	+	2×10^{6}
P-33		1×10^{5}	Fe-55		1×10^{4}
S-35		1×10^{4}	Fe-59		9×10^{3}
Cl-36		3×10^{3}	Fe-60		7×10^{1}
Cl-38		3×10^{8}	Co-55		1×10^{6}
K-40		NA[b,c]	Co-56		4×10^{3}
K-42		3×10^{6}	Co-57		2×10^{4}

[a] '+' indicates radionuclides with progeny listed in Table 11 that are assumed to be in equilibrium with the parent radionuclide and therefore do not need to be considered independently when assessing compliance with OILs.

[b] NA: not applicable.

[c] The dose from ingestion of ^{40}K is considered not to be relevant because ^{40}K does not accumulate in the body and is maintained at a constant level independent of intake [29].

TABLE 10. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS (cont.)

Radionuclide		OIL6 (Bq/kg)	Radionuclide		OIL6 (Bq/kg)
K-43		4×10^6	Co-58		2×10^4
Ca-41		4×10^4	Co-58m		9×10^7
Ca-45		8×10^3	Co-60		8×10^2
Ca-47	+	5×10^4	Ni-59		6×10^4
Ni-63		2×10^4	Sr-89		6×10^3
Ni-65		4×10^7	Sr-90	+	2×10^2
Cu-64		1×10^7	Sr-91		3×10^6
Cu-67		8×10^5	Sr-92		2×10^7
Zn-65		2×10^3	Y-87	+	4×10^5
Zn-69		6×10^8	Y-88		9×10^3
Zn-69m	+	3×10^6	Y-90		9×10^4
Ga-67		1×10^6	Y-91		5×10^3
Ga-68		2×10^8	Y-91m		2×10^9
Ga-72		1×10^6	Y-92		1×10^7
Ge-68	+	3×10^3	Y-93		1×10^6
Ge-71		5×10^6	Zr-88		3×10^4
Ge-77		6×10^6	Zr-93		2×10^4
As-72		4×10^5	Zr-95	+	6×10^3
As-73		3×10^4	Zr-97	+	5×10^5
As-74		3×10^4	Nb-93m		2×10^4
As-76		4×10^5	Nb-94		2×10^3
As-77		1×10^6	Nb-95		5×10^4
Se-75		4×10^3	Nb-97		2×10^8
Se-79		7×10^2	Mo-93		3×10^3
Br-76		3×10^6	Mo-99	+	5×10^5
Br-77		5×10^6	Tc-95m	+	3×10^4
Br-82		1×10^6	Tc-96		2×10^5
Rb-81		8×10^7	Tc-96m		2×10^9
Rb-83		7×10^3	Tc-97		4×10^4
Rb-84		1×10^4	Tc-97m		2×10^4
Rb-86		1×10^4	Tc-98		2×10^3
Rb-87		2×10^3	Tc-99		4×10^3

TABLE 10. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS (cont.)

Radionuclide		OIL6 (Bq/kg)	Radionuclide		OIL6 (Bq/kg)
Sr-82	+	5×10^3	Tc-99m		2×10^8
Sr-85		3×10^4	Ru-97		2×10^6
Sr-85m		3×10^9	Ru-103	+	3×10^4
Sr-87m		3×10^8	Ru-105		2×10^7
Ru-106	+	6×10^2	Sb-126		3×10^4
Rh-99		1×10^5	Te-121		1×10^5
Rh-101		8×10^3	Te-121m	+	3×10^3
Rh-102		2×10^3	Te-123m		5×10^3
Rh-102m		5×10^3	Te-125m		1×10^4
Rh-103m		5×10^9	Te-127		1×10^7
Rh-105		1×10^6	Te-127m	+	3×10^3
Pd-103	+	2×10^5	Te-129		2×10^8
Pd-107		7×10^4	Te-129m	+	6×10^3
Pd-109	+	2×10^6	Te-131		4×10^8
Ag-105		5×10^4	Te-131m		3×10^5
Ag-108m	+	2×10^3	Te-132	+	5×10^4
Ag-110m	+	2×10^3	I-123		5×10^6
Ag-111		7×10^4	I-124		1×10^4
Cd-109	+	3×10^3	I-125		1×10^3
Cd-113m		4×10^2	I-126		2×10^3
Cd-115	+	2×10^5	I-129		NA[d]
Cd-115m		6×10^3	I-131		3×10^3
In-111		1×10^6	I-132		2×10^7
In-113m		4×10^8	I-133		1×10^5
In-114m	+	3×10^3	I-134		2×10^8
In-115m		5×10^7	I-135		2×10^6
Sn-113	+	1×10^4	Cs-129		1×10^7
Sn-117m		7×10^4	Cs-131		2×10^6
Sn-119m		1×10^4	Cs-132		4×10^5
Sn-121m	+	5×10^3	Cs-134		1×10^3
Sn-123		3×10^3	Cs-134m		3×10^8

[d] Not a significant source of radiation because of the low specific activity.

TABLE 10. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS (cont.)

Radionuclide		OIL6 (Bq/kg)	Radionuclide		OIL6 (Bq/kg)
Sn-125		2×10^4	Cs-135		9×10^3
Sn-126	+	5×10^2	Cs-136		4×10^4
Sb-122		2×10^5	Cs-137	+	2×10^3
Sb-124		5×10^3	Ba-131	+	1×10^5
Sb-125	+	3×10^3	Ba-133		3×10^3
Ba-133m		9×10^5	Eu-156		2×10^4
Ba-140	+	1×10^4	Gd-146	+	8×10^3
La-137		4×10^4	Gd-148		1×10^2
La-140		2×10^5	Gd-153		2×10^4
Ce-139		3×10^4	Gd-159		2×10^6
Ce-141		3×10^4	Tb-157		9×10^4
Ce-143		5×10^5	Tb-158		3×10^3
Ce-144	+	8×10^2	Tb-160		7×10^3
Pr-142		6×10^5	Dy-159		7×10^4
Pr-143		4×10^4	Dy-165		7×10^7
Nd-147		6×10^4	Dy-166	+	6×10^4
Nd-149		8×10^7	Ho-166		5×10^5
Pm-143		3×10^4	Ho-166m		2×10^3
Pm-144		6×10^3	Er-169		2×10^5
Pm-145		3×10^4	Er-171		6×10^6
Pm-147		1×10^4	Tm-167		1×10^5
Pm-148m	+	1×10^4	Tm-170		5×10^3
Pm-149		3×10^5	Tm-171		3×10^4
Pm-151		8×10^5	Yb-169		3×10^4
Sm-145		2×10^4	Yb-175		4×10^5
Sm-147		1×10^2	Lu-172		1×10^5
Sm-151		3×10^4	Lu-173		2×10^4
Sm-153		5×10^5	Lu-174		1×10^4
Eu-147		8×10^4	Lu-174m		1×10^4
Eu-148		2×10^4	Lu-177		2×10^5
Eu-149		9×10^4	Hf-172	+	2×10^3
Eu-150b		3×10^6	Hf-175		3×10^4

TABLE 10. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS (cont.)

Radionuclide		OIL6 (Bq/kg)	Radionuclide		OIL6 (Bq/kg)
Eu-150a		4×10^3	Hf-181		2×10^4
Eu-152		3×10^3	Hf-182	+	1×10^3
Eu-152m		4×10^6	Ta-178a		1×10^8
Eu-154		2×10^3	Ta-179		6×10^4
Eu-155		1×10^4	Ta-182		5×10^3
W-178	+	2×10^5	Hg-194	+	2×10^2
W-181		1×10^5	Hg-195		2×10^7
W-185		2×10^4	Hg-195m		8×10^5
W-187		1×10^6	Hg-197		1×10^6
W-188	+	3×10^3	Hg-197m		2×10^6
Re-184		2×10^4	Hg-203		1×10^4
Re-184m	+	3×10^3	Tl-200		5×10^6
Re-186		1×10^5	Tl-201		3×10^6
Re-187		5×10^5	Tl-202		2×10^5
Re-188		7×10^5	Tl-204		3×10^3
Re-189		8×10^5	Pb-201		2×10^7
Os-185		2×10^4	Pb-202	+	1×10^3
Os-191		8×10^4	Pb-203		2×10^6
Os-191m		1×10^7	Pb-205		2×10^4
Os-193		7×10^5	Pb-210	+	2.0
Os-194	+	8×10^2	Pb-212	+	2×10^5
Ir-189		2×10^5	Bi-205		7×10^4
Ir-190		6×10^4	Bi-206		8×10^4
Ir-192		8×10^3	Bi-207		3×10^3
Ir-194		6×10^5	Bi-210		1×10^5
Pt-188	+	6×10^4	Bi-210m		2×10^2
Pt-191		9×10^5	Bi-212	+	7×10^7
Pt-193		8×10^4	Po-210		5.0
Pt-193m		3×10^5	At-211	+	2×10^5
Pt-195m		3×10^5	Ra-223	+	4×10^2
Pt-197		2×10^6	Ra-224	+	2×10^3
Pt-197m		1×10^8	Ra-225	+	2×10^2

TABLE 10. DEFAULT RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS (cont.)

Radionuclide		OIL6 (Bq/kg)	Radionuclide		OIL6 (Bq/kg)
Au-193		8×10^6	Ra-226	+	2×10^1
Au-194		1×10^6	Ra-228		3.0
Au-195		2×10^4	Ac-225		3×10^3
Au-198		3×10^5	Ac-227	+	5.0
Au-199		5×10^5	Ac-228		7×10^6
Th-227	+	9×10^1	Pu-242		5×10^1
Th-228	+	2×10^1	Pu-244	+	5×10^1
Th-229	+	8.0	Am-241		5×10^1
Th-230		5×10^1	Am-242m	+	5×10^1
Th-231		2×10^6	Am-243	+	5×10^1
Th-232		4.0	Am-244		4×10^6
Th-234	+	8×10^3	Am-241/Be-9		5×10^1
Pa-230		5×10^4	Cm-240		4×10^3
Pa-231		2×10^1	Cm-241		3×10^4
Pa-233		3×10^4	Cm-242		5×10^2
U-230	+	8×10^2	Cm-243		6×10^1
U-232		2×10^1	Cm-244		7×10^1
U-233		1×10^2	Cm-245		5×10^1
U-234		2×10^2	Cm-246		5×10^1
U-235	+	2×10^2	Cm-247		6×10^1
U-236		2×10^2	Cm-248		1×10^1
U-238	+	1×10^2	Bk-247		2×10^1
Np-235		7×10^4	Bk-249		1×10^4
Np-236l	+	8×10^2	Cf-248		2×10^2
Np-236s		4×10^6	Cf-249		2×10^1
Np-237	+	9×10^1	Cf-250		4×10^1
Np-239		4×10^5	Cf-251		2×10^1
Pu-236		1×10^2	Cf-252		4×10^1
Pu-237		2×10^5	Cf-253		3×10^4
Pu-238		5×10^1	Cf-254		3×10^1
Pu-239		5×10^1	Es-253		5×10^3
Pu-240		5×10^1	Pu-239/Be-9		5×10^1
Pu-241		4×10^3			

TABLE 11. EQUILIBRIUM RADIOACTIVE CHAINS

Parent radionuclide	Progeny radionuclides considered in OIL6 assessment as being in equilibrium with the parent
Mg-28	Al-28
Si-32	P-32
Ca-47	Sc-47 (3.8)[a]
Ti-44	Sc-44
Fe-52	Mn-52m
Zn-69m	Zn-69 (1.1)
Ge-68	Ga-68
Sr-90	Y-90
Y-87	Sr-87m
Zr-95	Nb-95 (2.2)
Zr-97	Nb-97m (0.95), Nb-97
Tc-95m	Tc-95 (0.041)
Mo-99	Tc-99m (0.96)
Ru-103	Rh-103m
Ru-106	Rh-106
Pd-103	Rh-103m
Pd-109	Ag-109m
Ag-108m	Ag-108 (0.09)
Ag-110m	Ag-110 (0.013)
Cd-109	Ag-109m
Cd-115	In-115m (1.1)
In-114m	In-114 (0.96)
Sn-113	In-113m
Sn-121m	Sn-121 (0.78)
Sn-126	Sb-126m, Sb-126 (0.14)
Sb-125	Te-125m (0.24)
Te-121m	Te-121
Te-127m	Te-127
Te-129m	Te-129 (0.65)
Te-132	I-132

[a] The value inside the parentheses is the activity of the daughter radionuclide, per unit of the parent, assumed to be present.

