GUIDELINES FOR REGULATORY REVIEW OF EOPs AND SAMGs

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TABLE OF CONTENTS

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1. INTRODUCTION

1.1. Background

The need for establishing guidance for the regulatory review of the Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs) developed by the licensee resulted from the recommendations and suggestions of the IRRS mission conducted by IAEA in 2011 at CNCAN, the Romanian regulatory body, as well as from the self-assessment process of CNCAN and the conclusions of "stress tests" conducted at the request of the European Council for all the nuclear power plants in Europe.

This activity has the objective to ensure that CNCAN develops the necessary tool to assess and review the licensee's procedures and guides supporting the response to emergency situations and severe accidents, based on the current international standards and on the best practice of other nuclear safety authorities with similar responsibilities and experience exchange in this area of regulatory assessment.

1.2. Purpose and scope of the guidelines

This document provides guidelines for a regulatory review of the licensee's development and implementation of on-site accident management programme at a nuclear power plant for both the preventive and the mitigatory domains. The review evaluates compliance of the accident management programme with the regulatory requirements, the comprehensiveness of the technical basis, strategies and measures and of procedures and guidance.

The review can be scheduled either during the development or the implementation process of the accident management programme. The aim may be the review of an existing set of procedures and guidance to identify deficiencies and issue recommendations for a successful completion of the programme, or for providing recommendations for the improvement of the guidance as a part of a periodic safety review process.

1.3. Structure of the guidelines

This document consists of five main chapters. The first two chapters provide the background, the objectives and the regulatory requirements for an accident management programme at a nuclear power plant. The third chapter presents the overall concept of the two domains of an accident management programme: the preventive and mitigatory domains.

The fourth chapter provides guidelines for the review of the accident management programme. The first section describes the objectives and scope of the review programme and identifies the technical qualifications expected from the review team.

Section 4.2 addresses the review of the technical bases for accident management.

Section 4.3 provides guidelines for review of the preventive domain of the accident management programme.

Section 4.4 addresses the review of the mitigatory part of the accident management.

Since the accident management includes a significant human factor the Section 4.5 provides some generic guidelines for the review of this aspect.

The review of verification and validation issues of accident management procedures and guidelines are addressed in Section 4.6.

The maintenance of accident management programmes during the life cycle of the plant to reflect the plant status and operational experience is addressed in Section 4.7.

Section 4.8 provides generic guidelines for review of the completeness and comprehensiveness of the accident management programme documentation.

Section 4.9 addresses the review of staff training and qualification for accident management programme.

The final chapter (Chapter 5) provides suggestions on documentation of the review results.

These review guidelines provided in this report identify the key issues for the review of main aspects of accident management programme development and implementation. Also questions are suggested that the review team should ask during the review. However, this guide does not replace a preparation and planning for a review, especially in the context of specific facility. The preparatory activities and review process are discussed in Section 4.1.

1.4. Definitions and acronyms

This section provides key relevant, to accident management, acronyms and definitions. The acronyms and definitions below are based primarily on the IAEA safety glossary terms. Also some definitions and acronyms specific to the Romanian regulatory framework are included.

Accident. Any unintended event, including operating errors, equipment failures or other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.

Accident conditions. Deviations from normal operation more severe than anticipated operational occurrences, including design basis accidents and design extension conditions without and with extensive core damage (severe accidents). Examples of such deviations include a major fuel failure or a loss of coolant accident (LOCA).

AM - accident management. The taking of a set of actions during the evolution of an 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.

AOO - anticipated operational occurrence. An operational process deviating from normal operation which is expected to occur at least once during the operating lifetime of a facility but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety nor lead to accident conditions. Examples of anticipated operational occurrences are loss of normal electrical power and faults such as a turbine trip, malfunction of individual items of a normally running plant, failure to function of individual items of control equipment, loss of power to the MCP. Some States and organizations use the term abnormal operation (for contrast with normal operation) for this concept.

DB - design basis. The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems. Used as a noun, with the definition above. Also often used as an adjective, applied to specific categories of conditions or events to mean ‘included in the design basis’ as, for example, in design basis accident, design basis external events, design basis earthquake, etc.

DBA - design basis accident. Accident conditions against which a nuclear power plant 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.

EOP – Emergency Operating Procedure. Plant specific procedures containing instructions for operating staff to implement preventive measures for managing accidents. Emergency operating procedures typically contain all preventive measures for both design basis accidents and beyond design basis accidents up to the point of core damage.

Initiating event. An identified event that leads to anticipated operational occurrences or accident conditions and challenges safety functions.

Normal operation. Operation within specified operational limits and conditions. For a nuclear power plant, this includes startup, power operation, shutting down, shutdown, maintenance, testing and refueling.

NSN – Nuclear Safety Norms. Generic name of Romanian mandatory regulations on nuclear safety issued by CNCAN.

Operational Limits and Conditions - OLCs. A set of rules setting forth parameter limits, the functional capability and the performance levels of equipment and personnel approved by the safety authorities for safe operation of an authorized facility.

Operational States. States defined under normal operation and anticipated operational occurrences. Some States and organizations use the term operating conditions (for contrast with accident conditions) for this concept.

Postulated Initiating Event – PIE. An event identified during design as capable of leading to anticipated operational occurrences or accident conditions. The primary causes of postulated initiating events may be credible equipment failures and operator errors (both within and external to the facility), human induced or natural events.

SA - severe accident. Accident conditions involving significant core degradation.

Safety function. A specific purpose that must be accomplished for safety.

Scenario. A postulated or assumed set of conditions and/or events. Most commonly used in analysis or assessment to represent possible future conditions and/or events to be modeled, such as possible accidents at a nuclear facility, or the possible future evolution of a repository and its surroundings. A scenario may represent the conditions at a single point in time or a single event, or a time history of conditions and/or events.

SAMG – Severe Accident Management Guideline. Guidelines providing a set of actions to arrest the progression and / or mitigate the consequences of a severe accident according to the various applicable strategies.

Symptom based procedure/guideline. Procedure or guideline containing actions which are taken depending on the values of directly measurable plant parameters. A symptom is a measurable plant parameter that is available to the operator in the control room.

SCS – Systems Structures and Components

2. REGULATORY REQUIREMENS

2.1 Romanian regulations related to accident management including EOPs, SAMGs and safety analysis

The nuclear power plant accident management programme is governed the regulation "Nuclear safety requirements on the response to transients, accidents and emergency situations at nuclear power plants" – NSN-07, officially issued in January 2014, which represents the main source of regulatory requirements on EOPs and SAMGs.

The NSN-07 provides requirements on:

- objectives, principles and factors to be taken into account for the response to transients, accidents and emergency situations on-site;
- transient and accident scenarios to be addressed in / covered by the EOPs;
- severe accident scenarios to be covered by the SAMGs;
- emergency situations to be covered by the on-site emergency response plan and emergency response procedures;
- establishment of the minimum number of staff with necessary qualifications to manage all scenarios required by the regulation (including combinations of events and scenarios in which multiple units on site are affected by accidents initiated by extreme external events beyond the design basis of the plants);
- facilities and equipment to be available for accident management and on-site emergency response, including in situations caused by extreme external events;
- development and validation of procedures; documentation of the technical basis for the procedures;
- configuration management in relation to the procedures and systems credited for accident management and emergency response;
- training programmes and exercises;
- use of operational experience for the improvement of accident management and emergency response.

