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SSG-54: Accident Management Programmes for Nuclear Power Plants

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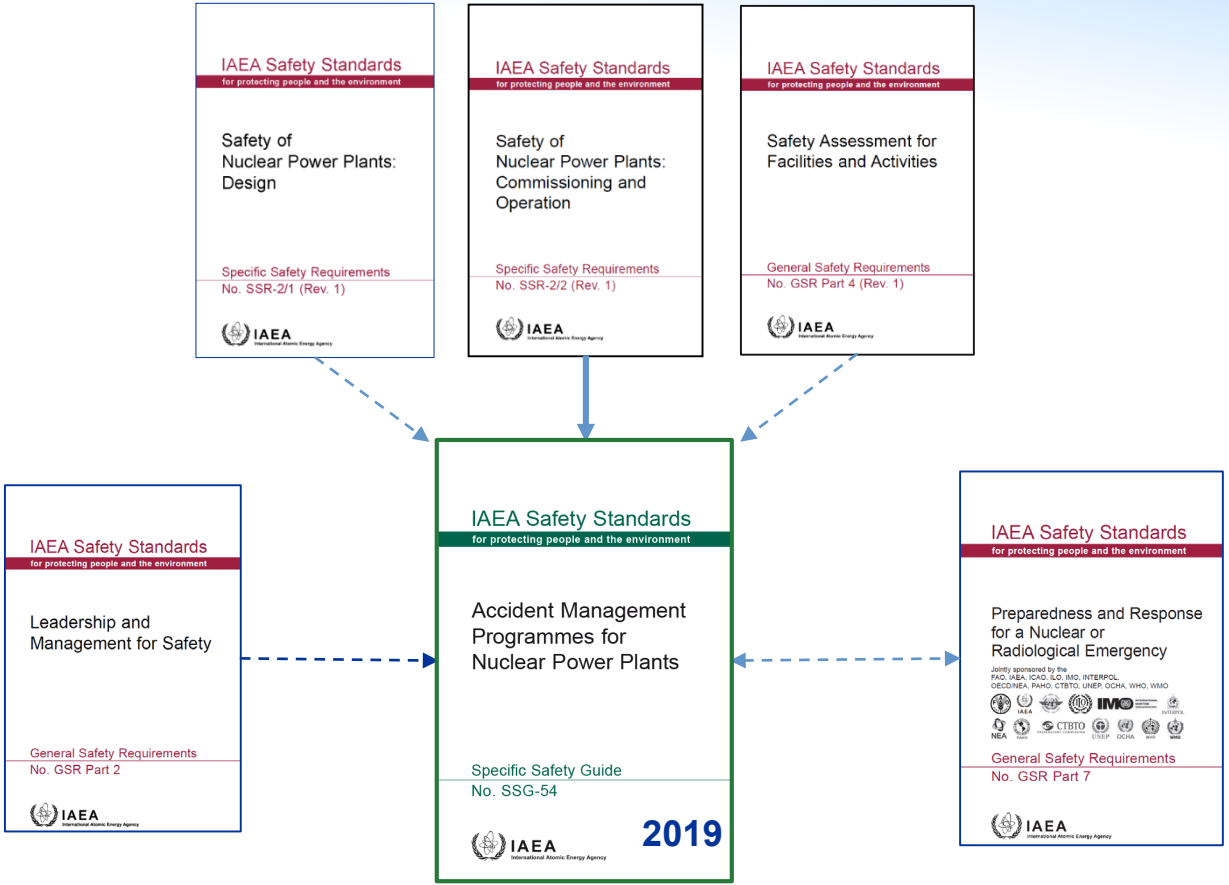
Outline

- ACCIDENT MANAGEMENT IN THE SAFETY STANDARDS
- APPLICABLE KEY REQUIREMENTS
- MAIN ELEMENTS OF AN ACCIDENT MANAGEMENT PROGRAMME AND KEY RECOMMENDATIONS IN SSG-54
- CONCLUSIONS

IAEA Safety Standards

Place in the Safety Standards and Interfaces



Changes Introduced in SSG-54 (2019)