TABLE 11. EQUILIBRIUM RADIOACTIVE CHAINS (cont.)

Parent radionuclide	Progeny radionuclides considered in OIL6 assessment as being in equilibrium with the parent
Cs-137	Ba-137m
Ba-131	Cs-131 (5.6)
Ba-140	La-140 (1.2)
Ce-144	Pr-144m (0.018), Pr-144
Pm-148m	Pm-148 (0.053)
Gd-146	Eu-146
Dy-166	Ho-166 (1.5)
Hf-172	Lu-172
Hf-182	Ta-182
W-178	Ta-178a
W-188	Re-188
Re-184m	Re-184 (0.97)
Os-194	Ir-194
Pt-188	Ir-188 (1.2)
Hg-194	Au-194
Pb-202	Tl-202
Pb-210	Bi-210, Po-210
Pb-212	Bi-212 , Tl-208 (0.40), Po-212 (0.71)
Bi-210m	Ti-206
Bi-212	Tl-208 (0.36), Po-212 (0.65)
At-211	Po-211 (0.58)
Rn-222	Po-218, Pb-214, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212 , Bi-212, Tl-208 (0.36), Po-212 (0.65)
Ra-225	Ac-225 (3.0), Fr-221 (3.0), At-217 (3.0), Bi-213 (3.0), Po-213 (2.9), Pb-209 (2.9), Tl-209 (0.067), Pb-209 (0.067)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214
Ac-225	Fr-221, At-217, Bi-213, Po-213 (0.98), Pb-209, Tl-209 (0.022)
Ac-227	Th-227 (0.99), Ra-223 (0.99), Rn-219 (0.99), Po-215 (0.99), Pb-211 (0.99), Bi-211 (0.99), Tl-207 (0.99), Fr-223 (0.014), Ra-223 (0.014), Rn-219 (0.014), Po-215 (0.014), Pb-211 (0.014), Bi-211 (0.014), Tl-207 (0.014)

TABLE 11. EQUILIBRIUM RADIOACTIVE CHAINS (cont.)

Parent radionuclide	Progeny radionuclides considered in OIL6 assessment as being in equilibrium with the parent
Th-227	Ra-223 (2.6), Rn-219 (2.6), Po-215 (2.6), Pb-211 (2.6), Bi-211 (2.6), Tl-207 (2.6)
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213 (0.98), Pb-209 (0.98), Tl-209 (0.02), Pb-209 (0.02)
Th-234	Pa-234m
U-232	Th-226, Ra-222, Rn-218, Po-214
U-235	Th-231
U-238	Th-234, Pa-234m
Np-237	Pa-233
Pu-244	U-240, Np-240m
Am-242m	Am-242, Cm-242 (0.83)
Am-243	Np-239

II.24. OIL6 is exceeded if the following condition is satisfied:

$$\sum_i \frac{C_{f,i}}{\mathrm{OIL6}_i} > 1 \qquad (6)$$

where

$C_{f,i}$ is the concentration of radionuclide *i* in the food, milk or water (Bq/kg);
$\mathrm{OIL6}_i$ is the concentration of radionuclide *i* from Table 10 (Bq/kg).

II.25. If OIL6 is exceeded, the following actions should be taken:

— Stop consumption of non-essential[15] food, milk or water and conduct an assessment on the basis of realistic consumption rates. Replace essential

[15] Restriction of the consumption of essential food could result in severe health effects (e.g. severe malnutrition).

food, milk and water promptly, or relocate people if replacement of essential food, milk and water is not possible.
- For fission products (e.g. containing iodine) and iodine contamination, consider providing iodine thyroid blocking if replacement of essential food, milk or water is not immediately possible.
- Estimate the dose to those who may have consumed food, milk or rainwater from the area where restrictions were implemented to determine if medical screening is warranted.

PLAIN LANGUAGE EXPLANATION

II.26. Experience has shown that decision makers take actions and the public follow instructions best when they understand how the actions provide for the safety of the public [32]. The default OILs are therefore supported by a plain language explanation of how criteria and associated actions provide for the safety of all members of the public. In addition, experience shows that use of overly conservative criteria can result in the public taking actions that do more harm than good. The default OILs are developed using realistically conservative assumptions that provide reasonable assurance that all members of the public are safe.

II.27. The development of plain language explanations for the default OILs should be based on the assumption that members of the public living under normal conditions, including those who are more vulnerable to radiation exposure such as children and pregnant women, will achieve a level of protection that meets international standards, provided that during the emergency phase they:

- Do not receive a dose to any organ approaching that resulting in severe deterministic effects. The thresholds for the onset of severe deterministic effects are listed in Table 2.
- Do not receive a dose above which the risk of health effects (e.g. cancers) is sufficiently high to justify taking protective actions during an emergency (generic criterion of 100 mSv per annum, as presented in Table 3). Below this generic criterion, protective actions are not always justified and will be taken (if at all) on the basis of justified criteria developed, with interested parties, after careful consideration of the conditions, including the impact of any protective action.

II.28. The plain language communications below provide text that may be given directly to those members of the public to whom the criterion applies.

OIL1 plain language explanation

II.29. Remaining in the area where OIL1 is exceeded may not be safe. Those living in the area should *[insert appropriate recommended actions for OIL1]* to reduce the risk of health effects due to radiation.

OIL2 plain language explanation

II.30. Remaining in the area where OIL2 is exceeded for a short time is possible if the following recommended actions are taken, but staying for longer periods may not be safe. Move out of the area (relocate) within a week and *[insert appropriated recommended actions for OIL2]*.

II.31. The recommended actions for OIL2 take into account those members of the public most vulnerable to radiation exposure (e.g. infants and pregnant women). They also consider all the ways a person can be exposed to radiation from radioactive material deposited on the ground, including inhalation of dust and inadvertent ingestion of dirt (e.g. from dirty hands). For some types of radioactive material this advice may be overly cautious, but it is considered prudent until further analysis is performed. The relocation is likely to be temporary.

OIL3 plain language explanation

II.32. If other food is available in the territories where OIL3 is exceeded, stop consuming local produce (e.g. vegetables), milk from grazing animals and rainwater until they have been screened and declared safe. However, if restriction of consumption is likely to result in severe malnutrition or dehydration because replacement food, milk or water is not available, these items may be consumed for a short time until replacements are available.

II.33. The recommended actions for OIL3 take into account the most vulnerable members of the public (e.g. infants and pregnant women). The actions assume that all the locally produced food and milk is contaminated with radioactive material and that little is done (e.g. washing) to reduce the levels of contamination in the food before consumption. Exceeding OIL3 does not mean that the food or milk produced in the area is not safe; however, it is prudent not to consume local non-essential food until further analysis has been performed.

OIL4 plain language explanation

II.34. Any person who may have radioactive material on the skin or clothing should take actions to prevent inadvertent ingestion of the material (which may not be visible). Appropriate actions include washing the hands before drinking, eating or smoking, and keeping the hands away from the mouth until they have been washed. Further actions include changing clothes as soon as possible and showering before putting on clean clothes. The removed clothing should be put in a bag until it can be dealt with. These recommendations also apply to those people who may have been monitored. The recommended actions for OIL4 take into account the most vulnerable members of the public (e.g. infants and pregnant women). It is assumed that people might eat with contaminated hands and thereby might ingest radioactive material. Timely monitoring and immediate decontamination by experts may not be possible, and the contamination levels may be very difficult to detect under emergency conditions, but potentially contaminated persons can take the effective actions mentioned above to protect themselves.

OIL5 plain language explanation

II.35. Below OIL5: Locally produced food, milk and water have been screened, and all members of the public, including infants, children and pregnant women, can safely drink the milk and water and eat the food during the emergency phase.

OIL6 plain language explanation

II.36. Below OIL6: Locally produced food, milk and water have been screened, and all members of the public, including infants, children and pregnant women, can safely drink the milk and water and eat the food during the emergency phase.

II.37. Above OIL6: Locally produced food, milk and water have been screened and the measurements indicate that further investigation is necessary before unrestricted general consumption of these items is allowed. However, if restriction of consumption is likely to result in severe malnutrition or dehydration, because no replacement food, milk or water is available, then these items may be consumed for a short time until replacements are available.

II.38. The analysis for OIL6 considers the most vulnerable members of the public (e.g. infants and pregnant women), and it assumes that all of the food, milk and water is contaminated. Exceeding the criteria therefore might not mean that the food, water or milk is unsuitable for consumption but might indicate that further investigation, including consideration of actual consumption rates and additional screening, is needed.

Appendix III

DEVELOPMENT OF EALs AND EXAMPLES OF EALs FOR LIGHT WATER REACTORS

III.1. Reference [2], in para. 4.19, requires the operator of a facility or a practice in threat category I, II, III or IV (which includes light water reactors) to implement a system for classifying all potential nuclear and radiological emergencies that would warrant an emergency intervention to protect workers and the public.

III.2. The events considered in the classification system should not be expanded to include all reportable events, but should be limited to alerts and emergencies that require immediate on-site action[16].

III.3. The following classes are defined for facilities in threat categories I and II: general emergency, site area emergency, facility emergency and alert [2].

III.4. Declaration of an emergency in any of these emergency classes should initiate a response that is considerably beyond normal operations. Four is the minimum number of classes. Each class initiates a distinctly different level of response, as shown in Fig. 6.

Alert	**Facility emergency**	**Site area emergency**	**General emergency**
Immediate actions to analyse the situation and mitigate the consequences			
	Immediate actions to protect those on the site		
		Preparations to take protective action off the site	
			Immediate actions to protect the public off the site

FIG. 6. Relationship of response actions under the classification system. (Note: The actions are not presented in a sequence for implementation.)

[16] Examples of events that should not be included in the emergency classification system are: technical deficiencies exceeding the limits of in-service inspection codes; equipment failure beyond expected reliability limits; detection of major design deficiencies or of potential accident sequences outside the plant's design basis; symptoms of severe deficiencies in operator training or behaviour; breaches of technical specifications or of transport regulations; and deficiencies in safety culture.

III.5. Reference [2], in para. 4.20, states that “The criteria for classification shall be predefined emergency action levels (EALs) that relate to abnormal conditions for the facility or practice concerned, security related concerns, releases of radioactive material, environmental measurements and other observable indications”.