The regulation has been developed by CNCAN taking account of the international standards and best practices. The references used by CNCAN for this regulation are provided below:

- Safety of Nuclear Power Plants: Commissioning and Operation: Specific Safety Requirements, IAEA Safety Standards Series No. SSR-2/2, 2011.
- Preparedness and Response for a Nuclear or Radiological Emergency, Safety Requirements, IAEA Safety Standards Series No. GS-R-2, 2002.
- Severe Accident Management Programmes for Nuclear Power Plants, Safety Guide, IAEA Safety Standards Series No. NS-G-2.15, 2009.
- Arrangements for Preparedness for a Nuclear or Radiological Emergency, Safety Guide, IAEA Safety Standards Series No. GS-G-2.1, 2007.
- Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency, General Safety Guide, IAEA Safety Standards Series No. GSG-2, 2011.
- WENRA Reactor Safety Reference Levels, Western European Nuclear Regulators' Association, 2008, with proposed updates.

The documents referenced in the regulation are recommended for use to the licensee as representing current standards. CNCAN reviewers may make use of the more detailed requirements and guidance in the documents referenced in order to judge compliance with the higher level requirements in the regulation.

2.2 International standards and guides relevant for regulatory review of EOPs and SAMGs

In addition to the international standards referenced in the regulation, CNCAN has used, for the development of the regulatory requirements and of the review guidelines, a comprehensive set of IAEA Safety Reports, US NRC NUREGs and inspection procedures and CNSC REGDOCs. All the documents used by CNCAN are listed in the References section.

3. ACCIDENT MANAGEMENT CONCEPTS

3.1 Concept of accident management: Emergency Operating Procedures and Severe Accident Management Guidelines

The defence in depth (DiD) concept is fundamental to the safety of nuclear power plants. It consists of a hierarchical deployment of different levels of equipment and procedures in order to maintain the effectiveness of physical barriers placed between radioactive materials and workers, the public or the environment, in normal operation, anticipated operational occurrences and in accident conditions at the plant. This concept is applied to all safety related activities, whether organizational, behavioural or design related, and whether in full power, low power or various shutdown states. This is to ensure that all safety related activities are subject to independent layers of provisions, so that if a failure were to occur, it would be detected and compensated for or corrected by appropriate measures. Application of the concept of defence in depth throughout design and operation provides protection against anticipated operational occurrences and accidents, including those resulting from equipment failure or human induced events within the plant, and against consequences of events that originate outside the plant.

The accident conditions include design extension conditions which probability of occurrence is very low, but it may lead to significant consequences resulting from degradation of the nuclear fuel. Design extension conditions represent postulated accident conditions that are not considered for design basis accidents, but that are considered in the design process of the facility in accordance with best estimate methodology, and for which releases of radioactive material are kept within acceptable limits. Design extension conditions could include conditions in events without significant fuel degradation and conditions with core melting severe accident conditions

The design extension conditions should be used to identify accident scenarios to be addressed in the planning of provisions for the prevention of such accidents and for the mitigation of their consequences if they do occur. The mitigating procedures have to be established by the operating organization and possibly, the establishment of off-site intervention measures by the appropriate authorities is required, supported as necessary by the operating organization, to mitigate exposures if an accident has occurred.

Accident management is the taking of a set of actions during the evolution of accident conditions with the objective of: preventing progression into a severe accident, mitigating the consequences of a severe accident, and achieving a long-term safe stable state. Characteristics of the preventive and mitigatory domains of accident management are presented in Table 1 below.

The accident management programme shall be developed and implemented irrespective of the core damage frequency and fission product release frequency calculated for the plant. For new plants equipped with dedicated systems for prevention and mitigation of severe accidents already in the design, appropriate procedures for accident management should be developed.

The accident management programme should address all modes of operation and external hazards (extreme weather conditions, earthquakes, external fires and floods, man-made hazards such as explosive and toxic gas clouds, oil-spills, etc.) relevant for the site considered, taking into account some possible dependencies between events. It should also consider that external hazards could result in significant damage to the infrastructure on-site or off-site. Accident management programme should be developed and maintained consistent with the plant design and its current configuration.

Table 1. Characteristics of the preventive and mitigatory domains of accident management

Subject/Attribute	Preventive domain	Mitigatory domain
Aim	Prevention of fuel damage, through fulfilment of a set of safety functions of primary importance ('critical safety functions')	Limitation of release of radioactive material into the environment through actions comprising termination of core/fuel melt progression, maintenance of reactor pressure vessel integrity, maintenance of containment integrity, preventing containment by-pass and control of releases
Establishment of priorities	Establishment of priorities among the various 'critical safety functions'	Establishment of priorities between mitigatory measures, with the highest priority to mitigation of significant ongoing releases and immediate threats to fission product barriers
Responsibilities (authorisation of actions)	Control room staff, or emergency director if deemed appropriate	Emergency director (or equivalent)
Role of emergency response organization	Technical Support Centre available for advice to control room, or decision making for complex tasks, if deemed appropriate	Technical Support Centre (or emergency response facility) responsible for evaluation/recommendation of actions
Procedures/ guidelines	Use of procedures for preventive accident management measures (emergency operating procedures [EOPs]) by the control room	Use of guidance documents (SAMGs) by Technical Support Centre or other designated staff
Use of equipment	Use of all systems still available, use of design margins admissible; possible use of design extension margins upon advice, or decision, by the Technical Support Centre Measures beyond the defined operational range of the systems require advice, or instructions, by the Technical Support Centre	Use of all systems still available, also beyond their design limits, with preference given to safety features for design extension conditions, if available

3.2 Development of EOPs and SAMGs

A structured top down approach should be used to develop the accident management guidance. This approach should begin with the objectives and strategies followed by measures to implement the strategies and finally 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.

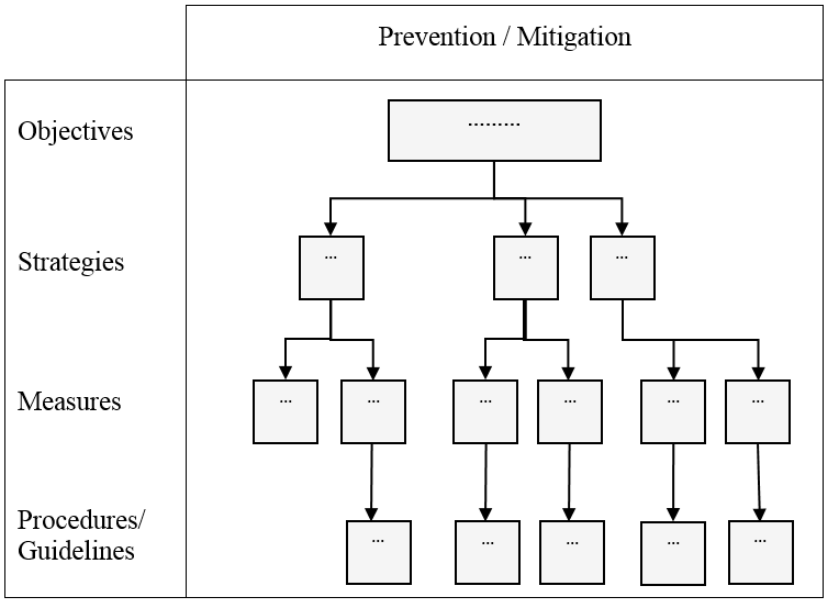

Figure 1. Top down approach to accident management

Multiple strategies should be developed to achieve the accident management objectives, which include:

- Preventing severe fuel damage by termination of accident progression, or, delaying the time at which significant fuel degradation happens;
- Terminating the progress of fuel damage once it has started as far as it does not preclude the following objectives;
- Maintaining the integrity of reactor pressure boundary (vessel or channels) to prevent melt through progression;
- Maintaining the integrity of the containment or any other confinement of fuel and preventing containment by-pass;
- Mitigating releases of radioactive material from any location of fuel outside containment; and
- Achieving a long-term safe stable state.