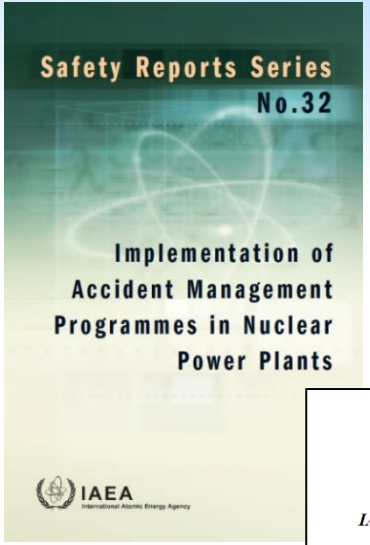
The previous safety guide, NS-G-2.15: “Severe Accident Management Programmes for Nuclear Power Plants, was published in 2009

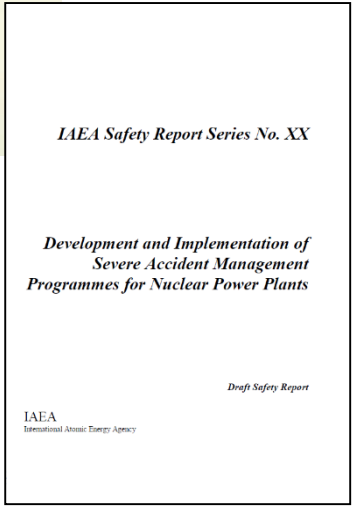
SSG-54 takes into account:

- Changes introduced in the family of safety requirements (in particular on NPP design) and safety guides relevant to accident management
- Lessons learned from the Fukushima Daiichi Accident, e.g. on:
  - Use of non permanent equipment for supply of electricity and cooling water
  - Equipment qualification
  - Transfer of responsibility
  - Reliable communication network
  - Decision making line and qualification of decision maker
  - Multi-unit site aspects: sharing TSC and equipment, assignment of an overall emergency director
  - Failure of command control due to a loss of MCR.
- Findings from IAEA review missions, e.g. OSART missions
- Current practices in Member States

Supporting Documents of Interest

- **Safety Report No. 32: Implementation of Accident Management Programmes in Nuclear Power Plants**
- It provides the elements and practical information for developing and implementing a plant specific AMP based on ample expertise from LWRs
- It takes into account all plant states and all possible fuel locations
- It focuses on Severe Accident Management Guidelines (SAMGs)





A New Safety Report has been finalized on the basis of SR-32, the new Safety Guide SSG-54 and recent experiences related to SAMGs (pending publication)

Accident Management Programme (AMP)

The IAEA Safety Glossary defines '**accident management**' as "The taking of a set of actions during the evolution of an accident:

(a) To prevent escalation to a severe accident;

(b) To mitigate the consequences of a severe accident;

(c) To achieve a long term safe stable state."

In order to undertake such actions an AMP is necessary. Its essential elements are addressed in the safety requirements for operation of NPPs.

An AMP encompasses plans and actions undertaken to ensure that plant personnel and other operating organization personnel with responsibilities for accident management are adequately prepared to decide on and implement effective on-site actions.

Accident management is an essential aspect of the application of defence in depth. AMP deals with accidents within and beyond the design basis. AMP needs to be supported by appropriate safety assessment.

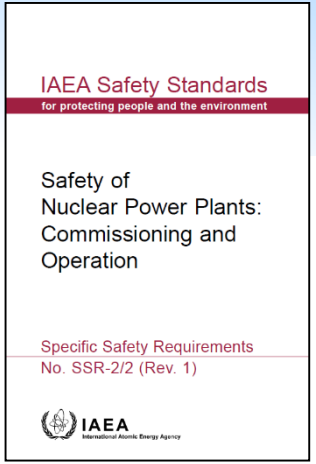
An AMP needs to be well integrated with the arrangements for EPR.

SSR-2/2 (Rev. 1) : Safety of Nuclear Power Plants: Commissioning and Operation

Requirement 19 “Accident Management Programme (AMP)”

The operating organization shall establish, and periodically review and as necessary revise, an accident management programme.