III.6. The following are examples of situations that could lead to a general emergency:

— Actual or projected[17] damage to the reactor core or large amounts of recently discharged fuel in combination with actual damage to barriers or critical safety systems such that a radioactive release becomes highly probable;
— Detection of radiation levels off the site that warrant urgent protective measures;
— A malicious act resulting in an inability to monitor or control critical safety systems that are needed to prevent a release, or in exposures off the site that could result in doses that warrant urgent protective actions.

III.7. The following are examples of situations that could lead to a site area emergency:

— A major decrease in the level of defence in depth provided for the reactor core or actively cooled fuel;
— A major decrease in protection against an accidental criticality;
— Conditions such that any additional failures could result in a general emergency;
— Doses off the site approaching the intervention levels for urgent protective actions;
— A malicious act with the potential to disrupt the performance of critical safety functions or to result in a major release or severe exposures.

III.8. The following are examples of situations that could lead to a facility emergency:

— A fuel handling emergency including the dropping of a fuel transport container[18];

[17] ‘Projected damage’ is indicated by a loss of critical safety functions necessary to protect the core or large amounts of recently discharged fuel.

[18] The dropping of a fuel transport container and a fuel handling accident are considered facility emergencies because they cannot give rise to doses that warrant protective actions off the site.

— An in-facility fire or other emergency not affecting safety systems;
— A malicious or criminal activity (e.g. extortion or blackmail) leading to hazardous on-site conditions but with no potential to result in a criticality or a release off the site that would warrant urgent protective actions;
— Loss of shielding or control for a large gamma emitter or for spent fuel;
— Rupture of a dangerous source;
— High doses on the site approaching intervention levels for urgent protective actions;
— Doses exceeding established limits for occupationally exposed staff, including workers in transport or handling activities, and including cases of confirmed high values measured by area or process radiation monitors or from contamination measurements;
— Spills of oil or chemicals that constitute a hazard to the environment;
— Civil disturbance (e.g. demonstrations in the vicinity of a nuclear power plant).

III.9. Alerts are events that do not represent an emergency but that warrant prompt activation of parts of the on-site response organization in support of the operating staff.

TECHNICAL BACKGROUND FOR EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS

III.10. This classification was developed to be as independent as possible of light water reactor designs. The aim is to develop a classification that can be considered a useful reference for the various designs of light water reactors used throughout the world. When it is applied, the specific reactor design features available have to be considered.

III.11. The foundation of the classification system is the fact that core damage and failure of confinement are both necessary for a severe release and high on-site doses to occur.

III.12. The classes are associated with increasing probability or confidence that conditions exist that will lead to core damage or to high doses on or off the site. Such a classification system provides the on-site staff with the greatest opportunity to mitigate the consequences of the event and the off-site responders with the greatest opportunity to take effective protective actions for the public.

APPLICATION OF THE EMERGENCY CLASSIFICATION

III.13. The criteria used for classifying the events are called emergency action levels (EALs). An EAL is a predetermined threshold for an observable that places the plant and off-site response organizations in preparedness for an emergency in a given emergency class. There are two fundamentally different types of EAL: symptom based and event based. Symptom based EALs are site specific instrument readings (e.g. reactor coolant system pressure higher than a certain level) or other observable or quantifiable thresholds (e.g. failure of emergency power supply systems as indicated by a specific parameter). Event based EALs are more subjective criteria requiring the judgement of the operating staff. An example of an event based EAL would be ‘fire detected in an area containing vital safety systems’.

III.14. When possible, symptom based EALs should be used because they make the classification process more timely and less subject to error. For facilities where safety significant systems are monitored by means of instruments and alarms, a large fraction of the EALs may be symptom based in nature, whereas classification procedures for simple facilities with few instruments will consist almost exclusively of event based EALs.

III.15. This appendix has two tables providing examples of EALs for classifying events[19]. Table 12 is for a reactor in operating, standby or hot shutdown mode. In these modes, all the fission product barriers, instruments and safety systems are in place and operational. Table 13 is for reactors in cold shutdown mode (reactor coolant system closed and reactor coolant system coolant temperature less than 100°C) or in refuelling mode. In these modes the amount of energy in the reactor coolant system, decay heat generation and short lived fission products are greatly reduced. In addition, in these modes the reactor coolant system and containment may not be in place (e.g. the reactor pressure vessel head may have been removed) and fewer safety systems and instruments are required to be operational. The scopes of these two tables, as described, conservatively bound the essential criterion, which is whether the reactor coolant system is sealed or not sealed (i.e. open to the atmosphere).

[19] Examples of EALs for a facility emergency are not included because research and generic studies have not been done to identify the range of possible facility emergencies that could be used as a firm basis for developing such examples. Events that are classified as a facility emergency and EALs for their classification should therefore be based on site specific analysis.

III.16. The criteria in the tables are organized to provide for the earliest possible classification of an event that could result in a severe release. The criteria are provided in the following order: (1) impairment of a critical safety function; (2) loss of fission product barriers; (3) increased radiation levels on the site; (4) increased radiation levels off the site; (5) security events, fires, explosions, releases of toxic gas, natural events and other events; and (6) spent fuel pool events.

III.17. Tables 12 and 13 contain examples of EALs that address the elements of the classification system. The EALs provided in the tables should therefore be replaced with site specific EALs. The following guidance applies for this process:

— It is crucial that the site specific classification procedure be designed for fast (to be completed in a few minutes) and easy use in an event.
— Care should be taken to ensure that the classification procedures are usable under accident conditions, when the workload and stress are very high.
— The performance of instruments in an emergency should also be considered in developing the EALs. Tables 12 and 13 include notes about facts that should be considered when using various instruments in an emergency. Not all instruments are qualified for reliable operation in harsh accident conditions.
— The site specific EALs should use the units of the instruments and the terminology used in the plant.
— Once the site specific EAL system has been developed, it should be tested and/or validated in drills and walk-through sessions to ensure that it is usable by the assigned control room staff in emergency conditions.
— The final step in implementation is to review the classification system with off-site officials. The off-site officials who would be tasked with the implementation of any protective action or other response action called for by a classification should be in agreement with the classification system.
— The EALs and corresponding procedures should be revised on the basis of operating experience and feedback from exercises.

ACCIDENT MANAGEMENT PROCEDURES AND EMERGENCY CLASSIFICATION

III.18. The main objectives of accident management are to prevent the escalation of an event to a severe accident, to mitigate the consequences of a severe accident once it has happened and to achieve a long term safe stable state.

III.19. Emergency operating procedures aimed at preventing a severe accident are used by the main control room staff in events not involving a severe accident. Severe accident management guidelines are developed to deal with a severe accident, should one occur; severe accident management guidelines are used primarily by the operating organization's technical support centre or emergency control centre to advise the main control room staff and off-site emergency groups on mitigatory measures.

III.20. Paragraph 4.19 of Ref. [2] requires that the operator "shall make arrangements for the prompt identification of an actual or potential nuclear or radiological emergency and determination of the appropriate level of response".

III.21. Any conditions that would warrant the use of emergency operating procedures would be classified as constituting an emergency and would trigger a predetermined emergency response on the site. Once conditions of actual or imminent core damage exist, a transition from the domain of emergency operating procedures to the domain of severe accident management guidelines should take place.

III.22. The emergency operating procedures and severe accident management guidelines should be integrated into the organizational structure defined in the plant emergency plan and should be coordinated with the plan to ensure a consistent and coordinated response to severe accident conditions. Plant conditions in the emergency operating procedures and severe accident management guidelines should provide clear inputs for accident entry conditions in the accident classification for declaring appropriate EALs on the site.

III.23. As part of the implementation of the plant specific emergency operating procedures and severe accident management guidelines, the emergency plan should be reviewed with respect to the actions that should be taken following the emergency operating procedures and severe accident management guidelines, to ensure that there are no conflicts. It should be ensured that there are no conflicts with the arrangements made for security, firefighting and support from off the site, such as off-site firefighters or off-site security services.

III.24. Paragraph 4.7 of Ref. [2] requires that it be ensured "that the transition to the emergency response and the performance of initial response actions do not impair the ability of the operational staff (such as the control room staff) to follow the procedures needed for safe operations and for taking mitigatory actions".

TECHNICAL ASSUMPTIONS

III.25. The examples of EALs in Tables 12 and 13 are based on the considerable amount of severe accident research conducted for light water reactors (such as pressurized water reactors, boiling water reactors and water moderated, water cooled reactors). The EALs should cover all possible events at a light water reactor that could result in high doses on the site or in a severe release. However, they should be compared with the results of any available site specific probabilistic safety assessment to ensure that all severe accidents are addressed.

III.26. The three possible levels of emergency in Tables 12 and 13 are defined as follows [27]:

General emergency. Events resulting in an actual release or a substantial risk of a release requiring the implementation of urgent protective actions off the site. This includes (a) actual severe damage[20] or projected severe damage to the core or to large amounts of spent fuel, or (b) releases off the site resulting in a dose exceeding the intervention levels for urgent protective actions. Urgent protective actions should be taken immediately for the public near the plant when this level of emergency is declared.

Site area emergency. Events resulting in a major decrease in the level of protection for on-site personnel or for the public. This includes: (i) a major decrease in the level of protection provided for the core or for large amounts of spent fuel; (ii) conditions in which any additional failures could result in damage to the core or to spent fuel; or (iii) high doses on the site or doses off the site approaching the intervention levels for urgent protective actions. For this class of emergency, actions should be taken to control the dose to on-site personnel and preparations should be made to take protective actions off the site.

Alert. Events involving an unknown or significant decrease in the level of protection for on-site personnel or for the public. For this class of emergency, the state of readiness of the on-site and off-site response organizations is increased and additional assessments are made.

[20] Severe damage resulting in a release of greater than 20% of the gap inventory.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Critical safety function impairment			
Failure to stop nuclear reaction[1]	Failure to scram when above 5% power *[or insert site specific power level]*[2] **and** any of the following: — Pressurized water reactor negative cooling margin on the basis of Fig. 7 **or** — Vessel water level below top of active fuel **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indication of actual or imminent core damage	Failure to scram when above 5% power *[or insert site specific power level]* and abnormal conditions indicate that an automatic or manual scram is necessary	Failure to fully shut down (increasing neutron flux)[3] as part of normal shutdown with sufficient heat removal available (ultimate heat sink available and sufficient)
Inadequate core cooling — vessel level[4]	Vessel water level is, or is projected to be, below top of active fuel for more than 15 min	Vessel water level is or is projected to be below top of active fuel	Vessel water level decreasing over a longer time period than expected while systems are responding as designed

[1] 'Stop nuclear reaction' is a general term that includes 'reactor scram', which is used only for the insertion of control rods into the reactor.
[2] Failure to scram the reactor is usually evaluated if reactor power is greater than 5% and conditions indicate that scram is necessary (safety systems are usually capable of removing heat for the heating rate at less than 5% of nominal power). For some plants, different, plant specific values should be used.
[3] Increasing neutron flux is an explicit symptom that the reactor is not fully shut down.
[4] Inadequate core cooling is characterized by three kinds of entry condition: vessel level, core temperature and decay heat removal capability. These conditions are valid for both pressurized water reactors and boiling water reactors, and are put before the primary system temperature, which is relevant for pressurized water reactors only.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Notes about level measurement: — Pressurized water reactor pressurizer levels may not be valid indicators of vessel water level under accident conditions — Pressurized water reactor water levels measured in the vessel can have considerable uncertainties (30%) and should only be used for trend assessment — Boiling water reactor high dry well temperature and low pressure accidents (e.g. LOCAs) can cause the water level to read erroneously high	Vessel water level is or is projected to be below top of active fuel **and** any of the following: — Vessel injection rate less than *[use Fig. 8 and capacity versus pressure curves of operating pumps]* **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indications of imminent or actual core damage **Note:** Imminent reactor coolant system or containment boundary failure might be considered as additional criteria.[5]		
Inadequate core cooling — core temperature[6]	Core exit thermocouple reading greater than 800°C	Core exit thermocouple reading greater than 650°C	Core exit thermocouple reading greater than 370°C
Inadequate core cooling — decay heat removal (considering the operations of pumps, piping, heat exchangers, heat sinks, power supply, auxiliary fluid)		Actual failure or projected long term failure of the ability to remove decay heat to the environment, potentially affecting the ability to protect the core	Unavailability of the normal feedwater system for decay heat removal[7]

[5] In the event of core damage, the status of the reactor containment system and the containment barriers will greatly affect the magnitude of the release of fission products.