From the strategies, suitable and effective measures for accident management should be derived, corresponding to available plant hardware provisions. Such measures may include plant modifications, where these are deemed important for managing accident conditions including severe accidents. Personnel actions initiated either in the control room or local actions could be an important part of these measures. During an accident such measures would include use of systems and equipment still available, recovery of failed equipment and use of portable and mobile equipment stored on-site or off-site.

Appropriate guidance should be developed for the preventive domain of accident management in form of Emergency Operating Procedures (EOPs) and Severe Accident Management Guidelines (SAMGs) for the mitigative domain.

In the preventive domain, the guidance should consist of descriptive steps, as the plant status is known from the available instrumentation and the consequences of actions can be predetermined by appropriate analysis. The EOPs procedures are of prescriptive nature and should cover both design

basis accidents and design extension conditions, but are typically limited to actions taken prior to fuel damage.

In the mitigatory domain, large uncertainties may exist both in the plant status, availability of the systems and in the timing and outcome of actions. Consequently, the guidance for the mitigatory domain should not be prescriptive in nature but rather should include a range of potential mitigatory actions and should allow for additional evaluation and alternative actions.

Accident management guidance, including guidance for management of severe accidents, should be developed for all physically identifiable challenge mechanisms for which the development of accident management guidance is practicable in order to minimize the impact of severe accident on public health and safety. Accident management guidance should be developed for high credible challenges irrespective of the probability of occurrence of the challenges.

When developing guidance on accident management, consideration should be given to the full design capabilities of the plant, using safety and non-safety systems and including possible plant modifications and the use of mobile equipment. Care should be taken if the possible use of some systems beyond their originally intended function and anticipated operating conditions and possibly outside their design basis is foreseen in the guidance on accident management. Specific consideration should also be given to maintaining conditions needed for continued operation of equipment ultimately necessary to prevent large or early radioactive releases.

Accident management guidance should assist plant personnel to prioritize, monitor, and execute actions in the working conditions that may exist during accidents including those resulting from external hazards which are more severe than external natural events.

A verification and validation processes should assess the technical accuracy and adequacy of the instructions, and the ability of personnel to follow and implement them. The teams responsible for execution of accident management strategies should be adequately staffed and qualified.

3.3 Licensee's responsibilities and lines of authorization for accident management programme

Accident management should be an integral part of the overall emergency arrangements at a nuclear power plant. The development and execution of the accident management guidance is the responsibility of the emergency response organization at the plant or the utility.

For the accident management, the NPP operating organization must establish a decision-making authority that should be clearly defined and established at an appropriate level, commensurate with the complexity of the task and the potential consequences of decisions taken. The roles assigned to the members of the on-site emergency response organization may be different in the preventive and mitigatory domains, and, where this is the case, transitions of responsibility and authority should be clearly defined.

In the preventive domain, the control room supervisor or a dedicated safety engineer or other designated official should be able to fulfill this responsibility.

In the mitigatory domain, decisions should be made by a person having a broader perspective of accident management activities and understanding comprehensive implications of the decisions.

Major decisions which could have significant adverse effects on public safety or the environment should be made with the full knowledge of the person entrusted with legal responsibility for the plant, where reasonably practicable.

The accident management guidance (EOPs an SAMGs) should be compatible with the assignment of responsibilities and should be consistent with the other functions considered in the overall emergency response arrangements.

A technical support centre, staffed by Specialized team or group of teams, should be available to provide technical support by performing evaluations and recommending recovery actions to a decision making authority, both in the preventive and mitigatory domains. The technical support centre should have the capability, based on their knowledge of plant status to recommend mitigatory actions as deemed most appropriate for the situation. This should be done only after evaluating potential negative consequences. If the technical support centre is composed of multiple teams, the role of each team should be specified.

Appropriate levels of training should be provided to members of the on-site emergency response organization; the training should be commensurate with their responsibilities in the preventive and mitigatory domains as well as support the transition between domains. For example, severe accident sequence development, procedures and guidelines in use at the time of the transition from the preventive to the mitigative domain, emergency response teams or actions performed for recovering unavailable systems the emergency response team that deals with coping with the consequences of extreme events should be trained to lead under extreme conditions and demonstrate their leadership abilities during exercises or drills.

4. REVIEW OF THE ACCIDENT MANAGEMENT PROGRAMMES

4.1 Objectives and scope of the review

This section identifies the principal objectives of a regulatory review of an accident management programme development and implementation. Normally, the function of the regulator is to ensure that the accident management programme provides the plant operators with reasonable, prudent and effective procedures and guidance. In performing the review the regulator will address various aspects of the accident management development and implementation. These reviews might include the technical bases documents, verification, validation and training programmes. It is reasonable to create an atmosphere of mutual co-operation (consensus on the requirements and specific features of the accident management procedures and guides) and understanding between the utility and the regulatory body, thus reducing the probability of disruptions later on.

The general objective of the review of the accident management programme is to determine whether the specific goals of the accident management can be achieved:

- Termination of the progression of the accident as early as possible;
- Prevention of the accident evolving to severe consequences
- Maintain the integrity of fission product barriers including containment and spent fuel storage
- Minimize the release of radioactive materials into the environment
- Achieving a long-term safe stable state of the reactor core or spent fuel storage

Further, the review of the accident management programme shall determine whether the development and implementation of the programme addressed the following key issues:

- Mechanisms that can challenge critical safety functions or boundaries to fission product release are identified;
- Plant vulnerabilities are identified, considering the challenging mechanisms;
- Plant capabilities under challenges to critical safety functions and fission product barriers are identified, including capabilities to mitigate such challenges, both in terms of available equipment and personnel;
- Suitable accident management strategies and measures are developed, including the use of fixed and onsite and offsite portable equipment to cope with the vulnerabilities identified;
- Procedures and guidelines to execute the strategies and measures are developed, considering the

actual plant configuration, documented and available;
- The staff is trained in conduct of accident management activities.
- Communication interfaces

The review shall identify whether the procedures and guidelines contain as a minimum the following elements:

- Objectives and strategies;
- Potential negative consequences of the actions;
- Initiation criteria / entry conditions;
- Transition criteria and exit/termination condition;
- The time window within which the actions are to be applied (if relevant);
- Monitoring of strategies;
- The equipment and resources (e.g. AC and DC power, water) required;
- Consideration of habitability for local action;
- Consideration of required personnel resources;
- Cautions and limitations;
- Local actions sheets, if relevant (field instructions); Assessment and monitoring of plant response; and
- Consideration of long-term accident management strategies.

The objective of the review of technical bases for the accident management programme is to determine that adequate measures were undertaken to assure understanding of accident evolution, response of the plant including all safety features in maintaining the fundamental safety function and preventing escalation of severity of accidents. The review shall assess the adequacy of:

- the robustness and reliability of analytical methods used, both DSA and PSAs, in accident management procedures development; use of sensitivity and uncertainty analyses in support of accident management guidance development
- the extent of the operational experience used;
- accident sequences spectrum developed and analyzed;
- the analytical assumptions and justification of those for initial and boundary conditions including systems availability and operator actions;
- the quality assurance programme for the accident management guidance development; and
- the documentation of the analysis including plant database, engineering handbooks, evaluation of results, sensitivity calculations, uncertainty assessment and qualification of computational methods.