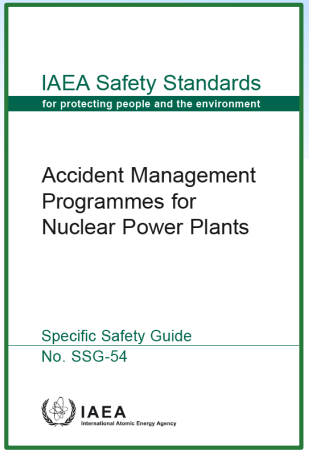
- “An AMP shall be established that covers the preparatory measures, procedures and guidelines, and equipment that are necessary for preventing the progression of accidents, including accidents more severe than design basis accidents, and for mitigating their consequences if they do occur.
- The AMP shall be documented and shall be periodically reviewed and as necessary revised”
- The AMP shall include instructions for the utilization of available equipment — safety related equipment as far as possible, but also items not important to safety (e.g. conventional equipment)”. It shall include also contingency measures.
- The AMP shall include the technical and administrative measures necessary to mitigate the consequences of an accident”.
- The AMP shall include training necessary for its implementation.



SSG-54: Main Contents

2. GENERAL GUIDANCE FOR AN ACCIDENT MANAGEMENT PROGRAMME

- Concept of an Accident Management Programme
- Main Principles
- Forms of Accident Management Guidance
- Verification and Validation of the Accident Management Programme
- Accident Management and External Hazards
- Accident Management for Multiple Unit Sites
- Equipment Upgrades
- Roles and Responsibilities
- Staffing, Qualification and Working Conditions for Accident Management

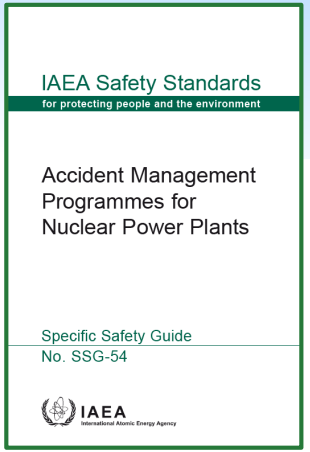


SSG-54: Main Contents

3. DEVELOPMENT AND IMPLEMENTATION OF A SEVERE ACCIDENT MANAGEMENT PROGRAMME (SAMP)

- Technical Bases
- Identification of Challenge Mechanisms , Plant Vulnerabilities and Plant Capabilities
- Development of Severe Accident Management Guidance
- Establishment of a Verification and Validation Process of the SAMP
- Integration of the SAMP into the Management System and the EPR Arrangements
- Hardware Provisions for Severe Accident Management
- Instrumentation and Control for Severe Accident Management
- Analyses for Development of a SAMP
- Training, Exercises and Drills for Accident Management
- Updating the SAMP

4. EXECUTION OF THE ACCIDENT MANAGEMENT PROGRAMME



Accident Management Programme

An AMP should be developed and implemented for the prevention and mitigation of severe accidents, irrespective of the frequency of accident sequences and of fission product releases considered in the design.

The AMP should address all modes and states of operation and all fuel locations, including the spent fuel pool, and should take into account possible combinations of events that could lead to an accident. It should also consider external hazards more severe than those considered for the design that could result in significant damage to the infrastructure on the site or off the site which would hinder actions

The accident management programme should be developed and maintained consistent with the plant design and its current configuration

Forms of Accident Management Guidance

Preventive domain (before the onset of fuel rod degradation)