[6] Elevated core exit temperature is a direct symptom of core cooling degradation. Therefore, this symptom is used as an entry condition for inadequate core cooling. The critical water temperature above which liquid water cannot exist irrespective of system pressure is 370°C; 650°C is a value usually used for inadequate core cooling in emergency procedures and indicates that steam–Zr reaction will start to produce hydrogen; 800°C indicates core damage that starts at a core temperature of about 1200°C.

[7] Normal feedwater is used for heat removal in these modes. If normal feedwater is not available, the alternate water sources should be used for steam generator (SG) feeding.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Pressurized water reactor — abnormal primary system temperature (inadequate core cooling) **Note:** Temperature should be measured in the vessel. Most pressurized water reactors have core exit thermocouples to measure temperatures in the vessel. Use the average of the highest four core exit thermocouple readings. If there is water flow, the hot leg temperature (T_{hot}) could be used if core exit thermocouples are not available, although this indication is less prompt.[8] For boiling water reactors there are no instruments that provide a valid reading of core temperature.	Pressurized water reactor — negative cooling margin on the basis of Fig. 7 or primary system temperature exceeds scale for more than 15 min *[or insert site specific time for core damage following a loss of coolant accident]* **and** any of the following: — Vessel injection rate less than water loss due to decay heat boil-off *[use Fig. 8 and capacity versus pressure curves of operating pumps]*[9] **or** — Vessel water level below top of active fuel **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indications of actual or imminent core damage **Note:** Imminent reactor coolant system or containment boundary failure might be considered as additional criteria.[10]	Pressurized water reactor — negative cooling margin on the basis of Fig. 7 for more than 15 min *[or insert site specific time that core damage is possible following a loss of coolant accident]*	Pressurized water reactor — primary system pressure and temperature indicate negative cooling margin on the basis of Fig. 7 for more than 5 min **Note:** Negative cooling margin is read as soon as the system temperature is higher than the saturation temperature at the set pressure of the reactor coolant system safety valves.[11]

[8] T_{hot} provides a backup for the core temperature since the flow through the core cannot readily be confirmed and T_{hot} changes are delayed relative to the core exit temperature.
[9] This provides a more accurate description of the phenomena inside the reactor vessel.
[10] In the event of core damage, the status of the reactor coolant system and containment barriers will greatly affect the magnitude of the release of fission products.
[11] If adequate coolant injection flow cannot be established to restore core heat removal, the reactor coolant system liquid starts to become saturated. If the system temperature is higher than the saturation temperature at the set pressure of the reactor coolant system safety valves, this prevents further pressurization of the reactor coolant system.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Loss of AC or DC power sources	Actual or projected loss of all AC or DC power needed for operation of safety systems and their supporting systems is likely for more than 45 min *[or insert site specific time required to uncover core for more than 15 min]* Loss of all AC or DC power needed for safety systems operation **and** any of the following: — Vessel water level below top of active fuel **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indication of actual or imminent core damage	Actual or projected loss of AC or DC power needed for operation of safety systems and their supporting systems for more than 30 min *[or insert site specific time required to uncover the core]*	AC or DC power needed for operation of safety systems and their supporting systems is lost or reduced to a single source
Conditions of an unknown cause affecting safety systems			Conditions which are not understood and which could potentially affect safety systems

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Loss of or degraded control of safety systems including post-accident instrumentation[12]	Unavailability of safety system instruments or controls in the control room and remote control locations **and** any of the following: — Vessel water level below top of active fuel **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indications of imminent or actual core damage	Unavailability of safety system instruments or controls in the control room for more than 15 min and major transient in progress potentially affecting the ability to protect the core	Unreliable functioning of several safety system instruments or controls in the control room for more than 15 min
Loss of fission product barriers			
Major increased risk of damage to the core or spent fuel **Note:** Core damage can occur if the core is uncovered for more than 15 min.	Loss for more than 45 min of all the systems required to protect the core or spent fuel *[or insert site specific time required to uncover core for more than 15 min]*	Failure of an additional safety system component will result in uncovering of the core or spent fuel	Actual or predicted failures leaving only one train to prevent core damage, spent fuel damage or a major release

[12] Safety system control capability can be either degraded or completely lost; both cases are reflected. Unreliable functioning of several safety system instruments or alarms and unavailability of safety system instruments or controls are considered. Post-accident instrumentation provides the essential information to support safety system operation and control and is included.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
High ^{131}I concentration in the primary coolant **Note:** Coolant samples should not be taken if they will result in high individual doses. — Use only concentrations from samples taken after the start of the event — Coolant concentrations may not be representative — Assumes the core may not be coolable after 10% melt	^{131}I concentration is greater than *[insert site specific values for release of 10% of core inventory]*	^{131}I concentration is greater than *[insert site specific value indicating release of 20% of the gap inventory]*	^{131}I concentration is greater than *[insert site specific value 100 times the technical specifications or other operational limits]*
Confirmed core damage	*[Insert site specific readings from post-accident sampling system[13] indicating release of 20% of gap inventory[14]]*	*[Insert site specific readings from post-accident sampling system indicating release of 1% of gap inventory]*	

[13] Reference to a failed fuel monitor in a pressurized water reactor and off-gas monitor in a boiling water reactor is replaced by reference to a post-accident sampling system.

[14] The gap inventory is the amount of fission products in the fuel pin gap during normal operations.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Primary system leak	Primary system leak requiring all normal and high pressure emergency core coolant systems to maintain primary system water level[15] **and** any of the following: — Injection into the vessel less than the rate found from Fig. 8 **or** — Vessel water level below top of active fuel and decreasing **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indications of imminent or actual core damage **Note:** Imminent containment boundary failure might be considered as an additional criterion[16].	Primary system leak for more than 15 min requiring all normal and high pressure emergency core coolant systems to maintain primary system water level *[insert site specific indicators]*	Primary system leak rate for more than 15 min greater than 2% of normal full power feedwater flow[17] (for boiling water reactor refer to the reactor coolant inventory control system) *[insert site specific indicators — as an alternative, reference to normal charging flow might be made]*

[15] The criterion was replaced by the same requirement used for site area emergency to refer to the leak rate instead of the (previously misleading) operational core cooling system.

[16] In the case of a loss of coolant accident and core damage, the status of the containment barrier will directly affect the magnitude of the fission product release.

[17] Leak rate with respect to normal feedwater flow for normal full power operation is used instead of leak rate with respect to the number of operating pumps. Such leak rate specification better covers the concern during a loss of coolant accident (i.e. to ensure sufficient core cooling). For some plants, the leak rate should also be determined on the basis of the normal charging flow rate.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Primary system leak directly to atmosphere, such as: — Pressurized water reactor: steam generator tube rupture — Boiling water reactor: main steam isolation valve failure outside of containment — A leak with a failure of the containment to achieve isolation — A plant with no containment	Primary system leak directly to the atmosphere **and** any of the following: — Projected or confirmed vessel water level below top of active fuel **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indication of actual or imminent core damage	— Primary system leak directly to atmosphere[18] **or** — Pressurized water reactor: significant leak from the primary to the secondary system[19]	Pressurized water reactor: primary system leak to the secondary system requiring continuous operation of more than the usually operating[20] charging pumps to maintain primary system water level Boiling water reactor: main steam isolation valve failure without loss of integrity of steam piping to turbine and/or condenser[21]
Radiation levels			
Effluent release rates greater than 100 times the release limits	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating that in 1 hour the off-site doses will be greater than the intervention levels for urgent protective actions, assuming average meteorological conditions]*	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating that in 4 hours the off-site doses will be greater than 0.10 of the intervention levels for urgent protective actions, assuming average meteorological conditions]*	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating 100 times the release limits]*

[18] Any significant primary leak directly to the atmosphere will cause releases of fission products to the environment, and it is necessary to take immediate actions to stop the leak.

[19] For pressurized water reactors, a significant primary system to secondary system leak could cause releases of fission products to the environment, and it is necessary to take immediate actions to stop the leak.

[20] For pressurized water reactors, a primary system to secondary system leak at a rate above the normal charging system capability can quickly cause releases of fission products to the environment, and it is necessary to take appropriate actions to stop the leak.

[21] For boiling water reactors, failure of the main steam isolation valve without loss of integrity of steam piping to the turbine and/or condenser could cause early releases of fission products to the environment, and it is necessary to take appropriate actions to stop the leak.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
High radiation levels in the control room or other areas requiring continuous access for safety system operation and maintenance **Note:** Inconsistent monitor readings could result from incomplete mixing, a failed monitor or irradiation from a contaminated system nearby. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand held monitors outside the area.	Radiation levels greater than 10 mSv/h	Radiation levels greater than 1 mSv/h potentially lasting several hours	Radiation levels greater than 0.10 mSv/h potentially lasting several hours
High radiation levels in areas requiring occasional occupancy to maintain or control safety systems	Radiation levels greater than 100 mSv/h potentially lasting several hours	Radiation levels greater than 10 mSv/h potentially lasting several hours	Radiation levels greater than 1 mSv/h potentially lasting several hours
Elevated containment (for boiling water reactors, dry well)[22] radiation levels **Note:** Inconsistent monitor readings could result from incomplete mixing or a failed monitor or irradiation from a contaminated system nearby[23]. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand held monitors outside the containment.	Containment radiation levels greater than 5 Gy/h *[or insert site specific reading indicating release of greater than 20% gap inventory]*	Containment radiation levels greater than 1 Gy/h *[or insert site specific reading indicating release of greater than 1% gap inventory]*	Containment radiation levels increase more than 0.10 mGy/h *[or insert site specific reading indicating release of greater than 10% coolant inventory]*

[22] For boiling water reactors, the dry well instead of the containment is more appropriate.

[23] Radiation from a contaminated system nearby could also affect the radiation monitors inside the containment.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Unplanned increase in plant radiation levels	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more and any other indication of actual core damage	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more and a major transient is in progress potentially affecting the ability to protect the core	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more
High ambient dose rates at or beyond[24] the site boundary	Ambient dose rates at or beyond the site boundary greater than 1 mSv/h *[or insert the site specific operational intervention level for evacuation; see Procedure B1 in Ref. [27]]*	Ambient dose rates at or beyond the site boundary greater than 0.1 mSv/h *[or insert one tenth of the site specific operational intervention level for evacuation; see Procedure B1 in Ref. [27]]*	Ambient dose rates at or beyond the site boundary greater than 10 µSv/h *[or insert site specific reading indicating 100 times the background]*
Security events, fires, explosions, toxic gas releases, natural and other events			
Security event (intruder or malicious act)	Security event resulting in loss of the ability to monitor and control safety functions needed to protect the core	Security event resulting in damage or impaired[25] access to safety systems	Security event with potential to affect safety system operation, or uncertain security conditions
Fire or explosion (including turbine failure)			Fire or explosion potentially affecting areas containing safety systems
Toxic or flammable gases including, for boiling water reactors, hydrogen in the dry well[26]		Flammable gas concentrations that prevent control or maintenance of safety systems	Toxic or flammable gases in the plant

[24] Ambient dose rate is usually measured at the site boundary. However, if any measurement of ambient dose rate beyond the site boundary is available, it can be used for the purpose of this EAL.