The regulatory review of an accident management programme is a complex process. The objective of the following sections is to provide an aid to the review team in planning and executing the review. For that purpose issues and questions related to the accident management technical bases, procedures and guidelines were identified, however for each review detailed planning must be performed that considers the actual plant and scope of the review. To support the planning and the review this guide identifies several technical references that should be used for preparation of the review.

The review consists usually of several phases. In the initial phase the preparatory activities are conducted. In the following phase the review is conducted which includes review of documentation, plant walk downs and interviews of plant staff.

4.1.1 Preparing the review

The preparation of the review include identification of the actual scope of the review as it might be conducted during the development or may address the implemented accident management

programme. During the preparatory activities review criteria are being defined, the review team is being set up and a draft schedule for the review is being prepared.

It is critical that the review criteria are clearly identified. The criteria must be based on the actual regulatory requirements, as well as international standards and practices.

For the review of technical bases the criteria might be based not only on regulations addressing the accident management but also on regulations addressing safety analysis requirements including requirements for quality assurance to be applied for analysis and associated documentation and verification and validation of computer codes used in the analysis. Also criteria related to use of sensitivity analysis and uncertainty analysis might be applied.

The criteria for review of the accident management implementation are more focused on effectiveness of programme and may focus, in the context of achieving and maintining fundamental safety functions, on whether adequate procedures or guidance is provided to the staff, whether there are sufficient design provisions or equipment to deal with severe accident and whether the staff is trained and prepared to perform required actions.

Some of the review criteria are identified in this document, however for each review conducted a specific set of criteria needs to be prepared and also communicated to the license.

In the second step in the review process the licensee is being notified about the review. Based on the scope of the planned review a listing of needed documentation, plant visits and interactions with licensee is prepared and communicated to the licensee. The documentation is collected and tasks are assigned to the review team. Also in this phase initial meetings with licensee are conducted to present the review objectives and agree on the schedule for the review.

4.1.2 Conducting the review

Initial review of the documentation against the overall review scope and objectives is conducted and if necessary additional information is requested to be provided by the licensee. This is followed by the in depth review of the relevant documentation (examples of requested documents including training and qualification records) to gain understanding of the comprehensiveness and adequacy of the technical bases for the accident management procedures and guidance. Site visits consisting of walk downs and interviews of licensee staff and witnessing emergency drills and exercises are being prepared in this step and conducted. This review guidelines provide lists of issues that should be addressed in the review and also suggest questions the review team might pose in its activities. Since the review consists also of interviews of the licensee staff the team might use checklists with interview questions.

4.1.3 Reporting of the review

The results of the documents review, findings from interviews of licensee staff and from walk-downs are documented and analyzed. In this last phase of the findings are presented to the license, their comments addressed and a final report is prepared and issued. Documentation of the review results is discussed in Chapter 5.

4.1.4 Required technical qualifications

Since the accident management is multi-disciplinary by nature it is important that a proper team is assembled that can cover variety of technical fields including: deterministic safety analysis thermal-hydraulic and severe accident, probabilistic safety analysis, containment design and management of safety and heat removal systems, structural and electrical engineering, human performance, as well as

training expertise.

It may be necessary for the plant/utility to provide the regulatory body's experts with theoretical training to enhance technical discussions. This is especially important if a reference system is being applied and the nuclear power plant is not able to present all the details of the development of the reference accident management package.

4.2 Review of the technical bases for accident management programme

The review team leader should identify, in consultation with the licensee staff, and obtain the set of relevant documentation for review. The documentation considered for this part of the review shall include:

- Administrative documents related to the development of accident management procedures and guidelines
- Relevant FSAR chapters and any other relevant documents in which the design bases (including design extension conditions) are discussed
- Operational limits and conditions / technical specifications
- Results of assessments of the efficiency of preventive and mitigatory actions
- Quality assurance procedures for analyses
- Documentation of codes used in the development of the technical bases
- Information on verification and validation of the codes showing their applicability to the plant and conditions under consideration for EOPs and SAMGs
- Plant vulnerabilities assessment
- Reports on analyses and sensitivity studies performed for evaluation of accident management action in the preventive and mitigatory domains.
- Evaluation of analytical uncertainties and their treatment

4.2.1 Assessment of plant vulnerabilities

In preparation of the accident management programme the licensee needs to identify and assess plant vulnerabilities. Therefore the regulatory review needs to determine whether such plant specific assessment has been performed; and whether a suitable and appropriate technical basis (including background documentation and analyses) was used to perform the identification of vulnerabilities.

Further, the review shall determine whether in assessment of plant vulnerabilities:

- A safety assessment was performed to identify and consider all credible challenges resulting from individual events or combinations of events that could challenge critical safety functions and cause failure of barriers against release of fission products.
- For external events, the safety assessment considered identified margins to events in which the consequences can significantly worsen for small changes in the event magnitude. These are called "cliff-edge effects". According to the IAEA Glossary: a cliff-edge effects refers to: "In a nuclear power plant, an instance of severely abnormal plant behaviour caused by an abrupt transition from one plant status to another following a small deviation in a plant parameter, and thus a sudden large variation in plant conditions in response to a small variation in an input.
- The possibility of being left with portable equipment only for mitigating some challenges should be contemplated.
- Vulnerabilities resulting from the failure of command and control due to loss of control room or impairment of the capability to set up the on-site Emergency Response Organization should were addressed.

- Vulnerabilities created by loss of communication with the control room, physical damage to the control room (e.g. fire), harsh environmental conditions in the control room (radiological conditions, toxic gases, smoke, ...) or staff injuries or even death were considered.
- The vulnerabilities to external hazards that can impact the use of accident management features, both permanently installed as well as portable, are identified. It should be investigated how specific external hazards can interfere with the use of accident management features.
- The behaviour of the plant during severe accidents, including those caused by external hazards, is well understood with identification of the phenomena that may occur together with their expected timing.

The information regarding the plant behavior in accident conditions should be obtained using appropriate analysis. Other inputs should also be used, such as the results of research on severe accidents, operational experience including insights from other plants and engineering judgment. Consideration should be given to uncertainties in the severe accident knowledge base and the assumptions made in models and analysis.

4.2.2 Review of EOPs technical basis and supporting analyses

As discussed in Section 3.2 the accident management programme needs to consider all modes of operation, all possible conditions, including combinations of events that could cause failure of fuel cooling and ultimately significant releases. The accident management programme has to consider also the external hazards relevant for the site. An accident management programme requires that plants establish the necessary infrastructure to prevent or mitigate effectively the severe accident conditions. The developed EOPs must be supported by appropriate background documents that form the technical basis for the EOPs and should describe and explain the rationale of the various parts of the guidelines, and include an explanation of each individual step in the guidance.

The review of the technical basis for EOPs includes the review the scope and adequacy of supporting analyses that were used throughout the development of EOPs. The review should focus on the scope of the analyses, whether they provide sufficient information on the plant's response to various accident conditions and a qualitative assessment of all recovery strategies used in EOPs. Careful evaluation should be made of the applicability of computer codes used for the analyses.

The review of relevant factors influencing the process and the scope of coverage are of particular concern, e.g. initial plant operating modes, operator actions and other factors known to challenge human performance and scenarios that have been adopted to justify the scope of EOPs.