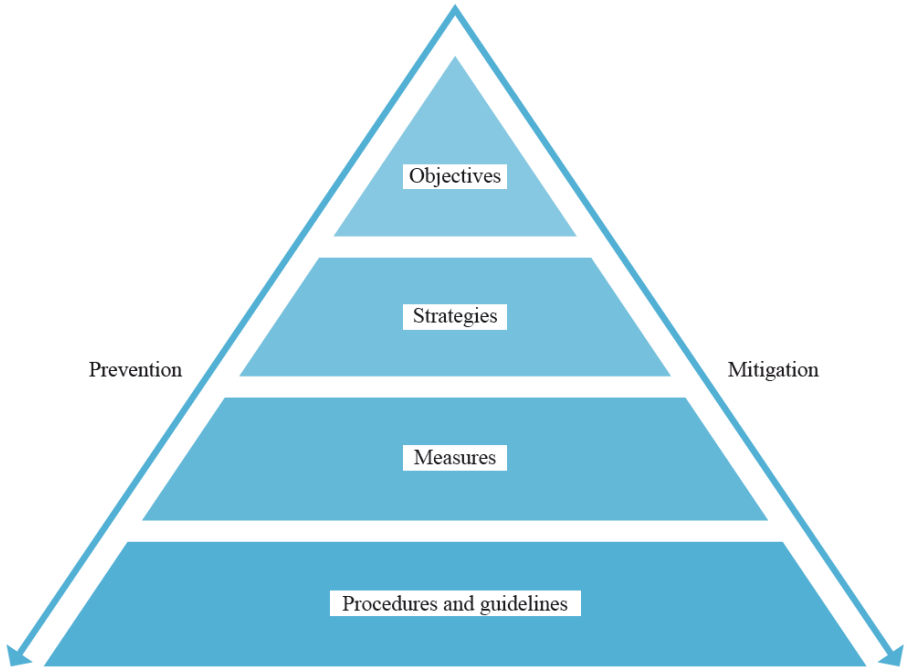
- Actions aimed at controlling accident progression to prevent significant fuel damage or to delay it
- Guidance is provided in the form of procedures (prescriptive in nature)

Mitigatory domain (when a severe accident, i.e. significant fuel degradation, is imminent or in progress)

- Priority is given to mitigating the consequences of the severe accident for avoiding or limiting fission product releases by maintaining the integrity of the containment (highest priority).

- Guidance is provided in the form of guidelines, which can be prescriptive for specific actions (no doubt about their benefits) or offer a range of actions that should be evaluated because of the uncertainties about on plant conditions and accident evolution.

Accident Management Programme



- A structured top-down approach should be used to develop the accident management guidance.
- This approach should begin with the objectives (including the identification of plant challenges and plant vulnerabilities) and the strategies, followed by measures to implement the strategies.
- In combination, these strategies and measures should include consideration of plant capabilities.
- Finally, procedures and guidelines should be developed to implement these strategies and measures.

AMP Strategies

Multiple strategies should be identified in both the preventive and mitigatory domain, evaluated and, when appropriate, developed, to achieve the objectives of accident management, which include:

- Preventing or delaying the occurrence of fuel rod degradation;
- Terminating the progress of fuel rod degradation once it has started;
- Maintaining the integrity of the reactor pressure vessel to prevent melt-through especially at high pressure;
- Maintaining the integrity of the containment and preventing containment bypass (strategies for the maintaining containment integrity and preventing bypass are of the highest priority once the mitigatory domain is entered);
- Minimizing releases of radioactive material from the fuel or at other locations where releases of radioactive material could occur;
- Returning the plant to a long term safe stable state in which the fundamental safety functions can be preserved.

AMP Strategies

Accident management strategies should be prioritized with account taken of the plant damage state and the existing and anticipated challenges.

- Before significant fuel rod degradation has occurred: Preventing fuel damage is the first priority, and maintaining or restoring the integrity of the containment is the second priority.
- After significant fuel rod degradation has occurred: Maintaining the integrity of the containment is the highest priority.

When prioritizing accident management strategies, special attention should be paid to the following:

- The time frames and severity of challenges to the barriers against releases of radioactive material.
- The availability of support functions, as well as the possibility of their restoration.
- The initial operating mode of the plant
- The adequacy of a strategy in the given domain
- The difficulty of implementing several in parallel.
- The long term implications of or concerns about their implementation

AMP Strategies

Implementation should be triggered either when certain parameters (relevant for the integrity of fission product barriers) reach thresholds or are trending imminently to them

Uncertainties should be taken into account in relation to the time windows for implementation

Suitable and effective measures should be derived that correspond to available hardware provisions, e.g. the use of systems and equipment available, the recovery of failed equipment and potentially the use of non-permanent equipment , stored on the site or off the site.

The accident management guidance should assist the operating organization personnel in prioritizing, monitoring and executing actions in the harsh environments that may exist during an accident, including conditions originated by internal and external hazards.