[25] Wording change to better reflect the intent of the criterion.

[26] For boiling water reactors, hydrogen concentration in the dry well could increase, which can cause significant damage in the event of ignition.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Evacuation of the main control room[27]		Neither the main control room nor the emergency control room is habitable	Plant can be controlled from emergency control room
Major natural disaster such as: — Earthquake — Tornado — Flood — High winds — Vehicle or aircraft[28] crash — Hurricane — Tsunami — Storm surge — Low water level — Lightning strike[29]		Major natural events resulting in damage or impaired[30] access to safety systems and/or decay heat removal systems or affecting their long term operation	Major natural events that threaten the plant such as: — Events beyond the design basis of the plant — Events resulting in actual or potential loss of access to the site for a long period of time
Loss of communications[31]			Events resulting in actual or potential loss of communications to the site for a long period of time

[27] New EAL: In the case of the need to evacuate the main control room, the ability to control the plant is affected (the severity of the situation depends on the plant design). If the emergency control room is used for plant control, an alert is the appropriate EAL; if both the main control room and the emergency control room are affected and the plant has to be controlled by alternative means, a site area emergency is the appropriate EAL.

[28] An aircraft crash could also cause severe damage to the plant and reduce plant safety.

[29] Lightning strikes could also cause severe damage to the plant and reduce plant safety.

[30] Wording changed to better reflect the intent of the criterion.

[31] This EAL is new and reflects the items that were deleted from the previous line.

TABLE 12. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN OPERATING, STANDBY OR HOT SHUTDOWN MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Plant shift supervisor's opinion	Conditions that warrant taking urgent protective actions off the site	Conditions that warrant preparing the public to implement urgent protective actions **or** Conditions that warrant taking protective actions on the site	Abnormal conditions that warrant obtaining immediate additional assistance for the on-site operations staff **or** Abnormal conditions that warrant increased preparedness on the part of off-site officials
Spent fuel pool events			
Abnormal refuelling or spent fuel conditions	Fully drained pool containing more than one third of a core removed from the reactor within the past 3 years **or** Radiation level in pool area greater than 3 Gy/h	Water level below top of irradiated fuel **or** Radiation level in pool area greater than 30 mGy/h	Loss of ability to maintain water level above spent fuel **or** Damage to spent fuel **or** Loss of ability to maintain pool water temperature below 80°C[32]

[32] High temperature in the spent fuel pool is a result of the degradation of heat removal from the spent fuel, and this temperature should also be used as an additional symptom of abnormal refuelling conditions or spent fuel conditions.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Critical safety function impairment			
Inability to maintain the plant in a safe shutdown (subcritical) state [a]	Failure to maintain the reactor in a subcritical condition **and** any of the following: — Vessel injection rate less than shown in Fig. 8 **or** — Vessel water level below top of active fuel **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indications of actual or imminent core damage or spent fuel damage	Failure to maintain the reactor in a subcritical condition	

[a] Inability to maintain the plant in a safe shutdown (subcritical) state is also a concern in the cold shutdown mode and the refuelling mode. Since all control rods are inserted into the core and there is no means for immediate insertion of negative reactivity into the core, the boron dilution in the reactor coolant system could return the reactor to criticality. This would cause the temperature of the reactor coolant system to increase and, because of the negative thermal reactivity coefficient, negative reactivity would be inserted into the core. This process is partly self-controlled. However, in the event of failure to maintain the reactor in a subcritical condition, it is necessary to take immediate action to return the reactor to a subcritical condition. Alert and site area emergency are appropriate EALs in this case, since this process is not so time critical as during power operation, or in the hot standby or the hot shutdown mode.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Pressurized water reactor inadequate core cooling — abnormal primary system temperature[b] **Note:** Temperature should be measured in the vessel. Most pressurized water reactors have core exit thermocouples to measure temperatures in the vessel. Use the average of the highest four core exit thermocouple readings. The hot leg temperature (T_{hot}) could also be used if no core exit thermocouples are available, although this indication is less prompt.[c]	Pressurized water reactor primary system temperature greater than 90°C **and** any of the following: — Vessel injection rate less than water loss due to decay heat boil-off *[use Fig. 8 and capacity versus pressure curves of operating pumps]*[d] **or** — Vessel water level below top of active fuel **or** — Major (100–1000 times) increases in multiple radiation monitors **or** — Other indications of imminent core damage or spent fuel damage	Pressurized water reactor primary system temperature greater than 90°C for more than 30 min **Note:** 90°C limit applies to refuelling mode; for cold shutdown mode it has to be replaced by temperature corresponding to the relieving pressure of the cold overpressure mitigating system.[e]	Pressurized water reactor primary system temperature greater than 80°C

[b] Different temperatures that characterize inadequate core cooling for pressurized water reactors should be used for the cold shutdown and refuelling modes. During refuelling the reactor upper head is removed and the reactor coolant system can only be at atmospheric pressure. The reactor coolant system temperature is maintained at a low level. The reactor coolant system temperature increase is a symptom of inadequate core cooling, and immediate action to restore core cooling should be taken. For temperatures above 80°C, alert is the appropriate EAL. If the reactor coolant system temperature continues to increase, it is a more severe situation and a site area emergency is the appropriate EAL.

[c] T_{hot} provides a backup for core temperature; however, water flow through the core cannot be readily confirmed and changes in T_{hot} occur after the core exit temperature changes.

[d] This is a more accurate description of the phenomena inside the reactor vessel.

[e] If the reactor coolant system is unsealed, 90°C is the appropriate temperature value for this EAL. However, if the reactor coolant system is sealed and the reactor coolant system temperature can increase without loss of subcooling, the temperature corresponding to saturation temperature at the relieving pressure of the cold overpressure mitigating system is the appropriate value.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Abnormal water level in the pressure vessel or in the refuelling area (inadequate core or spent fuel cooling)[f]	Water level is, or is projected to be, below top of active fuel for more than 30 min Water level is, or is projected to be, below top of active fuel **and** any of the following: — Vessel injection rate less than *[use Fig. 8 and capacity versus pressure curves of operating pumps]*[g] **or** — Major (100–1000 times) increases in areas or process radiation monitors **or** — Other indications of imminent core damage	Water level is, or is projected to be, below top of active fuel	Water level is, or is projected to be, below the mid-loop elevation **and** residual heat removal is interrupted for more than 15 min
Loss of AC or DC power sources	Actual or projected loss of all AC or DC power needed for operation of safety systems and their supporting systems[h] is likely for more than 90 min *[or insert site specific time required to uncover core or spent fuel for more than 30 min]*	Actual or projected loss of all AC or DC power needed for operation of safety systems and their supporting systems for more than 60 min *[or insert site specific time required to uncover the core or spent fuel]*	AC or DC power needed for operation of safety systems and their supporting systems reduced to a single source

[f] Actual or projected abnormal water level in the pressure vessel or the refuelling area is a symptom of inadequate core cooling or spent fuel cooling. The severity of the event increases as the water level decreases. If the water level is lower than is necessary for residual heat removal and cannot be restored, immediate action to restore core cooling should be taken. For this water level, alert is the appropriate EAL.

[g] This is a more accurate description of the phenomena inside the reactor vessel.

[h] Operation of the supporting systems for the safety systems is a necessary condition for operation of the safety systems.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
	Loss of all AC or DC power needed for the operation of safety systems **and** any of the following: — Vessel water level below top of active fuel **or** — Major (100–1000 times) increase in multiple radiation monitors **or** — Other indication of actual or imminent core damage		
Conditions of an unknown cause affecting safety systems			Conditions which are not understood and which could potentially affect safety systems
Loss or degraded control of safety systems including post-accident instrumentation[i]	Unavailability of safety system instruments or controls in the control room and remote control locations **and** any of the following: — Projected or confirmed vessel water level below top of irradiated fuel **or** — Major (100–1000 times) increase in multiple radiation monitors **or** — Other indications of actual or imminent core damage	Unavailability of safety system instruments or controls in the control room for more than 30 min and major transient in progress potentially affecting the ability to protect irradiated fuel	Unreliable functioning of some safety system instruments or controls in the control room for more than 30 min

[i] The control capability for safety systems could be either degraded or lost completely; both are reflected.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Loss of fission product barriers			
Major increased risk of core damage or spent fuel damage	Loss for more than 90 min of all systems required to protect the core *[or insert site specific time required to uncover core for more than 30 min]*	Failure of one or more safety system components will result in uncovering of the core or spent fuel (loss of redundancy in safety systems)	Actual or predicted safety system failures which increase the risk of core damage or spent fuel damage
Confirmed or projected core or spent fuel damage[j]	Confirmed release greater than 20% of gap inventory in the reactor core	Fuel handling accident or confirmed release greater than 1% of gap inventory **and** incomplete containment isolation (e.g. by ventilation, locks)	Fuel handling accident **and** containment isolation (e.g. by ventilation, locks)
Primary system coolant fluid leak[k]			Major leak from piping carrying primary system coolant fluid outside the containment (in purification systems, reactor heat removal system, etc.)

[j] A fuel handling accident or confirmed release of a significant amount of the gap inventory can cause release of fission products to the environment. In the cold shutdown and refuelling modes, the containment could be the only intact barrier to a release. In such a case, immediate action should be taken to mitigate or prevent the release. In the event that the containment is isolated, alert is the appropriate emergency class, and site area emergency may be appropriate in the event that the containment is not completely isolated.