Additionally the review may pose questions such as:

- Did the analyses use a dedicated methodology developed for the purpose of the EOP's development?
- Are the supporting analyses properly defined and technically correct?
- Is the approach to modeling and computer codes/models used for analyses up to date?
- Was there any independent assessment of the analysis results?
- Were the conditions in the facility in which responder actions are necessary and the response of the personnel, instrumentation and systems of the facility under emergency conditions considered?

4.2.2.1 Selection of accident sequences

It is necessary to provide EOP guidance for other operational modes, including unit startup and shutdown, and during various shutdown and outage conditions. The review needs evaluate whether

the conditions listed below were included in preparation of EOPs:

- Postulated DBAs;
- Abnormal situations with the potential of leading to accidents;
- Some BDBAs (combination of accidents, time evolving accidents, operator errors, etc.);
- Situations that cannot be clearly diagnosed;
- Challenges to a safety function ensuring overall safety of the plant, etc.;
- Multiple simultaneous failures;
- Continuous diagnosis;
- Shutdown accidents (if not already covered by DBAs).

Especially the review needs to evaluate whether the low power and shutdown conditions were adequately addressed as they contribute significantly to the overall risk.

4.2.2.2 Use of deterministic and probabilistic analyses supporting development of EOPs

During EOP development the proposed strategies and actions are checked through an analysis to optimize and validate the operating strategies before transcribing them into specific operator instructions.

Different types of analyses are performed during the development of EOPs to s support and justify EOP strategies.

For the selection of analyses for the review the same prioritization criteria can be applied as discussed in Section 4.2. Examples of categories of analysis for detailed review are:

- Specific thermal-hydraulic analyses from different sources, including those with the analytical background from the FSAR and PSAs, that were used for development of the EOP strategies;
- Probabilistic analysis in support of the determination of the scope of the EOP;
- Analysis related to equipment and system vulnerabilities, capabilities and set points;
- Analysis of specific parameter values for specific safety functions;
- Analysis in support of strategies applied in the EOPs;
- Specific data related to reactor vessel (pressure tubes, feeders, collectors) resistance to PTS.

Additionally, the review shall determine whether the conducted analyses were used to define the required support systems and restoration strategies, and if analyses to support priorities when multiple strategies or techniques are available.

4.2.2.3 Analytical assumptions

Accident analyses are the main tool in development of EOPs as they provide the information on plant response to accidents. Due to complexity of plant response to initiating events, equipment failures, safety systems operation and operator actions it is important that these analyses are defined and interpreted by operational experts with analytical staff providing calculational support.

The review shall determine whether for the analyses supporting EOP development realistic and adequate assumptions were made with respect to initial and boundary conditions, availability and capacity of systems and answer questions such as:

- Were specific values used for the safety functions?
- Were specific values used for EOP set points and criteria?
- What time dependent parameters were used in the EOPs?
- Were specific plant data applied in the area of natural circulation operation (for evaluation of

the heat sink capability), subcriticality margins, vessel resistance to pressurized thermal shock (PTS) (e.g. to specify the acceptable vessel cooldown rate) etc.?
- Was equipment and instrumentation qualification and uncertainties considered
- Were analyses or calculations related to equipment and system capacities and limits performed?

4.2.3 Review of SAMGs technical basis and supporting analyses

The accident management in the mitigatory domain addresses challenges caused by significant reactor fuel damage (in the core, the spent fuel pool or any other location where fuel is stored). SAMGs should address the full spectrum of challenges to fission product barriers, including those arising from multiple hardware failures and external hazards, and possible physical phenomena that may occur during the evolution of a severe accident. In this process, even highly improbable failures should be considered. In general the objective of analyses supporting severe accident management programme are:

- formulation of the technical basis for development of strategies, procedures or guidance;
- demonstration of the acceptability of design solutions to support the selected strategies, procedures and guidelines in accordance with the established criteria;
- determination of the reference source terms for emergency plans.

The basic approach is the use of best estimate analysis.

A technical basis for SAM should document the understanding of severe accident phenomena and reactor-specific physical processes, such as core degradation, in-vessel core debris retention, ex-vessel corium spreading and coolability, molten fuel coolant interaction, molten core concrete interaction, and all known containment challenge mechanisms. The technical basis should also include severe accident phenomena in spent fuel bays and multi-unit distress. The technical basis should be updated as necessary to reflect the state-of-the-art knowledge and experimental data obtained from applicable severe accident research programs and lessons learned from the reactors that have experienced severe core damage. The updated knowledge and data should be used to evaluate the reactor ability to cope with accidents and to deduce suitable accident management strategies, provisions, procedures, and guidelines.

Reactor-specific beyond-design-basis initiating events, such as events triggered by extreme external hazards (e.g., earthquakes, flooding, and extreme weather conditions), should also be considered to increase the reactor coping capability. The aim is to ensure that a set of sufficient, supplementary onsite equipment and consumables (e.g., fuel and water inventories) are identified, obtained, protected and stored onsite or offsite. These can be used to maintain or restore the cooling of the core, the containment, and the spent fuel pool following a beyond-design-basis initiating event. After the consumables are used up, offsite resources should be obtained to sustain those cooling functions indefinitely.

Accident management should consider that some beyond-design-basis initiating events may result in similar challenges to all units on the site.

Challenges for severe accidents and beyond-design-basis initiating events may be identified using a targeted assessment of safety margins against a set of postulated extreme conditions that cause a consequential loss of safety functions leading to severe core damage. Such a reactor-specific “stress test” can be used to determine the time of autonomy of reactor-critical safety functions, any potential weak points, and any cliff-edge effects for a given set of the considered extreme situations.

The severity of these phenomena should be assessed. In the severe accident domain, analysis results should be collected and set out in a report that could serve as the technical basis for severe accident management.

4.2.3.1 Use of DSA and PSA

In the development of SAMGs both, deterministic and probabilistic analytical tools and computer codes should be used. The review shall determine whether adequate analytical tools were used (See Section 4.2.4) and whether specific analyses were used to assist in developing the accident management guidelines by:

- Formulating the technical basis for identification of reactor challenges and capabilities and development of strategies, measures, procedures and guidelines;
- Demonstrating the acceptability of the identified solutions to support the selected strategies, measures, procedures and guidelines against the established criteria;
- Determining the reference source terms and accident conditions for environmental qualification of equipment for DBAs and survivability/operability assessments of equipment for design extension conditions including severe accidents.

Additionally, the review shall answer questions such as:

- Have been specification of the criteria that would indicate the onset of a severe accident developed using appropriate analyses?
- Were specific analyses performed for identification of the symptoms (i.e., parameters and their values) by which plant personnel may determine the reactor core condition and state of protective barriers?
- Were challenges to fission product boundaries in different reactor states, including shutdown states identified through analyses?
- Was the timing of such challenges evaluated through analyses in order to improve the potential for successful human intervention?
- Were the plant systems and material resources that may be used for SAM purposes identified through analyses?
- Were the SAM actions verified by analyses to be effective in countering challenges to protective barriers?

Analysis performed to support SAM should use the best-estimate approach. Uncertainties in the analytical prediction of challenges to fission product barriers should be taken into account if the level of knowledge of important severe accident phenomena and physical processes is low and if the associated supporting experimental data are insufficient.

Necessary computational aids should be identified and developed to assist in the overall success of accident management activities performed by the response organization prior to an actual event. These computational aids are typically obtained using simplified assumptions and are often presented graphically. The results of deterministic severe accident analysis should assist the licensee to:

The review shall also address whether the documentation of the codes including user manuals and V&V documentation is available (discussed in Section 4.2.4).