Main principles of Accident Management Guidance

Accident management guidance should address the full spectrum of events, including credible and relevant internal and external hazards and give consideration to the following:

Promoting consistent implementation by all staff during an accident.

Emphasizing the use of components and systems that are not likely to fail in their expected operating regimes, including during severe accidents.

The instrumentation available and its reliability for evaluating plant conditions

Implementing all feasible measures that will either maintain or increase the margin to failure or that will gain time prior to the failure of safety functions or barriers

The possibility of adding components, including non-permanent equipment,

Human and organizational factors, such as the performance of personnel under the contextual and adverse boundary conditions given (e.g. radiation, temperature, lightning, stress), the command and control structure, including information sharing and cooperation among the staff involved.

Supporting Documentation and Analysis of the AMP

Procedures and guidelines developed for accident management should be supported by appropriate background documentation (this is sometimes referred to as the technical basis document). This documentation should describe and explain the rationale of the various parts of the accident management guidance.

The development and implementation of the severe accident management programme should be supported by appropriate computational analysis showing the progression of representative accident sequences to be addressed, with the results of such analysis to be used for formulation of the technical basis for development of strategies, procedures and guidelines

Best estimate computer codes, assumptions and data regarding initial and boundary plant conditions should be used, providing appropriate consideration is given to uncertainties in the determination of the timing and severity of the phenomena

Development of Accident Management Procedures and Guidelines

Accident management guidance should be developed to implement the strategies and measures in the preventive and the mitigatory domains and contain the necessary information and instructions for the responsible personnel, including the use of equipment, equipment limitations, cautions and benefits.

Preventive domain: Emergency Operating Procedures (EOPs)

- Actions to prevent the escalation of an event into a severe accident.

Mitigatory Domain: Severe Accident Management Guidelines (SAMGs)

- Actions to mitigate the consequences of a severe accident according to the chosen strategies, addressing positive and negative consequences of proposed actions and different options

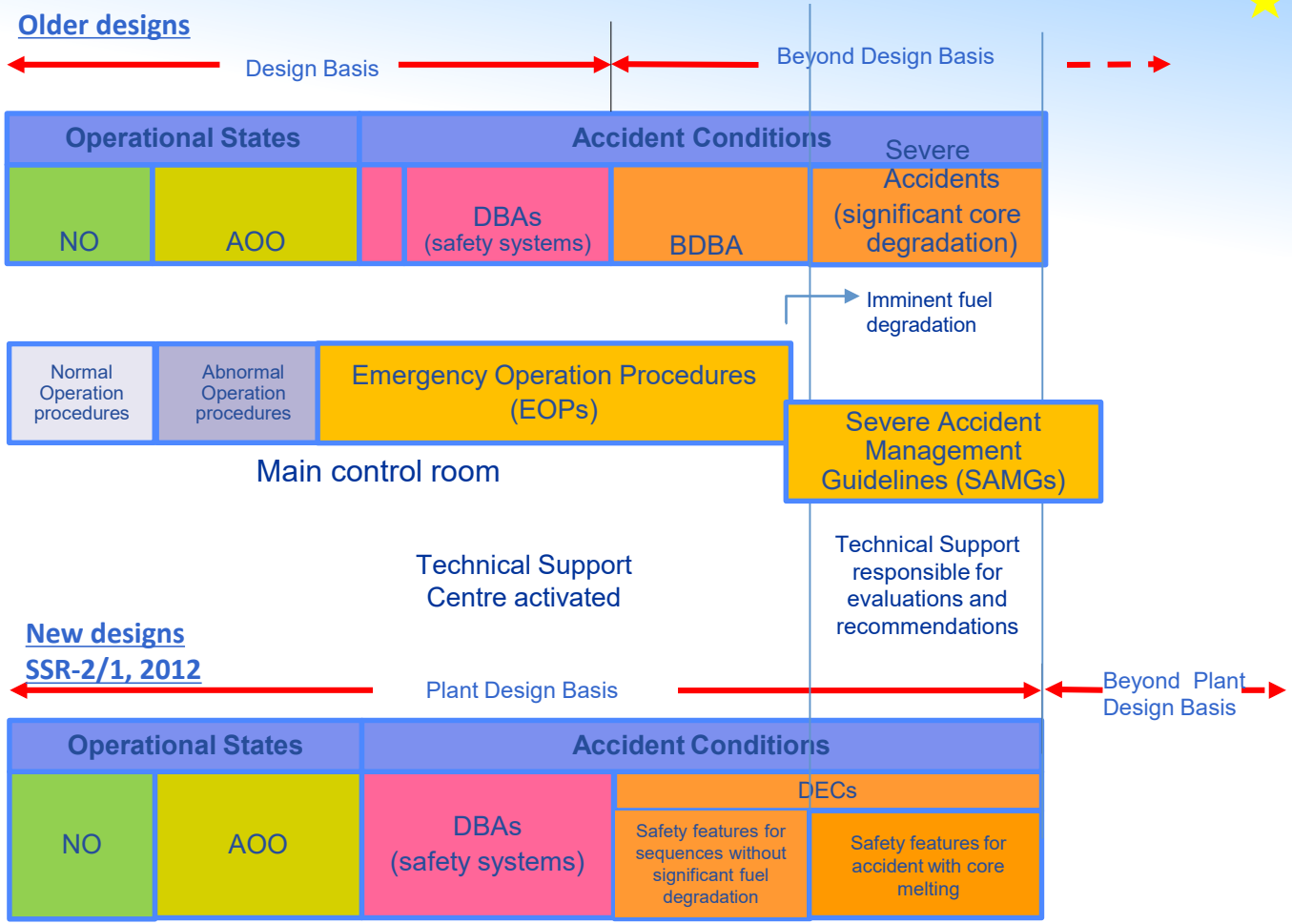
The transition point from EOPs to SAMGs should be set with careful consideration of the timing and magnitude of subsequent challenges to the barriers. Specific and measurable parameter values should be defined for the transition to the use of SAMGs, e.g. core exit temperature. If the transition point is specified on the basis of conditional criteria, the time necessary to confirm that the transition point has been reached should be taken into account.