[k] Even if a leak is less probable in the cold shutdown and refuelling modes than in the power operation, hot standby and hot shutdown modes, there still exists a possibility of primary system coolant leak. If a leak affecting core cooling occurs, immediate action to stop the leak and to prevent the loss of core cooling should be taken. The alert EAL is appropriate in such cases.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Radiation levels			
Effluent release rates greater than 100 times the release limits	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating that in 1 hour the off-site doses will be greater than the intervention levels for urgent protective actions, assuming average meteorological conditions]*	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating that in 4 hours the off-site doses will be greater than 0.10 of the intervention levels for urgent protective actions, assuming average meteorological conditions]*	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating 100 times the release limits]*
High radiation levels in areas requiring continuous access for operation and maintenance of safety systems **Note:** Inconsistent monitor readings could result from incomplete mixing, a failed monitor or irradiation from a contaminated system nearby. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand held monitors outside the area.	Radiation levels greater than 10 mSv/h	Radiation levels greater than 1 mSv/h potentially lasting several hours	Radiation levels greater than 0.10 mSv/h potentially lasting several hours
High radiation levels in areas requiring occasional occupancy to maintain or inspect safety systems	Radiation levels greater than 100 mSv/h potentially lasting several hours	Radiation levels greater than 10 mSv/h potentially lasting several hours	Radiation levels greater than 1 mSv/h potentially lasting several hours

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Evaluated containment radiation levels **Note:** Inconsistent monitor readings could result from incomplete mixing, a failed monitor or irradiation from a contaminated system nearby. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand held monitors outside the containment.	Containment radiation levels greater than 5 Gy/h *[or insert site specific reading indicating release of greater than 20% of gap inventory]*	Containment radiation levels greater than 1 Gy/h *[or insert site specific reading indicating release of greater than 1% of gap inventory]*	Containment radiation levels increasing faster than 0.10 mGy/h *[or insert site specific reading indicating release of greater than 10% of coolant]*
Unplanned increase in plant radiation levels as indicated by monitors	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more **and** any other indication of actual core damage	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more **and** a major transient in progress potentially affecting the ability to protect the core	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more
High ambient dose rates at or beyond[1] the site boundary	Ambient dose rates at or beyond the site boundary greater than 1 mSv/h *[or insert the site specific operational intervention level for evacuation; see Procedure B1 in Ref. [27]]*	Ambient dose rates at or beyond the site boundary greater than 0.1 mSv/h *[or insert one tenth of the site specific operational intervention level for evacuation; see Procedure B1 in Ref. [27]]*	Ambient dose rates at or beyond the site boundary greater than 10 µSv/h *[or insert site specific reading indicating 100 times the dose rate due to background radiation levels]*

[1] Ambient dose rate is usually measured at the site boundary. However, if any measurement of ambient dose rate beyond the site boundary is available, it can be used for the purpose of this EAL.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Security events, fires, explosions, toxic gas releases, natural and other events			
Security event (intruder or malicious act)	Security event resulting in loss of the ability to monitor and control safety functions needed to protect the core	Security event resulting in damage or impaired access to safety systems that are required to be operable[m]	Security event with potential to affect safety system operation, or uncertain security conditions
Fire or explosion[n]			Fire or explosion potentially affecting areas containing safety systems
Toxic or flammable gases			Toxic or flammable gases in plant
A major natural disaster such as: — Earthquake — Tornado — Floods — High winds — Vehicle or aircraft crash[o] — Hurricane — Tsunami — Storm surge — Low water — Lightning strike[p]		Major natural events resulting in damage or impaired access to safety and/or decay heat removal systems or affecting their long term operation[q]	Major natural events that threaten the plant such as: — Events beyond the design basis of the plant — Events resulting in actual or potential loss of access to the site for a long period of time

[m] Formal wording change to better convey the intent of the criterion. Only safety systems that are required to be operable are referenced in this EAL.
[n] Turbine is not in operation in the cold shutdown and refuelling modes.
[o] Aircraft crash can also cause severe damage to the plant and reduce plant safety.
[p] Lightning strikes can cause severe damage to the plant and reduce plant safety.
[q] Wording changed to better convey the intent of the criterion.

TABLE 13. EMERGENCY CLASSIFICATION FOR LIGHT WATER REACTORS IN COLD SHUTDOWN OR REFUELLING MODE (cont.)

For the following entry conditions:	Declare a general emergency if:	Declare a site area emergency if:	Declare an alert if:
Loss of communications[r]			Events resulting in actual or potential loss of communications to the site for a long period of time
Plant shift supervisor's opinion	Conditions that warrant taking urgent protective actions off the site	Conditions that warrant preparing the public to implement urgent protective actions or taking protective actions on the site	Abnormal conditions that warrant immediate additional assistance for the on-site operations staff or increased preparedness of off-site officials
Spent fuel pool events			
Abnormal refuelling or spent fuel conditions	Fully drained pool containing fuel removed from the reactor core within the past 6 months **or** Radiation level in pool area greater than 3 Gy/h	Water level below top of irradiated fuel **or** Radiation level in pool area greater than 30 mGy/h	Loss of ability to maintain water level in pool containing irradiated fuel **or** Damage to irradiated fuel **or** Loss of ability to maintain pool water temperature below 80°C [s]

[r] This EAL is new and reflects items deleted from the previous line.

[s] High temperature in the spent fuel pool is a result of a degradation in heat removal from the spent fuel, and this temperature should also be used as an additional symptom of abnormal refuelling or abnormal spent fuel conditions.

EXAMPLE EALs

III.27. When using Tables 12 and 13, all the abnormal entry conditions in the first column should be reviewed. For each entry condition that applies to a specific case, the class is selected by matching the EAL criteria to the left. The accident is classified at the highest class indicated, the highest class being ‘general emergency’ and the lowest class being ‘alert’.

III.28. These example EALs are based on an example system from Ref. [27]. Changes in the original guidance of Ref. [27] are accompanied by footnotes to explain and distinguish them from the technical comments included in the original guidance in Ref. [33]. This was done to help users of the previous guidance to better understand how to apply the changes. Some of the EALs from the original guidance were removed (this is not noted in the tables).

COOLING MARGIN–SATURATION CURVE

III.29. A primary system temperature equal to or greater than the saturation temperature indicates that the water in the core is boiling. The cooling margin can be approximated (neglecting instrument inaccuracies) by subtracting the coolant temperature from the saturation temperature for the given primary system pressure. For a pressurized water reactor a negative cooling margin indicates that water is boiling in the reactor pressure vessel and that the reactor core may be uncovered [33].

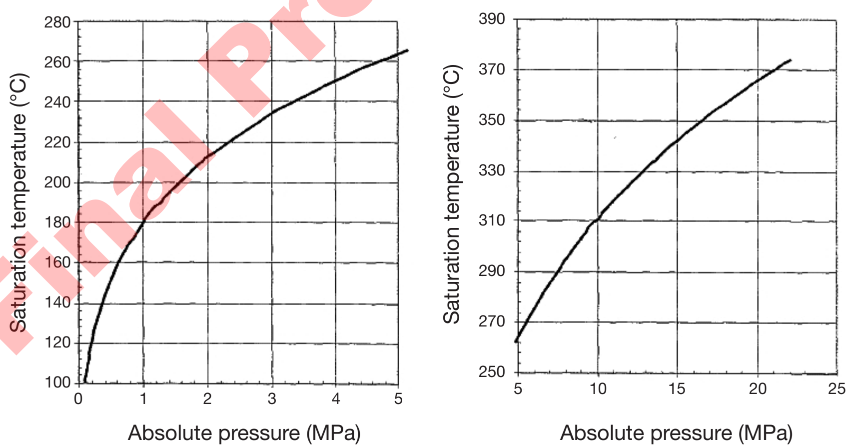

FIG. 7. Cooling margin–saturation curve [27].

How to use Fig. 7:

III.30. Determine the absolute pressure and temperature in the primary system T_{ps}; then use the graphs to determine the saturation temperature T_{sat}, and thus the cooling margin, by using the equation below:

$$\text{Cooling margin} = T_{sat} - T_{ps}$$

where

T_{ps} is the temperature in the primary system;
T_{sat} is the saturation temperature from Fig. 7.

WATER LOST BY BOILING DUE TO DECAY HEAT IN A 3000 MW(th) NUCLEAR POWER PLANT

III.31. The curve in Fig. 8 shows the amount of water that must be injected into the reactor pressure vessel to replace water lost by boiling due to decay heat. This curve is based on a 3000 MW(th) reactor operated at a constant power for a nominally infinite period and then shut down instantaneously. This is the minimum water flow rate that must be injected into a reactor core to cool it once it is shut down [33].

Step 1: Determine the amount of water injection required, from:

$$W_i = W_i^{3000} \frac{P_{plant}(\text{MW(th)})}{3000(\text{MW(th)})}$$

where

W_i is the water injection required (m^3/h);
W_i^{3000} is the water injection required for a 3000 MW(th) plant (m^3/h), from Fig. 8;
P_{plant} is the power output of the plant in MW(th) (MW(th) = 3 × MW(e)).

Step 2: If the core has been uncovered for more than 15 min, increase the injection rate by a factor of three to accommodate the heat from the $Zr–H_2O$ reaction and built-up (stored) energy.

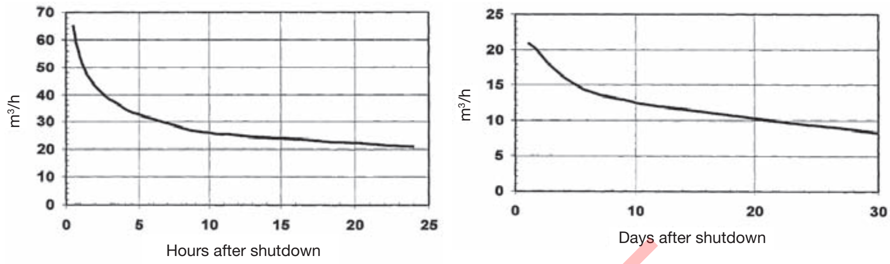

FIG. 8. Rate of injection of water required to replace water lost by boiling due to decay heat in a 3000 MW(th) nuclear power plant [27].

Appendix IV

OBSERVABLES ON THE SCENE OF A RADIOLOGICAL EMERGENCY

IV.1. In a radiological emergency, the inner cordoned area is where protective action is implemented to protect responders and the public. Initially the size of the area is determined on the basis of information that can be directly observed (e.g. markings). The size of the area may be expanded on the basis of dose rates and environmental measurement OILs (see Appendix II) when these data become available. Table 14 [7, 17] provides suggestions for the approximate radius of the inner cordoned area. Instruction 1 in Ref. [17] provides a list of observables that can be used by first responders to identify a dangerous source. The actual boundaries of the safety and security perimeters should be defined in such a way that they are easily recognizable (e.g. by roads) and should be secured. However, the safety perimeter should be established at least as far from the source as is indicated in the table until the radiological assessor has assessed the situation.

TABLE 14. SUGGESTED RADIUS OF THE INNER CORDONED AREA (SAFETY PERIMETER) IN A NUCLEAR OR RADIOLOGICAL EMERGENCY

Situation	Initial inner cordoned area (safety perimeter)
Initial determination — Outside	
Unshielded or damaged potentially dangerous source	30 m radius around the source
Major spill from a potentially dangerous source	100 m radius around the source
Fire, explosion or fumes involving a dangerous source	300 m radius
Suspected bomb (possible radiological dispersal device), exploded or unexploded	400 m radius or more to protect against an explosion
Conventional (non-nuclear) explosion or a fire involving a nuclear weapon (no nuclear yield)	1000 m radius
Initial determination — Inside a building	
Damage, loss of shielding or spill involving a potentially dangerous source	Affected and adjacent areas (including floors above and below)
Fire or other event involving a potentially dangerous source that can spread radioactive material throughout the building (e.g. through the ventilation system)	Entire building and appropriate outside distance as indicated above
Expansion based on radiological monitoring	
OIL1 and OIL2 from Table 8	Wherever these levels are measured

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, Legal Series No. 14, IAEA, Vienna (1987).

[2] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE CO-ORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, WORLD HEALTH ORGANIZATION, Development of an Extended Framework for Emergency Response Criteria: Interim Report for Comment, IAEA-TECDOC-1432, IAEA, Vienna (2005).

[4] EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIROMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection, 2007 Edition, IAEA, Vienna (2007).

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

[7] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE CO-ORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Arrangements for Preparedness for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-G-2.1, IAEA, Vienna (2007).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency, EPR-METHOD (2003), IAEA, Vienna (2003).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Planning and Preparing for Emergency Response to Transport Accidents Involving Radioactive Material, IAEA Safety Standards Series No. TS-G-1.2 (ST-3), IAEA, Vienna (2002).