4.2.3.2. Selection of accident sequences

In order to develop the technical basis documents for the accident management programme, a range of accident sequences should be analyzed. The review shall identify whether adequate consideration has been given to selection severe accident sequences, using a combination of engineering judgment and probabilistic methods, to determine those sequences for which reasonably practicable preventive or mitigatory measures can be identified (using best-estimate analyses and realistic assumptions).

Also, the review should determine whether adequately the operational experience (including information from similar plants), relevant safety analysis including precursor analyses, results from safety research, design activities addressing severe accidents, and equipment technical specifications were taken into account, and questions should be posed such as:

- Were important event sequences that may lead to severe accidents identified by using a combination of probabilistic methods, deterministic methods and sound engineering judgement?
- Were these event sequences reviewed against a set of criteria aimed at determining which severe accidents shall be addressed in the design of accident management programmes?
- Have been potential design changes or procedural changes evaluated that could either reduce the likelihood of these selected events, or mitigate their consequences should these selected events occur, and implementation of those if reasonably practicable?
- Has been consideration given of 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)?
- I the use of available means and/or support from other units for multi-unit plants addressed (provided that the safe operation of the other units is not compromised)?

The review shall also address whether in the sequence selection process

- plant specific severe accident phenomena have been considered?
- accident sequence classes been chosen which focus on risk significant accidents?
- the selected accident sequences analysed pose the maximum challenge to the safety concerns or target parameters being evaluated? For example, to evaluate the effectiveness of in-vessel retention (for LWR), or the accident sequence that leads to the earliest formation of the terminal debris bed (thus maximum decay power and highest thermal-mechanical challenge for calandria vessel integrity) should be selected. However, for placement However, for placement and evaluation of PARs (passive autocatalytic recombiners) and igniters, the accident sequence that leads to the highest hydrogen production should be selected.
- guidance has been obtained from the PSA Level 2, for determination of the full spectrum of challenge mechanisms?
- identification of potential challenge mechanisms was comprehensive enough to provide a basis for guidance for the plant personnel in any situation, even if the evolution of the accident would constitute a very unlikely path within the PSA Level 2 or is not identified in the PSA Level 2 at all?

4.2.3.3 Analytical assumptions

Analyses performed in support of the severe accident management guides have to be realistic and represent as best as possible the plant and its systems (including relevant non-safety systems) and other equipment available for mitigating severe accidents.

The review may address questions such as:

- Are the system availability or unavailability assumptions justified and documented in the definition of accident sequences selected for deterministic accident analysis?
- Have the boundary conditions been properly characterized?
- Are modelling assumptions, including initial and boundary conditions, adequately explained, described, and justified?

The review may also consider questions raised in Section 4.2.2.3.

4.2.4 Quality assurance of the analysis and verification and validation of analytical tools

The regulatory review needs to determine whether the computer codes used for development of the technical basis and simulation of accident management procedure and guides were adequately verified and validated.

The review should answer questions such as:

- Were well established and documented codes used with documented verification and validation for parameter ranges expected in the sequences?
- Do the DSA best estimate codes have adequate capability to simulate all relevant thermal-hydraulic, neutronic, severe accident mechanical and chemical processes, fission product release and transport, generation of non-condensable gases, containment response?
- Were the uncertainties addressed through sensitivity and or formal uncertainty analyses for both DSAs and PSAs, and was the impact of the uncertainties addressed in development of SAMGs?

The verification of the code design should be performed and documented to demonstrate that the code design conforms to the design requirements i.e. that the numerical methods, the transformation of the numerical equations into a numerical scheme to provide solutions, and user options and their restrictions are appropriately implemented in accordance with the design requirements.

The review needs to address code validation and needs to determine whether it was performed and whether documentation is available that provides confidence in the ability of a code to predict, realistically, the values of the safety and control parameters or other parameters of interest. It should also quantify the accuracy with which the values of parameters can be calculated.

The review shall determine whether the verification and validation of computer codes was performed according to the CNCAN regulatory requirements and recommendations.

The review shall determine whether systematic process in the development and quality assurance, including independent verification and checks, of analytical input models was applied and whether the process and the models are adequately documented.

- Was a database developed contains all necessary information such as geometry, thermal-hydraulic parameters, control and safety systems' characteristics, set points, and includes drawings and other graphical documents?
- Is there an Engineering Handbook exists that describes the process of converting the plant's database into a computer input deck?
- Which methodology was applied and what simplifying assumptions and calculations were made to convert technical plant data to the code input deck?
- Were input data verified by review and crosschecking by qualified individuals and groups that were not involved in the input deck development process?
- Is verification appropriately documented?
- For important physical processes have any alternative assessments or calculations been performed and documented (e.g., analytical calculations, supporting single-effect simulations using other qualified computer codes, detailed CFD (computational fluid dynamics?
- Were plant data (startup and other operational data) used for validation of the input model?
- Is an input model configuration control system in place?

The review shall determine whether a collection of plant documentation exists which was used for the preparation of computer code(s) input data.

4.3 Review of EOPs

The review the EOPs may be oriented towards either administrative or technical aspects of the programme. While the administrative review will be mainly focused on a review of the development/implementation process and the QA and methodology used, the technical review will concentrate more on the correctness and accuracy of the procedures themselves, including human factor considerations. The section below provides an overall guidance on the review of the scope and technical justification of the EOPs, issues related to the technical bases were covered in Section 4.2 and aspects such as human factors, verification and validation of procedures, maintenance of EOPs, documentation and training are addressed in Sections 4.5, 4.6, 4.7, 4, 8 and 4.9 respectively.

4.3.1 Review of EOP scope and their technical justifications

The review team leader should identify and obtain the set of relevant documentation for review. Since the review of technical basis for SAMGs was earlier in the review process (Section 4.2) the documentation considered for this part of the review shall include:

- Limits and conditions (technical specifications)
- Results of assessments of the efficiency of preventive actions;
- Normal operating procedures
- Alarm response procedures
- EOPs procedures;
- Responsibilities of staff involved in emergency operating procedure;
- Results of EOPs validation and reviews;

The review shall identify whether the preventive accident management strategies and measures address the full spectrum of events i.e. all events considered on the basis of credible initiating events, and possible complications during the evolution of the event that could be caused by additional hardware failures, and relevant external hazards, and whether reliable procedural guidance for operators is provided to deal with accident conditions up to the point of core damage. Thus, the EOPs generally provide actions for a wide spectrum of operating conditions, ranging from abnormal operation up to accidents exceeding the design basis of the nuclear power plant.

The review of the EOP scope shall consider questions such as:

- Was for accident sequences considered: consistency with the FSAR, with the plant specific PSA, with the regulatory body requirements, with the plant specific and international experience feedback?
- Are the initial operating modes taken into account?
- Was the interface with other plant procedures addressed fort the conditions covered by the EOP package?
- Is the compliance with the present plant system status assured?
- Has been a strategy developed concerning planned modifications of EOPs?
- Has been guidance developed and is in place for situations where a diagnosis of the accident based on alarms and procedures cannot be obtained or, when it has been obtained, it later has been found to be incorrect or has changed due to the evolution of the accident? Alternatively, the guidance can be fully linked to the observed physical state of the plant and so further diagnosis of the accident sequence is not necessary. Nevertheless, it may be appropriate to apply the diagnostic procedure at regular intervals to make it possible to return to the procedure specifically developed for the observed accident sequence. The guidance should be aimed at monitoring and preserving or restoring critical safety functions on the basis of the selected strategies.
- Was the possibility of transition from EOPs to SAMGs before the technical support centre is

operable considered in the development of procedures and guidelines?
    - Any mitigatory guidance provided to control room operators in this case should be presented in a way that makes prompt and easy execution possible and, therefore should be presented in a format operators are able to work with and already trained for.
- Are there any strategic decisions that may interfere with existing documents and/or regulatory policies?
- When the decision on the scope of EOPs was taken (based on plant specific probabilistic arguments) what was the cut-off probability of scenarios covered in the EOP package?
- What is the basis for the assignment of priority to operator actions versus safety systems logic circuits?

