

IAEA Safety Standards

for protecting people and the environment

Severe Accident Management Programmes for Nuclear Power Plants

Safety Guide
No. NS-G-2.15



IAEA
International Atomic Energy Agency



Documents
Document Sharing Hub

SEVERE ACCIDENT MANAGEMENT PROGRAMMES FOR NUCLEAR POWER PLANTS

Safety standards survey

The IAEA welcomes your response. Please see:
<http://www-ns.iaea.org/standards/feedback.htm>

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN	GREECE	OMAN
ALBANIA	GUATEMALA	PAKISTAN
ALGERIA	HAITI	PALAU
ANGOLA	HOLY SEE	PANAMA
ARGENTINA	HONDURAS	PARAGUAY
ARMENIA	HUNGARY	PERU
AUSTRALIA	ICELAND	PHILIPPINES
AUSTRIA	INDIA	POLAND
AZERBAIJAN	INDONESIA	PORTUGAL
BAHRAIN	IRAN, ISLAMIC REPUBLIC OF	QATAR
BANGLADESH	IRAQ	REPUBLIC OF MOLDOVA
BELARUS	IRELAND	ROMANIA
BELGIUM	ISRAEL	RUSSIAN FEDERATION
BELIZE	ITALY	SAUDI ARABIA
BENIN	JAMAICA	SENEGAL
BOLIVIA	JAPAN	SERBIA
BOSNIA AND HERZEGOVINA	JORDAN	SEYCHELLES
BOTSWANA	KAZAKHSTAN	SIERRA LEONE
BRAZIL	KENYA	SINGAPORE
BULGARIA	KOREA, REPUBLIC OF	SLOVAKIA
BURKINA FASO	KUWAIT	SLOVENIA
BURUNDI	KYRGYZSTAN	SOUTH AFRICA
CAMEROON	LATVIA	SPAIN
CANADA	LEBANON	SRI LANKA
CENTRAL AFRICAN REPUBLIC	LIBERIA	SUDAN
CHAD	LIBYAN ARAB JAMAHIRIYA	SWEDEN
CHILE	LIECHTENSTEIN	SWITZERLAND
CHINA	LITHUANIA	SYRIAN ARAB REPUBLIC
COLOMBIA	LUXEMBOURG	TAJIKISTAN
COSTA RICA	MADAGASCAR	THAILAND
CÔTE D'IVOIRE	MALAWI	THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
CROATIA	MALAYSIA	TUNISIA
CUBA	MALI	TURKEY
CYPRUS	MALTA	UGANDA
CZECH REPUBLIC	MARSHALL ISLANDS	UKRAINE
DEMOCRATIC REPUBLIC OF THE CONGO	MAURITANIA	UNITED ARAB EMIRATES
DENMARK	MAURITIUS	UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
DOMINICAN REPUBLIC	MEXICO	UNITED REPUBLIC OF TANZANIA
ECUADOR	MONACO	UNITED STATES OF AMERICA
EGYPT	MONGOLIA	URUGUAY
EL SALVADOR	MONTENEGRO	UZBEKISTAN
ERITREA	MOROCCO	VENEZUELA
ESTONIA	MOZAMBIQUE	VIETNAM
ETHIOPIA	MYANMAR	YEMEN
FINLAND	NAMIBIA	ZAMBIA
FRANCE	NEPAL	ZIMBABWE
GABON	NETHERLANDS	
GEORGIA	NEW ZEALAND	
GERMANY	NICARAGUA	
GHANA	NIGER	
	NIGERIA	
	NORWAY	

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

This publication has been superseded by SSG-54.

IAEA SAFETY STANDARDS SERIES No. NS-G-2.15

SEVERE ACCIDENT MANAGEMENT PROGRAMMES FOR NUCLEAR POWER PLANTS

SAFETY GUIDE

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2009

COPYRIGHT NOTICE

All IAEA scientific and technical publications are protected by the terms of the Universal Copyright Convention as adopted in 1952 (Berne) and as revised in 1972 (Paris). The copyright has since been extended by the World Intellectual Property Organization (Geneva) to include electronic and virtual intellectual property. Permission to use whole or parts of texts contained in IAEA publications in printed or electronic form must be obtained and is usually subject to royalty agreements. Proposals for non-commercial reproductions and translations are welcomed and considered on a case-by-case basis. Enquiries should be addressed to the IAEA Publishing Section at:

Sales and Promotion, Publishing Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. 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>

© IAEA, 2009

Printed by the IAEA in Austria
July 2009
STI/PUB/1376

IAEA Library Cataloguing in Publication Data

Severe accident management programmes for nuclear power plants :
safety guide. — Vienna : International Atomic Energy Agency, 2008.
p. ; 24 cm. — (IAEA safety standards series, ISSN 1020-525X ;
no. NS-G-2.15)
STI/PUB/1376
ISBN 978-92-0-112908-6
Includes bibliographical references.

1. Nuclear power plants — Accidents — Management. 2. Nuclear
reactor accidents — Management. I. International Atomic Energy
Agency. II. Series.

IAEAL

08-00559

FOREWORD

by Mohamed ElBaradei
Director General

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

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

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

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

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

This publication has been superseded by SSG-54.

THE IAEA SAFETY STANDARDS

BACKGROUND

Radioactivity is a natural phenomenon and natural sources of radiation are features of the environment. Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers and the public and to the environment that may arise from these applications have to be assessed and, if necessary, controlled.

Activities such as the medical uses of radiation, the operation of nuclear installations, the production, transport and use of radioactive material, and the management of radioactive waste must therefore be subject to standards of safety.

Regulating safety is a national responsibility. However, radiation risks may transcend national borders, and international cooperation serves to promote and enhance safety globally by exchanging experience and by improving capabilities to control hazards, to prevent accidents, to respond to emergencies and to mitigate any harmful consequences.

States have an obligation of diligence and duty of care, and are expected to fulfil their national and international undertakings and obligations.

International safety standards provide support for States in meeting their obligations under general principles of international law, such as those relating to environmental protection. International safety standards also promote and assure confidence in safety and facilitate international commerce and trade.

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

THE IAEA SAFETY STANDARDS

The status of the IAEA safety standards derives from the IAEA's Statute, which authorizes the IAEA to establish or adopt, in consultation and, where appropriate, in collaboration with the competent organs of the United Nations and with the specialized agencies concerned, standards of safety for protection

of health and minimization of danger to life and property, and to provide for their application.

With a view to ensuring the protection of people and the environment from harmful effects of ionizing radiation, the IAEA safety standards establish fundamental safety principles, requirements and measures to control the radiation exposure of people and the release of radioactive material to the environment, to restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation, and to mitigate the consequences of such events if they were to occur. The standards apply to facilities and activities that give rise to radiation risks, including nuclear installations, the use of radiation and radioactive sources, the transport of radioactive material and the management of radioactive waste.

Safety measures and security measures¹ have in common the aim of protecting human life and health and the environment. Safety measures and security measures must be designed and implemented in an integrated manner so that security measures do not compromise safety and safety measures do not compromise security.

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

Safety Fundamentals

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

Safety Requirements

An integrated and consistent set of Safety Requirements establishes the requirements that must be met to ensure the protection of people and the environment, both now and in the future. The requirements are governed by the objective and principles of the Safety Fundamentals. If the requirements are not met, measures must be taken to reach or restore the required level of safety. The format and style of the requirements facilitate their use for the establishment, in a harmonized manner, of a national regulatory framework. The safety requirements use 'shall' statements together with statements of