Hardware provisions for AM

New plant designs incorporate design features for SAs. In older designs, the upgrading of equipment in the mitigatory domain should be focused on preserving the containment function or minimizing releases when the containment has failed.

The increase of equipment capability or its margin to failure, against relevant challenges related to a SA for the following functions should be considered:

- Monitoring essential containment parameters (P,T, radiation, etc.)
- Ensuring the leak-tightness of the containment, e.g. functionality of isolation devices and penetrations for a reasonable time.
- Establishing or restoring the ultimate heat sink and removing the heat from the containment and molten core.
- Control of combustible gases, fission products and other materials released, including any necessary instrumentation;
- Monitoring and control of containment leakages and of fission product releases


Older designs
Design Basis
Beyond Design Basis
Operational States
Accident Conditions
NO
AOO
DBAs
(safety systems)
BDBA
Severe Accidents
(significant core degradation)
Imminent fuel degradation
Normal Operation procedures
Abnormal Operation procedures
Emergency Operation Procedures (EOPs)
Severe Accident Management Guidelines (SAMGs)
Main control room
Technical Support Centre activated
Technical Support responsible for evaluations and recommendations
New designs
SSR-2/1, 2012
Plant Design Basis
Beyond Plant Design Basis
Operational States
Accident Conditions
NO
AOO
DBAs
(safety systems)
DECs
Safety features for sequences without significant fuel degradation
Safety features for accident with core melting

Role of instrumentation and control

Accident management actions depend on the ability to measure or estimate the magnitude of physical and chemical variables and control them in both the preventive and mitigatory domain.

Instrumentation may not be available due to the lack of support systems (e.g. power) or not work properly or reliably under conditions for which is not designed or qualified (e.g. those caused by severe accident phenomena or external hazards)

Alternative instrumentation should be identified where the primary instrumentation is not available or not reliable.

The expected failure modes of the instrumentation (e.g. off-scale high, off-scale low, floating behavior) under beyond its design basis conditions should be analyzed.

Role of instrumentation and control

The ability to infer important plant parameters from local instrumentation or from unconventional means should also be considered.

- For example, the steam generator level can be inferred from local pressure measurements on the steam line and steam generator blowdown lines.