The review needs to address the technical justifications for the procedures implemented and needs to consider

- Is there consistency with the basic/generic principles?
- How were the administrative reference documents used?
- Are the procedures consistent with the EOP writer's guide?
- Is there consistency between the reviewed procedures?
- Is the justification, the correctness and the technical effectiveness of the strategies assured through adequate technical basis?
- Is there consideration given to radiation risks, availability of tools and information?

Procedures and guidelines should be based on directly measurable plant parameters. Where measurements are not available, parameters should be estimated by means of simple computations and/or pre-calculated graphs. Use of parameters that could be obtained after carrying out complex calculations during the accident should only be contemplated if there is ample time for such calculations and there is reasonable assurance that the likelihood of error is reasonably low.

Due to its limited scope the review should focus on the most important procedures. The criteria that can be used to prioritize the procedures in terms of importance are:

- Is the procedure addressing a severe safety issue/challenge (examples: diagnostic procedure, inadequate core cooling, total blackout, total loss of heat sink, PTS, SG tube rupture (SGTR), etc.)?
- Is the procedure responding to a higher probability event (examples: simple reactor trip, spurious ECCS actuation, SGTR, etc.)?
- Does the procedure require much operator involvement, with unusual actions (examples: SGTR, plant cooldown and depressurization with a small LOCA, etc.)?

Generally if the answer to these three screening questions is "no" the procedure does not have to be considered in the review.

4.4 Review of SAMGs

The review of a SAMGs program aims to assess the adequacy of the operational guidance, of design provisions and equipment, and of human resources for the accomplishment of the accident management goals as stated in Chapter 3. The review shall identify whether the following general principles were followed in the development of the SAMGs:

- The SAMGs are presented in the appropriate form, including guidelines, manuals or handbooks. The term guideline here is used to describe a set of strategies and measures that describe the tasks to be executed in the plant, but which are still less strict and prescriptive than the procedures found in the EOPs, i.e. used in the preventive domain.. Manuals or handbooks typically contain a more general description of the tasks to be executed and their justification.

- The SAMGs are designed with the appropriate level of detail and in a format that facilitates their effective use under stressful conditions. The usability of the guidelines (step-by-step instructions or flexible decisions) should be considered in the development process and be clear to the user.

4.4.1 SAMGs scope and severe accident management strategies

The review team leader should identify, in consultation with the licensee staff, and obtain the set of relevant documentation for review. Since the review of technical basis for SAMGs was earlier in the review process (discussed in Section 4.3) the documentation considered for this part of the review shall include:

- Results of assessments of the efficiency of preventive and mitigating actions;
- SAMGs guidelines and procedures;
- Performance capabilities for the systems and equipment that can be used in support of SAMG procedures;
- Information requirements for effective accident management;
- Responsibilities of persons and organizations involved in severe accident management;
- Requirements for personnel training; and
- Results of SAM validation and reviews.

The review of SAMGs should determine whether they contain sets of information, instructions and actions designed to mitigate the consequences of a severe accident according to the chosen strategies. Uncertainties may exist both in the reactor status and in the outcome of a selected action. Therefore, SAMGs should propose a range of possible actions and allow for additional evaluation and alternative actions. SAMGs should also address various positive and negative consequences of proposed actions, including the use of equipment, limitations of the equipment, cautions and benefits.

The review shall verify that the strategies for severe accident management were developed based on the vulnerability assessment and identified plant capabilities as well as the understanding of accident phenomena. The implementation of specific mitigatory strategies should be triggered when certain parameters reach their threshold values. These parameters should be selected to be indicative of challenges to fission product barriers.

The review shall also identify whether the strategies were developed according the principal objectives of the severe accident management:

- Terminating the progress of fuel degradation;
- Maintaining the integrity of the reactor vessel or pressure tubes;
- Maintaining sub-criticality;
- Maintaining the integrity of the containment or any other confinement of fuel and preventing containment bypass;
- Mitigating releases of radioactive material from any location of fuel; and
- Achieving a long term safe stable state.

The review shall address questions such as:

- Was a systematic evaluation of the possible strategies conducted to confirm feasibility and effectiveness, to determine potential negative impacts, and develop prioritisation, using appropriate methods? Adverse conditions that may affect the execution of the strategy during evolution of the accident should be considered.
- Are the strategies (including those for using portable equipment, and including the technical background), documented and maintained? Changes to the documentation should contain a record of previous strategies and the basis for changes.
- Was consideration given to strategies that have both positive and negative impacts in order to

provide the basis for a decision as to which strategies constitute a proper response under a given plant damage condition? An example is withholding water from the reactor cavity to extend the time to overpressure failure of the containment; this has the negative impact of assured possible core concrete interactions that may be irreversible. A further example is flooding the cavity, with the negative impact of possible occurrence of an ex-vessel steam explosion.

- Were the strategies prioritized taking into account plant status and the existing and anticipated challenges? The basis for the selection of priorities in accident management strategies should be documented.
- For the prioritization has the licensee considered:
  - Timeframes and severity of challenges to the barriers against releases of radioactive material;
  - Availability of support functions (for example AC power, DC power, cooling water) as well as possibility of their restoration;
  - Plant initial operating mode, as accidents can develop in operating modes where one or more fission product barriers could already be lost at the beginning of the accident. For example at shutdown the reactor coolant system and containment might be open. Priority could be given to restoring containment integrity before anything happens to the fuel.
  - Adequacy of a strategy in the given domain; some strategies can be adequate in the preventive domain, but not as relevant in the mitigatory domain due to changing priorities;
  - The difficulty of developing several strategies in parallel; and
  - Long-term implications or concerns of implementing the strategies?
- For strategies that rely on portable equipment following an extended loss of all AC power, was it considered and accounted that personnel can install and operate such equipment within the time frame necessary to avoid loss of critical safety functions taking into account possible adverse conditions on the site? Support items such as fuel for portable equipment should be available.
- Was the possibility of large uncertainties considered in identifying time windows for strategies that need to be implemented within a certain time? (without discarding potentially useful strategies)
- Was a systematic identification of the plant control and logic interlocks that need to be defeated or reset for the successful implementation of accident management strategies performed? It should also be verified that the potential negative effects of such actions have been adequately characterized and documented.
- Was adequate consideration in selection of AM strategies given to the potential usefulness of maintaining strategies initiated in the preventive domain (EOP)? Limitations that could arise from harsh environmental and radiological conditions should be taken into account.
- Are strategies preferred which avoid or minimize the accumulation of large amounts of potentially contaminated water, including leakage from a failed containment?
- Were strategies considered for storing and remediating accumulated contaminated water?