[10] FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANISATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, WORLD HEALTH ORGANIZATION, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No. 115, IAEA, Vienna (1996).

[11] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Protection of the Public in Situations of Prolonged Radiation Exposure, ICRP Publication 82, Ann. ICRP **29** 1–2, Pergamon Press, Oxford (2000).
[12] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, Ann. ICRP **21** 1–3, Pergamon Press, Oxford (1991).
[13] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Principles for Intervention for Protection of the Public in a Radiological Emergency, ICRP Publication 63, Ann. ICRP **22** 4, Pergamon Press, Oxford (1991).
[14] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, Ann. ICRP **37** 2–4 (2007).
[15] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Application of the Commission's Recommendations for the Protection of People in Emergency Exposure Situations, ICRP Publication 109, Ann. ICRP **39** 1, Elsevier, Amsterdam (2009).
[16] UNITED STATES NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Management of Terrorist Events Involving Radioactive Material, Rep. No. 138, US NCRP, Bethesda (2001).
[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Dangerous Quantities of Radioactive Material, EPR-D-VALUES (2006), IAEA, Vienna (2006).
[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Manual for First Responders to a Radiological Emergency, EPR-FIRST RESPONDERS (2006), IAEA, Vienna (2006).
[19] UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION, Sources and Effects of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation, 2000 Report to the General Assembly with Scientific Annexes, Vol. 2: Effects, Annex G: Biological Effects at Low Radiation Doses, United Nations, New York (2000).
[20] WORLD HEALTH ORGANIZATION, Health Effects of the Chernobyl Accident and Special Health Care Programmes, Report of the UN Chernobyl Forum (BENNETT, B., REPACHOLI, M., CARR, Z., Eds), WHO, Geneva (2006).
[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Procedures for Medical Response during a Nuclear or Radiological Emergency, EPR-MEDICAL (2005), IAEA, Vienna (2005).
[22] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Relative Biological Effectiveness (RBE), Quality Factor (Q) and Radiation Weighting Factor (w_R), ICRP Publication 92, Ann. ICRP **33** 4, Elsevier, Amsterdam (2003).
[23] EVANS, J.S., ABRAHAMSON, S., BENDER, M.A., BOECKER, B.B., GILBERT, E.S., SCOTT, B.R., Health Effects Models for Nuclear Power Accident Consequence Analysis, Part I: Introduction, Integration, and Summary, NUREG/CR-4214 Rev. 2, Part I ITRI-141, United States Nuclear Regulatory Commission, Washington, DC (1993).
[24] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, The Evolution of the System of Radiological Protection: The Justification for new ICRP Recommendations, J. Radiol. Prot. **23** (2003) 129–142.

[25] INTERNATIONAL COMMISSION ON RADIATION UNITS AND MEASUREMENTS, Quantities and Units in Radiation Protection Dosimetry, ICRU Rep. 51, ICRU, Bethesda (1993).
[26] INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION, Biological Effects after Prenatal Irradiation (Embryo and Fetus), ICRP Publication 90, Ann. ICRP **33** (1–2) (2003).
[27] INTERNATIONAL ATOMIC ENERGY AGENCY, Generic Assessment Procedures for Determining Protective Actions during a Reactor Accident, IAEA-TECDOC-955, IAEA, Vienna (1997).
[28] INTERNATIONAL ATOMIC ENERGY AGENCY, The Radiological Accident in Goiânia, IAEA, Vienna (1988).
[29] JOINT FAO/WHO FOOD STANDARDS PROGRAMME, CODEX ALIMENTARIUS COMMISSION, Codex General Standard for Contaminants and Toxins in Foods, Schedule 1 — Radionuclides, CODEX STAN 193-1995, CAC, Rome (2006).
[30] WORLD HEALTH ORGANIZATION, Guidelines for Drinking-Water Quality: Incorporating First and Second Addenda, Vol. 1, Recommendations — 3rd edn, WHO, Geneva (2006).
[31] INTERNATIONAL ATOMIC ENERGY AGENCY, The International Chernobyl Project: Technical Report, IAEA, Vienna (1991).
[32] McKENNA, T., BUGLOVA, E., KUTKOV, V., Lessons learned from Chernobyl and other emergencies: Establishing international requirements and guidance, Health Physics **93** 5 (2007) 527–537.
[33] UNITED STATES NUCLEAR REGULATORY COMMISSION, Response Technical Manual, NUREG/BR-0150, Vol. 1, Rev. 4, USNRC, Washington, DC (1996).

CONTRIBUTORS TO DRAFTING AND REVIEW

Aeberli, W.	Beznau Nuclear Power Plant, Switzerland
Ahmad, S.	Pakistan Atomic Energy Commission, Pakistan
Barabanova, A.	State Research Centre, Institute of Biophysics, Russian Federation
Boecker, B.	Consultant, United States of America
Buglova, E.	International Atomic Energy Agency
Carr, Z.	World Health Organization
Crick, M.	International Atomic Energy Agency
Ford, J.	Health Canada, Canada
Hedemann Jensen, P.	Risø National Laboratory, Denmark
Homma, T.	Japan Atomic Energy Agency, Japan
Hončarenko, R.	Temelin Nuclear Power Plant, Czech Republic
Janko, K.	Nuclear Regulatory Authority of the Slovak Republic, Slovakia
Jaworska, A.	Norwegian Radiation Protection Authority, Norway
Kenigsberg, J.	National Commission on Radiation Protection, Belarus
Kocheyev, V.	World Association for Disaster and Emergency Medicine, United States of America
Kostadinov, V.	Slovenian Nuclear Safety Administration, Slovenia
Kutkov, V.	Russian Research Centre 'Kurchatov Institute', Russian Federation
Lafortune, J.	International Safety Research, Canada
Lee, S.	International Atomic Energy Agency

Lim, S.	Korea Institute of Radiological and Medical Sciences (KIRAMS), Republic of Korea
Martinčič, R.	International Atomic Energy Agency
McClelland, V.	United States Department of Energy, United States of America
McKenna, T.	International Atomic Energy Agency
Miller, C.	Centers for Disease Control and Prevention, United States of America
Nagataki, S.	Japan Radioisotope Association, Japan
Paile, W.	Radiation and Nuclear Safety Authority, Finland
Pellet, S.	OSSKI National Research Institute for Radiobiology and Radiohygiene, Hungary
Perez, M.	World Health Organization
Ricks, R.	Radiation Emergency Assistance Center/Training Site, United States of America
Robinson, J.	Nuclear Safety Directorate, United Kingdom
Rochedo, E.	National Nuclear Energy Commission, Brazil
Scott, B.	Lovelace Respiratory Research Institute, United States of America
Sjöblom, K.	Fortum Power and Heat Oy, Loviisa Power Plant, Finland
Sládek, V.	Nuclear Regulatory Authority of the Slovak Republic, Slovakia
Smith, J.	Centers for Disease Control and Prevention, United States of America
Solomon, S.	Australian Radiation Protection and Nuclear Safety Agency, Australia

Sundnes, K.	World Association for Disaster and Emergency Medicine, Norway
Turai, I.	OSSKI National Research Institute for Radiobiology and Radiohygiene, Hungary
Weiss, W.	Bundesamt für Strahlenschutz, Germany
Whitcomb, R.	Centers for Disease Control and Prevention, United States of America

BODIES FOR THE ENDORSEMENT OF IAEA SAFETY STANDARDS

An asterisk denotes a corresponding member. Corresponding members receive drafts for comment and other documentation but they do not generally participate in meetings. Two asterisks denote an alternate.

Commission on Safety Standards

Argentina: González, A.J.; *Australia*: Loy, J.; *Belgium*: Samain, J.-P.; *Brazil*: Vinhas, L.A.; *Canada*: Jammal, R.; *China*: Liu Hua; *Egypt*: Barakat, M.; *Finland*: Laaksonen, J.; *France*: Lacoste, A.-C. (Chairperson); *Germany*: Majer, D.; *India*: Sharma, S.K.; *Israel*: Levanon, I.; *Japan*: Fukushima, A.; *Korea, Republic of*: Choul-Ho Yun; *Lithuania*: Maksimovas, G.; *Pakistan*: Rahman, M.S.; *Russian Federation*: Adamchik, S.; *South Africa*: Magugumela, M.T.; *Spain*: Barceló Vernet, J.; *Sweden*: Larsson, C.M.; *Ukraine*: Mykolaichuk, O.; *United Kingdom*: Weightman, M.; *United States of America*: Virgilio, M.; *Vietnam*: Le-chi Dung; *IAEA*: Delattre, D. (Coordinator); *Advisory Group on Nuclear Security*: Hashmi, J.A.; *European Commission*: Faross, P.; *International Nuclear Safety Group*: Meserve, R.; *International Commission on Radiological Protection*: Holm, L.-E.; *OECD Nuclear Energy Agency*: Yoshimura, U.; *Safety Standards Committee Chairpersons*: Brach, E.W. (TRANSSC); Magnusson, S. (RASSC); Pather, T. (WASSC); Vaughan, G.J. (NUSSC).

Nuclear Safety Standards Committee

Algeria: Merrouche, D.; *Argentina*: Waldman, R.; *Australia*: Le Cann, G.; *Austria*: Sholly, S.; *Belgium*: De Boeck, B.; *Brazil*: Gromann, A.; **Bulgaria*: Gledachev, Y.; *Canada*: Rzentkowski, G.; *China*: Jingxi Li; *Croatia*: Valčić, I.; **Cyprus*: Demetriades, P.; *Czech Republic*: Šváb, M.; *Egypt*: Ibrahim, M.; *Finland*: Järvinen, M.-L.; *France*: Feron, F.; *Germany*: Wassilew, C.; *Ghana*: Emi-Reynolds, G.; **Greece*: Camarinopoulos, L.; *Hungary*: Adorján, F.; *India*: Vaze, K.; *Indonesia*: Antariksawan, A.; *Iran, Islamic Republic of*: Asgharizadeh, F.; *Israel*: Hirshfeld, H.; *Italy*: Bava, G.; *Japan*: Kanda, T.; *Korea, Republic of*: Hyun-Koon Kim; *Libyan Arab Jamahiriya*: Abuzid, O.; *Lithuania*: Demčenko, M.; *Malaysia*: Azlina Mohammed Jais; *Mexico*: Carrera, A.; *Morocco*: Soufi, I.; *Netherlands*: van der Wiel, L.; *Pakistan*: Habib, M.A.; *Poland*: Jurkowski, M.; *Romania*: Biro, L.; *Russian Federation*: Baranaev, Y.; *Slovakia*: Uhrik, P.; *Slovenia*: Vojnovič, D.; *South Africa*: Leotwane, W.; *Spain*: Zarzuela, J.; *Sweden*: Hallman, A.; *Switzerland*: Flury, P.; *Tunisia*: Baccouche, S.;

Turkey: Bezdegumeli, U.; *Ukraine*: Shumkova, N.; *United Kingdom*: Vaughan, G.J. (Chairperson); *United States of America*: Mayfield, M.; *Uruguay*: Nader, A.; *European Commission*: Vigne, S.; *FORATOM*: Fourest, B.; *IAEA*: Feige, G. (Coordinator); *International Electrotechnical Commission*: Bouard, J.-P.; *International Organization for Standardization*: Sevestre, B.; *OECD Nuclear Energy Agency*: Reig, J.; **World Nuclear Association*: Borysova, I.