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

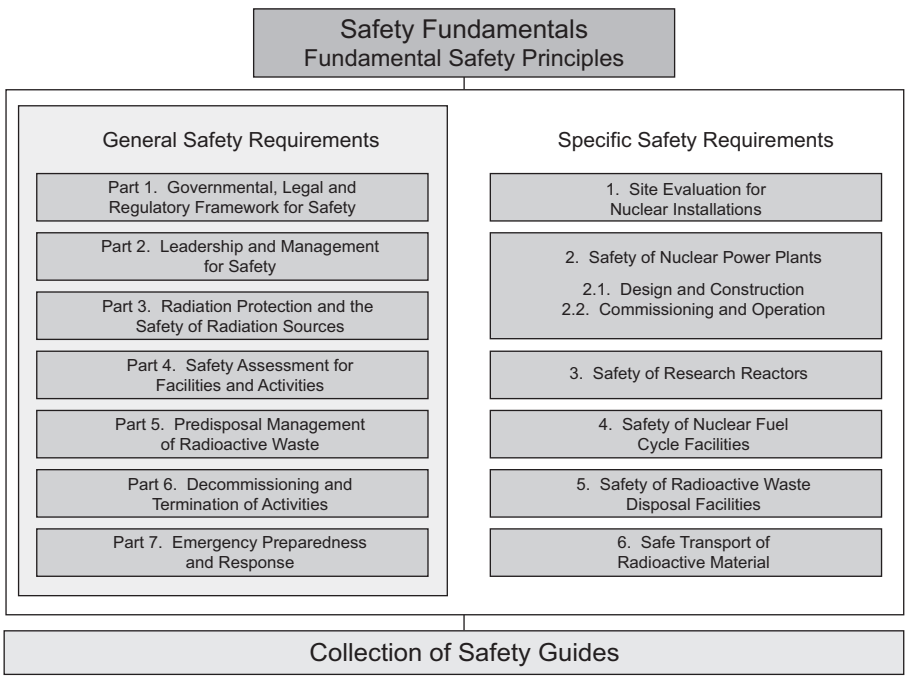


FIG. 1. The long term structure of the IAEA Safety Standards Series.

associated conditions to be met. 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 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

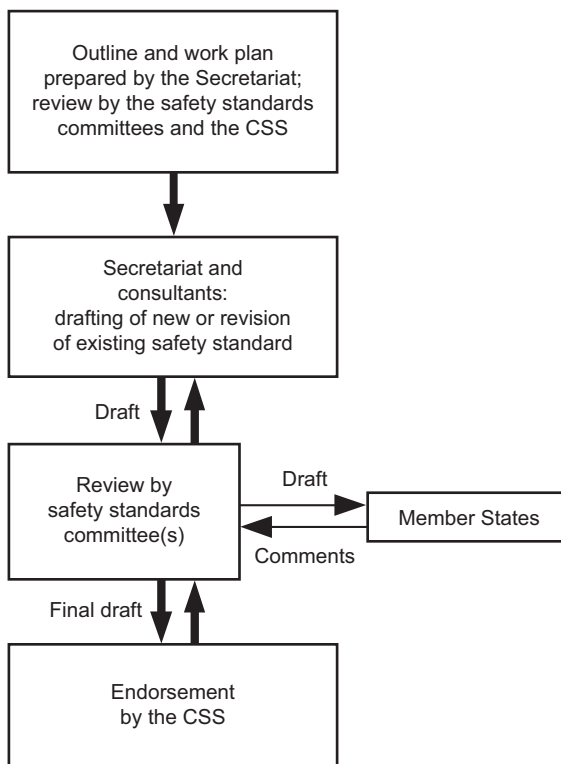


FIG. 2. The process for developing a new safety standard or revising an existing standard.

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 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	1
	Background (1.1–1.4)	1
	Objective (1.5–1.7)	2
	Scope (1.8–1.11)	2
	Structure (1.12)	2
2.	CONCEPT OF THE ACCIDENT MANAGEMENT PROGRAMME	3
	Requirements (2.1–2.3)	3
	Concept of accident management (2.4–2.11)	5
	Main principles (2.12–2.18)	7
	Equipment upgrades (2.19–2.22)	8
	Forms of accident management guidance (2.23–2.30)	9
	Roles and responsibilities (2.31–2.38)	11
3.	DEVELOPMENT OF AN ACCIDENT MANAGEMENT PROGRAMME	12
	General remarks: Preventive regime (3.1–3.2)	12
	General remarks: Mitigatory regime (3.3–3.13)	13
	Identification of plant vulnerabilities (3.14–3.16)	15
	Identification of plant capabilities (3.17–3.19)	16
	Development of accident management strategies (3.20–3.31)	17
	Development of procedures and guidelines (3.32–3.57)	20
	Hardware provisions for accident management (3.58–3.70)	27
	Role of instrumentation and control (3.71–3.77)	31
	Responsibilities and lines of authorization (3.78–3.98)	33
	Verification and validation (3.99–3.103)	38
	Education and training (3.104–3.110)	41
	Processing new information (3.111–3.114)	42
	Supporting analysis (3.115–3.129)	43
	Management system (3.130)	46
	APPENDIX: PRACTICAL USE OF THE SAMGs	47
	REFERENCES	51