The need for development of computational aids to obtain information where parameters are missing or their measurements are unreliable should be identified and appropriate computational aids should be developed accordingly.

Role of instrumentation and control

Instrumentation essential for monitoring the conditions of the core, the containment and SFP should be maintained to the extent practicable throughout an extended loss of AC power.

A plant specific assessment should be performed to restore power to the minimum essential components in the event of loss of DC power.

Guidance should be provided on validating important instrumentation outputs. All important instrumentation readings should be verified with other independent information whenever possible.

All available information and background documentation on essential instrumentation necessary to support decision making in severe accident management should be made available to appropriate members of the emergency response teams.

The uncertainty of readings of instruments essential for severe accident management should be assessed. In many cases, trends may be more important than the accuracy of the indicated values.

The capabilities of instrumentation essential for severe accident management should be carefully considered. Instrumentation might continue to operate beyond its design range with decreasing accuracy.

Verification and Validation of the AMP

The independent verification and validation processes should assess the technical accuracy and adequacy of the accident management guidance to the extent possible, and the ability of personnel to follow and implement them.

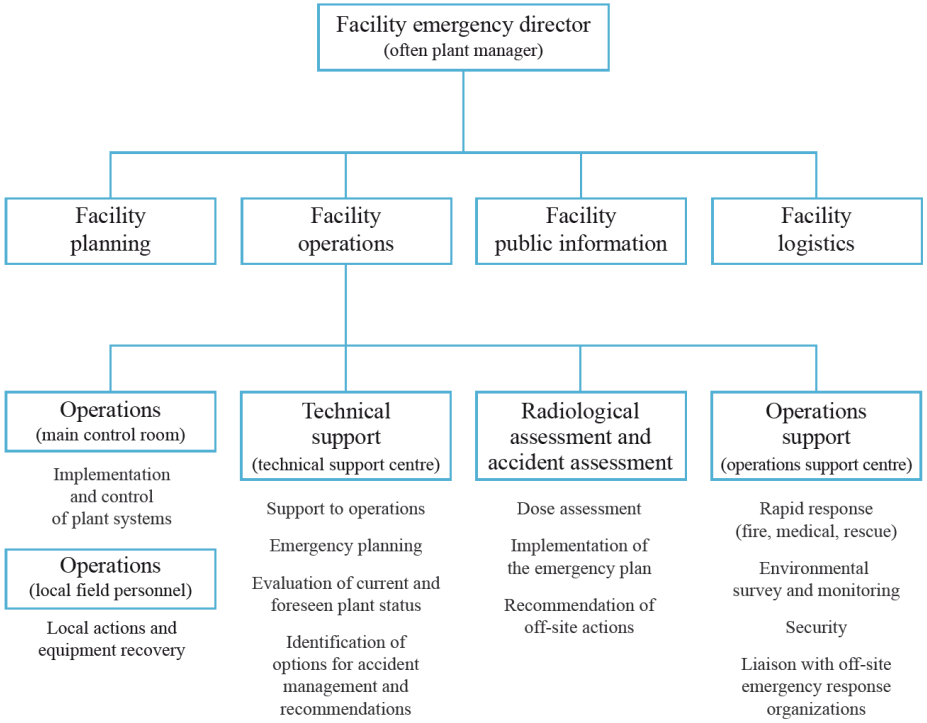
All procedures and guidelines should be verified. The verification process should confirm their compatibility with referenced equipment, user aids and supplies,

All procedures and guidelines should be validated. Validation should be carried out to confirm that the actions specified in the procedures and guidelines can be followed by trained staff to manage emergency events.

Possible methods for validation of the SAMGs are the use of an engineering simulator that may include a full scope simulator or other plant analysis tool and a tabletop method. Scenarios should be developed that describe a number of fairly realistic (complex) situations that would require the application of major portions of the EOPs and the SAMGs.

Responsibilities and lines of authorization

- Functions and responsibilities in accident management, in both the preventive and mitigatory domains, should be clearly defined within the documentation of the accident management programme and of the overall emergency response organization.