Radiation Safety Standards Committee

**Algeria*: Chelbani, S.; *Argentina*: Massera, G.; *Australia*: Melbourne, A.; **Austria*: Karg, V.; *Belgium*: van Bladel, L.; *Brazil*: Rodriguez Rochedo, E.R.; **Bulgaria*: Katzarska, L.; *Canada*: Clement, C.; *China*: Huating Yang; *Croatia*: Kralik, I.; **Cuba*: Betancourt Hernandez, L.; **Cyprus*: Demetriades, P.; *Czech Republic*: Petrova, K.; *Denmark*: Øhlenschlæger, M.; *Egypt*: Hassib, G.M.; *Estonia*: Lust, M.; *Finland*: Markkanen, M.; *France*: Godet, J.-L.; *Germany*: Helming, M.; *Ghana*: Amoako, J.; **Greece*: Kamenopoulou, V.; *Hungary*: Koblinger, L.; *Iceland*: Magnusson, S. (Chairperson); *India*: Sharma, D.N.; *Indonesia*: Widodo, S.; *Iran, Islamic Republic of*: Kardan, M.R.; *Ireland*: Colgan, T.; *Israel*: Koch, J.; *Italy*: Bologna, L.; *Japan*: Kiryu, Y.; *Korea, Republic of*: Byung-Soo Lee; **Latvia*: Salmins, A.; *Libyan Arab Jamahiriya*: Busitta, M.; *Lithuania*: Mastauskas, A.; *Malaysia*: Hamrah, M.A.; *Mexico*: Delgado Guardado, J.; *Morocco*: Tazi, S.; *Netherlands*: Zuur, C.; *Norway*: Saxebol, G.; *Pakistan*: Ali, M.; *Paraguay*: Romero de Gonzalez, V.; *Philippines*: Valdezco, E.; *Poland*: Merta, A.; *Portugal*: Dias de Oliveira, A.M.; *Romania*: Rodna, A.; *Russian Federation*: Savkin, M.; *Slovakia*: Jurina, V.; *Slovenia*: Sutej, T.; *South Africa*: Olivier, J.H.I.; *Spain*: Amor Calvo, I.; *Sweden*: Almen, A.; *Switzerland*: Piller, G.; **Thailand*: Suntarapai, P.; *Tunisia*: Chékir, Z.; *Turkey*: Okyar, H.B.; *Ukraine*: Pavlenko, T.; *United Kingdom*: Robinson, I.; *United States of America*: Lewis, R.; **Uruguay*: Nader, A.; *European Commission*: Janssens, A.; *Food and Agriculture Organization of the United Nations*: Byron, D.; *IAEA*: Boal, T. (Coordinator); *International Commission on Radiological Protection*: Valentin, J.; *International Electrotechnical Commission*: Thompson, I.; *International Labour Office*: Niu, S.; *International Organization for Standardization*: Rannou, A.; *International Source Suppliers and Producers Association*: Fasten, W.; *OECD Nuclear Energy Agency*: Lazo, T.E.; *Pan American Health Organization*: Jiménez, P.; *United Nations Scientific Committee on the Effects of Atomic Radiation*: Crick, M.; *World Health Organization*: Carr, Z.; *World Nuclear Association*: Saint-Pierre, S.

Transport Safety Standards Committee

Argentina: López Vietri, J.; **Capadona, N.M.; *Australia*: Sarkar, S.; *Austria*: Kirchnawy, F.; *Belgium*: Cottens, E.; *Brazil*: Xavier, A.M.; *Bulgaria*: Bakalova, A.; *Canada*: Régimbald, A.; *China*: Xiaoqing Li; *Croatia*: Belamarić, N.; **Cuba*: Quevedo Garcia, J.R.; **Cyprus*: Demetriades, P.; *Czech Republic*: Ducháček, V.; *Denmark*: Breddam, K.; *Egypt*: El-Shinawy, R.M.K.; *Finland*: Lahkola, A.; *France*: Landier, D.; *Germany*: Rein, H.; *Nitsche, F.; **Alter, U.; *Ghana*: Emi-Reynolds, G.; **Greece*: Vogiatzi, S.; *Hungary*: Sáfár, J.; *India*: Agarwal, S.P.; *Indonesia*: Wisnubroto, D.; *Iran, Islamic Republic of*: Eshraghi, A.; *Emamjomeh, A.; *Ireland*: Duffy, J.; *Israel*: Koch, J.; *Italy*: Trivelloni, S.; **Orsini, A.; *Japan*: Hanaki, I.; *Korea, Republic of*: Dae-Hyung Cho; *Libyan Arab Jamahiriya*: Kekli, A.T.; *Lithuania*: Statkus, V.; *Malaysia*: Sobari, M.P.M.; **Husain, Z.A.; *Mexico*: Bautista Arteaga, D.M.; **Delgado Guardado, J.L.; **Morocco*: Allach, A.; *Netherlands*: Ter Morshuizen, M.; **New Zealand*: Ardouin, C.; *Norway*: Hornkjøl, S.; *Pakistan*: Rashid, M.; **Paraguay*: More Torres, L.E.; *Poland*: Dziubiak, T.; *Portugal*: Buxo da Trindade, R.; *Russian Federation*: Buchelnikov, A.E.; *South Africa*: Hinrichsen, P.; *Spain*: Zamora Martin, F.; *Sweden*: Häggblom, E.; **Svahn, B.; *Switzerland*: Krietsch, T.; *Thailand*: Jerachanchai, S.; *Turkey*: Ertürk, K.; *Ukraine*: Lopatin, S.; *United Kingdom*: Sallit, G.; *United States of America*: Boyle, R.W.; Brach, E.W. (Chairperson); *Uruguay*: Nader, A.; *Cabral, W.; *European Commission*: Binet, J.; *IAEA*: Stewart, J.T. (Coordinator); *International Air Transport Association*: Brennan, D.; *International Civil Aviation Organization*: Rooney, K.; *International Federation of Air Line Pilots' Associations*: Tisdall, A.; **Gessl, M.; *International Maritime Organization*: Rahim, I.; *International Organization for Standardization*: Malesys, P.; *International Source Supplies and Producers Association*: Miller, J.J.; **Roughan, K.; *United Nations Economic Commission for Europe*: Kervella, O.; *Universal Postal Union*: Bowers, D.G.; *World Nuclear Association*: Gorlin, S.; *World Nuclear Transport Institute*: Green, L.

Waste Safety Standards Committee

Algeria: Abdenacer, G.; *Argentina*: Biaggio, A.; *Australia*: Williams, G.; **Austria*: Fischer, H.; *Belgium*: Blommaert, W.; *Brazil*: Tostes, M.; **Bulgaria*: Simeonov, G.; *Canada*: Howard, D.; *China*: Zhimin Qu; *Croatia*: Trifunovic, D.; *Cuba*: Fernandez, A.; *Cyprus*: Demetriades, P.; *Czech Republic*: Lietava, P.; *Denmark*: Nielsen, C.; *Egypt*: Mohamed, Y.; *Estonia*: Lust, M.; *Finland*: Hutri, K.; *France*: Rieu, J.; *Germany*: Götz, C.; *Ghana*: Faanu, A.; *Greece*: Tzika, F.; *Hungary*: Czoch, I.; *India*: Rana, D.; *Indonesia*: Wisnubroto, D.; *Iran, Islamic*

Republic of: Assadi, M.; *Zarghami, R.; *Iraq*: Abbas, H.; *Israel*: Dody, A.; *Italy*: Dionisi, M.; *Japan*: Matsuo, H.; *Korea, Republic of*: Won-Jae Park; **Latvia*: Salmins, A.; *Libyan Arab Jamahiriya*: Elfawares, A.; *Lithuania*: Paulikas, V.; *Malaysia*: Sudin, M.; *Mexico*: Aguirre Gómez, J.; **Morocco*: Barkouch, R.; *Netherlands*: van der Shaaf, M.; *Pakistan*: Mannan, A.; **Paraguay*: Idoyaga Navarro, M.; *Poland*: Wlodarski, J.; *Portugal*: Flausino de Paiva, M.; *Slovakia*: Homola, J.; *Slovenia*: Mele, I.; *South Africa*: Pather, T. (Chairperson); *Spain*: Sanz Aludan, M.; *Sweden*: Frise, L.; *Switzerland*: Wanner, H.; **Thailand*: Supaokit, P.; *Tunisia*: Bousselmi, M.; *Turkey*: Özdemir, T.; *Ukraine*: Makarovska, O.; *United Kingdom*: Chandler, S.; *United States of America*: Camper, L.; **Uruguay*: Nader, A.; *European Commission*: Necheva, C.; *European Nuclear Installations Safety Standards*: Lorenz, B.; **European Nuclear Installations Safety Standards*: Zaiss, W.; *IAEA*: Siraky, G. (Coordinator); *International Organization for Standardization*: Hutson, G.; *International Source Suppliers and Producers Association*: Fasten, W.; *OECD Nuclear Energy Agency*: Riotte, H.; *World Nuclear Association*: Saint-Pierre, S.

PREPAREDNESS AND RESPONSE FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY
IAEA Safety Standards Series No. GS-R-2
STI/PUB/1133 (72 pp.; 2002)
ISBN 92–0–116702–4 Price: €20.50

ARRANGEMENTS FOR PREPAREDNESS FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY
IAEA Safety Standards Series No. GS-G-2.1
STI/PUB/1265 (145 pp.; 2007)
ISBN 92–0–109306–3 Price: €31.00

PLANNING AND PREPARING FOR EMERGENCY RESPONSE TO TRANSPORT ACCIDENTS INVOLVING RADIOACTIVE MATERIAL
IAEA Safety Standards Series No. TS-G-1.2 (ST-3)
STI/PUB/1119 (125 pp.; 2002)
ISBN 92–0–111602–0 Price: €14.50

FUNDAMENTAL SAFETY PRINCIPLES
IAEA Safety Standards Series No. SF-1
STI/PUB/1273 (37 pp.; 2006)
ISBN 92–0–110706–4 Price: €25.00

CATEGORIZATION OF RADIOACTIVE SOURCES
IAEA Safety Standards Series No. RS-G-1.9
STI/PUB/1227 (70 pp.; 2005)
ISBN 92–0–103905–0 Price: €18.00

GOVERNMENTAL, LEGAL AND REGULATORY FRAMEWORK FOR SAFETY
IAEA Safety Standards Series No. GSR Part 1
STI/PUB/1465 (63 pp.; 2010)
ISBN 978–92–0–106410–3 Price: €45.00

SAFETY ASSESSMENT FOR FACILITIES AND ACTIVITIES
IAEA Safety Standards Series No. GSR Part 4
STI/PUB/1375 (56 pp.; 2009)
ISBN 978–92–0–112808–9 Price: €48.00

PREDISPOSAL MANAGEMENT OF RADIOACTIVE WASTE
IAEA Safety Standards Series No. GSR Part 5
STI/PUB/1368 (38 pp.; 2009)
ISBN 978–92–0–111508–9 Price: €45.00

THE MANAGEMENT SYSTEM FOR FACILITIES AND ACTIVITIES
IAEA Safety Standards Series No. GS-R-3
STI/PUB/1252 (39 pp.; 2006)
ISBN 92–0–106506–X Price: €25.00

Safety through international standards

"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."

Yukiya Amano
Director General

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA
ISBN 978–92–0–107410–2
ISSN 1020–525X