ANNEX: AN EXAMPLE OF A CATEGORIZATION SCHEME
 FOR ACCIDENT SEQUENCES 53

CONTRIBUTORS TO DRAFTING AND REVIEW 61

BODIES FOR THE ENDORESEMENT OF IAEA
SAFETY STANDARDS 63

1. INTRODUCTION

BACKGROUND

1.1. Consideration of beyond design basis accidents at nuclear power plants is an essential component of the defence in depth approach used in ensuring nuclear safety [1–3]. The probability of occurrence of a beyond design basis accident is very low, but such an accident may lead to significant consequences resulting from the degradation of nuclear fuel.

1.2. A design basis accident is defined as accident conditions against which a facility is designed according to established design criteria, and for which the damage to the fuel and the release of radioactive material are kept within authorized limits [4].

1.3. A beyond design basis accident comprises accident conditions more severe than a design basis accident, and may or may not involve core degradation. Accident conditions more severe than a design basis accident and involving significant core degradation are termed severe accidents [4].¹

1.4. Accident management is the taking of a set of actions during the evolution of a beyond design basis accident:

- (a) To prevent the escalation of the event into a severe accident;
- (b) To mitigate the consequences of a severe accident;
- (c) To achieve a long term safe stable state [4].

The second aspect of accident management (to mitigate the consequences of a severe accident) is also termed severe accident management. Accident management is essential to ensure effective defence in depth at the fourth level [2].²

¹ See para. 2.1.

² The objective of the fourth level of defence in depth is to ensure that both the likelihood of an accident entailing significant core damage (a severe accident) and the magnitude of a release of radioactive material following a severe accident are kept as low as reasonably achievable and, thereby, to reduce risk.

OBJECTIVE

1.5. This Safety Guide provides recommendations on meeting the requirements for accident management, including managing severe accidents, that are established in Section 5 of Ref. [5], in Sections 3 and 5 of Ref. [6] and in Section 4 of Ref. [7].

1.6. This Safety Guide presents recommendations for the development and implementation of an accident management programme.

1.7. This Safety Guide is intended primarily for use by operating organizations of nuclear power plants, utilities and their support organizations; it may also be used by regulatory bodies to facilitate preparation of the relevant national regulatory requirements.

SCOPE

1.8. This Safety Guide includes recommendations for the development of an accident management programme to prevent and to mitigate the consequences of beyond design basis accidents, including severe accidents. This Safety Guide focuses on the severe accident management programme.

1.9. Although the recommendations of this Safety Guide have been developed primarily for use for light water reactors, they are anticipated to be valid for a wide range of nuclear reactors, both existing and new.

1.10. The recommendations of this Safety Guide have been developed primarily for accident management during at-power states, but are intended to be valid also for other modes of operation, including shutdown states.

1.11. For more details, reference is made to other IAEA Safety Guides [8–10]. References [11–13] present elements of accident management programmes, give examples of how to prepare, develop, implement and review accident management programmes and provide useful background material.

STRUCTURE

1.12. This Safety Guide consists of two main sections. Section 2 presents the overall concept of an accident management programme. High level

considerations are described in Section 2, while the process of development and implementation of an accident management programme is treated in Section 3. Recommendations for the use of severe accident management guidelines are provided in the Appendix. An example of a categorization scheme for accident sequences is provided in the Annex.

2. CONCEPT OF THE ACCIDENT MANAGEMENT PROGRAMME

REQUIREMENTS

2.1. Reference [5] establishes the following requirements on addressing severe accidents and accident management in the design of nuclear power plants:

“Certain very low probability plant states that are beyond design basis accident conditions and which may arise owing to multiple failures of safety systems leading to significant core degradation may jeopardize the integrity of many or all of the barriers to the release of radioactive material. These event sequences are called severe accidents. Consideration shall be given to these severe accident sequences, using a combination of engineering judgement and probabilistic methods, to determine those sequences for which reasonably practicable preventive or mitigatory measures can be identified. Acceptable measures need not involve the application of conservative engineering practices used in setting and evaluating design basis accidents, but rather should be based upon realistic or best estimate assumptions, methods and analytical criteria. On the basis of operational experience, relevant safety analysis and results from safety research, design activities for addressing severe accidents shall take into account the following:

- (1) Important event sequences that may lead to severe accidents shall be identified using a combination of probabilistic methods, deterministic methods and sound engineering judgement.
- (2) These event sequences shall then be reviewed against a set of criteria aimed at determining which severe accidents shall be addressed in the design.