Responsibilities and lines of authorization

The roles of personnel involved in severe accident management should be considered. There are three categories of functions:

- **Evaluation/recommendation**
  - e.g. assessment of plant conditions, identification of potential actions, evaluation of the potential impacts of these actions, and recommendation of actions
- **Decision making / Authorization**
- **Implementation of actions**

In an event that degrades into a severe accident, transfer of responsibilities and decision making authority from the control room staff to a higher level of authority should be made at some specified point in time

TABLE 1. SUMMARY OF THE FEATURES OF AN ACCIDENT MANAGEMENT PROGRAMME

	Preventive domain (prevention of significant fuel rod degradation)	Mitigatory domain (mitigation of the consequences of significant fuel rod degradation)
Objective	Prevention of fuel damage and fulfilment of the fundamental safety functions.	Limitation of releases of radioactive material to the environment through: (a) actions intended to maintain the integrity of the containment, and (b) emergency response measures to minimize radiological consequences.
Establishment of priorities	Establishment of priorities among the various fundamental safety functions.	Establishment of priorities between mitigatory measures, with the highest priority given to the mitigation of significant ongoing releases and immediate threats to fission product barriers.
Responsible staff (authorization of actions)	Main control room staff.	On-site emergency director (or equivalent).
Role of relevant emergency response organization	Technical support centre available to provide advice to the main control room for decisions about complex tasks, if requested, in accordance with the EOPs.	Technical support centre (or other emergency response facility) responsible for evaluating and recommending actions or for making recommendations to decision makers about complex tasks to be carried out by the main control room.
Procedures/guidelines	Use of EOPs by staff in the main control room to prevent significant fuel rod degradation.	Use of SAMGs by technical support centre staff, main control room staff or other personnel of the operating organization. Use of procedures, if any, by the main control room staff.
Use of equipment	In EOPs, at least one success path relies on structures, systems and components qualified, as required by Requirement 30 of SSR-2/1 (Rev. 1) [3], for design basis accidents and for the design extension conditions those structures, systems and components were designed to cope with. However, EOPs may be implemented by using all available equipment (e.g. mobile, portable).	SAMGs favour the use of structures, systems and components with capabilities consistent with the performance and environmental conditions expected in a severe accident, as required by paras 5.28 and 5.29 of SSR-2/1 (Rev. 1) [3] and para. 5.8B of SSR-2/2 (Rev. 1) [6]. However, SAMGs may be implemented by using all equipment still available and alternatives (i.e. non-permanent equipment) to fulfil the fundamental safety functions; available systems may also be used beyond their design limits, if appropriate.

Education and training

For each group involved in accident management, including the management of the operating organization and other decision making levels, and also, where applicable, regulatory personnel, specific objectives and training needs should be defined.

Regulators, where they participate in utility decisions, should be trained so that they fully understand the basis of proposed utility decisions.

Exercises and drills should be based on appropriate scenarios that will require the application of a substantial number of procedures and guidelines. They should reflect to the extent possible the conditions expected during the accident.

Update of the Severe Accident management Programme

For any change in plant configuration, the effect on EOPs and SAMGs as well as on organizational aspects of accident management should be checked. A revision of the documents should be made if it is found that there is an effect on these procedures and guidelines.

International research on severe accident phenomena should be followed actively and new insights should be processed accordingly in the accident management programme.

Exchange of information with peers should be used to improve the SAMGs for future revision.

Management of the severe accident management programme

Development of a severe accident management programme should be the responsibility of the operating organization and should be consistent with the applicable requirements for management systems established in GSR Part 2: “Leadership and Management for Safety” and recommendations in related safety guides, e.g. GS-G-3.5: “The Management System for Nuclear Installations”

The operating organization should integrate all the elements of the severe accident management programme within its management system so that processes and activities that may affect safety are established and conducted coherently for the protection of site personnel and the public, and the protection of the environment.

Conclusions

Conclusion

The accident management programme provides the necessary arrangements and actions to :

- **To prevent the escalation of the event into a severe accident;**
- **To mitigate the consequences of a severe accident;**
- **To achieve a long term safe stable state.**

Accident management programme is essential to ensure effective defence in depth at the fourth level.

Accident management programmes needs to be well integrated with the arrangements for emergency preparedness and response

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