- (3) Potential design changes or procedural changes that could either reduce the likelihood of these selected events, or mitigate their consequences should these selected events occur, shall be evaluated and shall be implemented if reasonably practicable.
- (4) Consideration shall be given to the plant's full design capabilities, including the possible use of some systems (i.e. safety and non-safety systems) beyond their originally intended function and anticipated operational states, and the use of additional temporary systems, to return the plant to a controlled state and/or to mitigate the consequences of a severe accident, provided that it can be shown that the systems are able to function in the environmental conditions to be expected.
- (5) For multiunit plants, consideration shall be given to the use of available means and/or support from other units, provided that the safe operation of the other units is not compromised.
- (6) Accident management procedures shall be established, taking into account representative and dominant severe accident scenarios" (Ref. [5], para. 5.31).

2.2. Reference [6] establishes the following requirements on severe accident management and accident management in the operation of nuclear power plants:

"Plant staff shall receive instructions in the management of accidents beyond the design basis. The training of operating personnel shall ensure their familiarity with the symptoms of accidents beyond the design basis and with the procedures for accident management" (Ref. [6], para. 3.12).

"Emergency operating procedures or guidance for managing severe accidents (beyond the design basis) shall be developed" (Ref. [6], para. 5.12).

2.3. Requirement 13 of Ref. [7] on assessment of defence in depth states:

"It has to be determined in the assessment of defence in depth whether adequate provisions have been made at each of the levels of defence in depth to ensure that the legal person responsible for the facility can:

- (a) Address deviations from normal operation or, in the case of a repository, from its expected evolution in the long term;
- (b) Detect and terminate safety related deviations from normal operation or from its expected evolution in the long term, should deviations occur;

- (c) Control accidents within the limits established for the design;
- (d) Specify measures to mitigate the consequences of accidents that exceed design limits;
- (e) Mitigate radiation risks associated with possible releases of radioactive material” (Ref. [7], para. 4.45).

CONCEPT OF ACCIDENT MANAGEMENT

2.4. An accident management programme should be developed for all plants, irrespective of the total core damage frequency and fission product release frequency calculated for the plant.

2.5. A structured top-down approach should be used to develop the accident management guidance. This approach should begin with the objectives and strategies, and result in procedures and guidelines, and should cover both the preventive and the mitigatory domains. Figure 1 illustrates the top-down approach to accident management.

2.6. At the top level, the objectives of accident management are defined as follows:

- Preventing significant core damage;
- Terminating the progress of core damage once it has started;
- Maintaining the integrity of the containment as long as possible;
- Minimizing releases of radioactive material;
- Achieving a long term stable state.

To achieve these objectives, a number of strategies should be developed.

2.7. From the strategies, suitable and effective measures for accident management should be derived. Such measures include plant modifications, where these are deemed important for managing beyond design basis accidents and severe accidents, and personnel actions. These measures include repair of failed equipment.

2.8. Appropriate guidance, in the form of procedures and guidelines, should be developed for the personnel responsible for executing the measures for accident management.

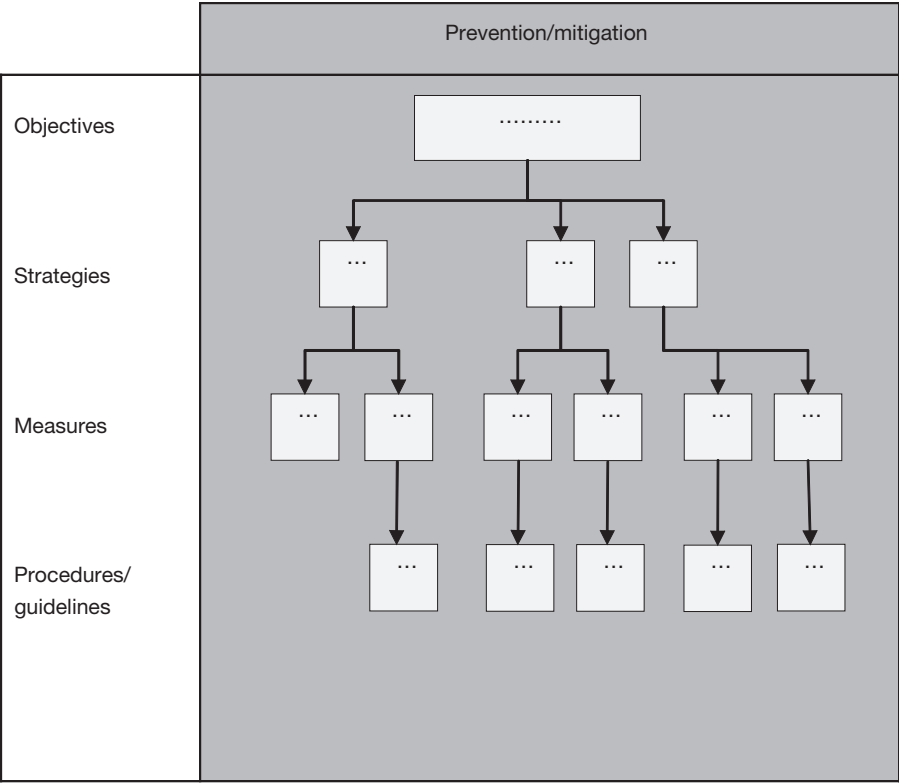


FIG. 1. The top-down approach to accident management.

2.9. When developing guidance on accident management, consideration should be given to the full design capabilities of the plant, using both safety and non-safety systems, and including the possible use of some systems beyond their originally intended function and anticipated operating conditions, and possibly outside their design basis.

2.10. The point at which the transition of responsibility and authority is to be made from the preventive to the mitigatory domain should be specified and should be based on properly defined and documented criteria.

2.11. For any change in the plant configuration or if new results from research on physical phenomena become available, the implications for accident management guidance should be checked and, if necessary, a revision of the accident management guidance should be made.

MAIN PRINCIPLES

2.12. In view of the uncertainties involved in severe accidents, severe accident management guidance should be developed for all physically identifiable challenge mechanisms for which the development of severe accident management guidance is feasible; severe accident management guidance should be developed irrespective of predicted frequencies of occurrence of the challenge.

2.13. Accident management guidance should be set out in such a way that it is not necessary for the responsible staff to identify the accident sequence or to follow some pre-analysed accident in order to be able to execute the accident management guidance correctly.

2.14. The approach in accident management should be based on directly measurable plant parameters or parameters derived from these by simple calculations.³

2.15. Development of accident management guidance should be based on best estimate analyses in order to capture the proper physical response of the plant. In the accident management guidance, consideration should be given to uncertainties in knowledge about the timing and magnitude of phenomena that might occur in the progression of the accident. Hence, mitigatory actions should be initiated at parameter levels and at a time that gives sufficient confidence that the protection intended by carrying out the action will be achieved. For example, venting the containment, if necessary to protect the structural integrity of this fission product barrier, should be initiated at a time and at a containment pressure level that gives confidence that the structural integrity of the containment will not be lost.

2.16. Severe accidents may also occur when the plant is in the shutdown state. In the severe accident management guidance, consideration should be given to any specific challenges posed by shutdown plant configurations and large scale maintenance, such as an open containment equipment hatch. The potential damage of spent fuel both in the reactor vessel and in the spent fuel

³ This is often referred to as a 'symptom based approach'. The simple calculations are often referred to as 'computational aids'.

pool or in storage⁴ should also be considered in the accident management guidance. As large scale maintenance is frequently carried out during planned shutdown states, the first concern of accident management guidance should be the safety of the workforce.⁵

2.17. Severe accident management should cover all modes of plant operation and also appropriately selected external events, such as fires, floods, seismic events and extreme weather conditions (e.g. high winds, extremely high or low temperatures, droughts) that could damage large parts of the plant. In the severe accident management guidance, consideration should be given to specific challenges posed by external events, such as loss of the power supply, loss of the control room or switchgear room and reduced access to systems and components.⁶

2.18. External events can also influence the availability of resources for severe accident management (e.g. severe droughts can limit available natural cooling water sources, such as rivers and lakes, which are a backup for normal resources; seismic events may damage dams). Such possible influences should be taken into account in the development of the accident management guidance.

EQUIPMENT UPGRADES

2.19. Design features important for the prevention or mitigation of severe accidents should be evaluated. Accordingly, existing equipment and/or instrumentation should be upgraded or new equipment and/or instrumentation should be added, if necessary or considered useful⁷ for the development of a meaningful severe accident management programme, i.e. a severe accident management programme that reduces risks in an appreciable way or to an

⁴ It is prudent also to consider any other potential large source of radiation, although this is not formally a part of severe accident management.

⁵ 'Stop work' could be one of the first commands in such accident management guidance.

⁶ Such limited accessibility could arise from fires, floods or extended area damage caused by, for example, collapse of non-seismically qualified structures in a seismic event.

⁷ Equipment may not be necessary, in the strict sense of the word, but can be very useful, for example, passive autocatalytic recombiners remove uncertainties about hydrogen burns.

acceptable level. The decision to add or upgrade equipment may depend on cost–benefit considerations.

2.20. If a decision is taken to add or upgrade equipment or instrumentation, the design specification of such equipment or instrumentation should be such as to ensure appropriate independence from existing systems and preferably appropriate margins with regard to the use of the equipment or instrumentation under accident and/or severe accident conditions. These margins should be such as to provide confidence or, where possible, to enable demonstration that the new equipment or instrumentation will function properly under the anticipated conditions. Where feasible, these conditions should be selected as the design conditions for the equipment under consideration. In that case, proper acceptance criteria for the equipment should be selected that are commensurate with the safety function of the equipment and the level of understanding of the severe accident processes.

2.21. Where existing equipment or instrumentation is upgraded or otherwise to be used outside its normal design basis range, the severe accident management guidance for the use of such equipment should be updated accordingly. Preferably, dedicated operating procedures should be developed for the equipment or instrumentation in the severe accident domain.

2.22. The installation of new equipment or the upgrading of existing equipment should not remove the need for the development of guidance in the case of an equipment malfunction, even if such a malfunction has a low probability.

FORMS OF ACCIDENT MANAGEMENT GUIDANCE

Preventive domain

2.23. In the preventive domain, the guidance should consist of descriptive steps, as the plant status will be known from the available instrumentation and the consequences of actions can be predetermined by appropriate analysis. The guidance for the preventive domain, therefore, takes the form of procedures, usually called emergency operating procedures (EOPs), and is prescriptive in nature. EOPs cover both design basis accidents and beyond design basis accidents, but are generally limited to actions taken before core damage occurs. Further details on EOPs can be found in Refs [10, 11].

Mitigatory domain

2.24. In the mitigatory domain, uncertainties may exist both in the plant status and in the outcome of actions. Consequently, the guidance for the mitigatory domain should not be prescriptive in nature but rather should propose a range of possible mitigatory actions and should allow for additional evaluation and alternative actions. Such guidance is usually termed severe accident management guidelines (SAMGs).

2.25. The guidance should contain a description of both the positive and negative potential consequences of proposed actions, including quantitative data where available and relevant, and should contain sufficient information for the plant staff to reach an adequate decision on the actions to be taken during the evolution of the accident.

2.26. The guidance for the mitigatory domain should be presented in the form of guidelines, manuals or handbooks. The term ‘guideline’ here is used to describe a fairly detailed set of instructions that describe the tasks to be executed on the plant, but which are still less strict and prescriptive than the procedures found in the EOPs; that is, used in the preventive domain. Manuals or handbooks will contain a more general description of the tasks to be executed and their background reasoning.

2.27. The guidance should be sufficiently detailed to support the responsible members of staff in carrying out deliberations and making decisions in a high stress environment, and should be such as to minimize chances that relevant information is deleted or overlooked.

2.28. The guidance should not be set out in such a form and with such detail that responsible personnel will tend to follow it verbatim, unless that is the intended type of action.

2.29. The overall form of the guidance and the selected amount of detail should be tested in drills and exercises. Based on the outcome of such drills, it should be judged whether the form is appropriate and whether additional detail or less detail should be included in the guidance.

Both preventive and mitigatory domains

2.30. The guidance in both the preventive and mitigatory domains should be supported by appropriate background documentation. This documentation