Additionally the regulatory review shall verify whether:

- The SAMGs include organizational structure of the severe accident management program within the facility, with identification of the roles and responsibilities of all program participants, including operating staff and emergency response and support groups;
- The parameters that define the transition from emergency operating procedures to SAM procedures are selected and justified;
- Key parameters to diagnose the state of various reactor and plant systems throughout the progression of the accident are selected and included in the procedures;
- Actions to be taken to counter challenges to the reactor and plant systems are clearly defined

and described in the SAMGs;
- Indicators that can be used to judge the success of the implemented actions are included in the SAMGs; and
- a communication protocol to be followed during implementation of SAMGs is provided.

The review should address questions such as:

- Do the procedures and guidelines contain at minimum the elements defined in Section 4.8?
- Has a consistent approach to procedure and guideline writing been adopted (language, use of specific terms, etc.)? Has a 'writer's guide' been followed?
- Were the guidelines or procedures developed for all groups participating in accident management such as control room operators, technical support group, and decision makers in accordance with their respective roles?
- Are the instructions to implementers clear and unambiguous, using consistent language and specific terms in accordance with established rules (preferably in a writer's guide)?
- Is the text and supplementary diagrams in the guidelines and procedures easy to read?
- Are there a clear criteria for transition from EOPs to SAMGs?
- Do the SAMGs cover events with multi-unit damage, potential damage to the fuel in spent fuel pools, releases of radioactive materials and hydrogen into buildings adjacent to the containment, and run-off of contaminated water to the environment?
- Have the guidelines been verified and validated?
- Has user-friendliness of guidelines and procedures been properly addressed, in particular regarding the assessment of availability and capability of plant systems to perform the different strategies?
- Have the long-term implications or concerns of implementing the strategies been considered?
- Is trend information asked for from the instrumentation in addition to point-value information?
- Has it been verified that access to equipment will be possible for local actions required by the guidelines?
- Have requirements and means to override or block automatic protection system signals or interlocks been identified?
- Have potential confusions due to translation between languages been addressed?
- Has background information been prepared which is plant specific, comprehensive and clear?
- Has the need to produce revisions of the guidelines and background information been considered within the structure of the material?

The review shall also determine whether guidance for plant damage assessment is included and instructions provided to address challenges to physical barriers and safety functions before any significant fission product release. Of particular importance is the assessment of site and building structural damage in case of extreme external event.

4.4.2 Evaluation of plant equipment and instrumentation

The review needs to determine whether the nuclear power plant is equipped with hardware provisions, which may include supplementary onsite and offsite equipment, to fulfill the fundamental safety functions (i.e., control of reactivity, removal of heat from the fuel, confinement of radioactive material) as far as reasonable for all accidents considered in the in the accident management programme, including severe accidents.

The review shall address questions such as:

- Has a systematic review of plant specific systems capabilities (including use of systems for purposes outside their original design basis) been performed, and have the results been specifically reflected in the procedures/guidelines?

- Have any limitations (including power supply, cooling media) associated with operating the equipment been identified and addressed? E.g. can interlocks be removed in a user friendly way?
- Have possible alternative ways to implement a given strategy been identified?
- Are dedicated systems and design features provided to practically eliminate some severe accident phenomena such as core melt at high pressures and hydrogen detonation?
- Were all complementary design features and available water sources for removal of decay heat from damaged reactor fuel identified in advance and put in place for managing severe accidents, particularly for maintaining the cooling of the core debris and the integrity of the containment?
- Was buildup of a diverse and flexible mitigation capability considered for the most serious design extension challenges, such as an extended loss of heat sinks? For example, portable or supplementary equipment as multiple means of obtaining power and water to support key safety functions for all reactors at a site.
- Has the licensee performed equipment survivability assessments to provide reasonable assurance that equipment used in SAM is available at the time it is called upon to perform. Design extension conditions with severe accidents potentially create harsh environments with high temperature, high pressure, high radiation level, and high concentration of combustible gases. These environmental conditions, which could well exceed those of DBAs used for equipment qualification, present additional challenges to the equipment. Survivability of the equipment that could be used in SAM should be evaluated through a systematic review and assessment of equipment functions and conditions based on the available knowledge and data, such as from equipment environmental qualification for DBA, severe accident testing and analysis, and engineering judgment. Therefore the review shall determine whether the licensee has considered in the survivability assessment:
  - identification of accident management actions used to mitigate severe accidents
  - definition of fuel and core damage state and time period for each accident management action
  - identification of equipment used to perform each of the actions
  - determination of the bounding environmental conditions to the equipment within each time period
  - demonstration that the equipment will survive to perform its function;
- Was the habitability of the facilities used in accident management (such as the main control room, the secondary control room, and the emergency support facilities, including an onsite technical support centre and on onsite emergency support centre) assessed and assured, taking into account the environmental conditions (e.g., radiological conditions and other conditions related to lighting, ventilation, temperature and communication, damage) within and surrounding the facilities during an accident?

The review shall determine whether adequate instrumentation is available for each stage of an accident for the monitoring and diagnosis of reactor conditions and for assisting in accident evaluation, accident management decision-making, and action execution.

The review shall consider questions such as:

- Do the guidelines for equipment survivability specified for severe accident conditions also apply to reactor instrumentation?
- Is a list of instrumentation for each stage of the severe accident established?
- Is a reasonable assurance provided that the instrumentation used to monitor severe accident progression and facilitate accident management actions will be available?
- Were the effects of environmental conditions on the instrument reading estimated and taken into account to produce the procedures and guidelines?

- Were harsh environmental conditions, including the effects of hydrogen burn within the containment on cables and electrical containment penetrations, also taken into account?
- Were alternate methods considered (including computational aids) for reading from a non-qualified instrument to diagnose reactor conditions for SAM?
- Has been considered to upgrade or replace the instruments where the risks associated with faulty readings are high under local environmental conditions?
- For scenarios where the required parameters are missing or their measurements are unreliable, was development of computational aids to obtain information identified, and appropriate computational aids developed in advance?
- Have the necessary arrangements been made to ensure that the instrument data is available to the SAMG users?

4.4.3 Integration of SAMP and plant emergency arrangements

The review shall determine whether the SAMGs are an integral part of the overall emergency arrangements defined in the plant's Emergency Plan. This should include lines of responsibility and accountability for implementing response actions during execution of accident management guidance to maintain or restore safety functions throughout the duration of the accident and is applicable to organization, coordination, personnel, plans, procedures, facilities, equipment or training, etc.

The review should address questions such as:

- Have the duties of onsite emergency response organization (ERO) been reviewed and perhaps modified to incorporate the new severe accident management functions?
    - Has the SAMP been integrated into the emergency response arrangements? Has the plant emergency arrangements been reviewed and perhaps modified to include new severe accident management functions and responsibilities?
- Are criteria and procedures used by the operational staff for classification and activation of the response organization (to include the accident management components) adequate for timely implementation of the accident management functions?
- Do the emergency arrangements support performance of the accident management functions under emergency conditions and consider other response actions, hazardous work conditions, time constraints and stress?
- Have the accident management actions and assessments that may influence taking protective action on- or off-site (e.g., intentional venting of the containment) been coordinated with the on- and off-site response organizations responsible for taking such actions?
- Has the utilization of off-site emergency services been integrated into the emergency arrangements?
- Have the lines of responsibility been clearly defined for evaluators, decision makers and implementers, for all severe accident management functions?
- Has the method and responsibility for communications between the different involved parts of the emergency response organization been defined?
- Are the criteria, responsibilities and required time response for activation of the severe accident management team defined and achievable?
- Have the required information needs been provided at the appropriate location for the severe accident management team to monitor plant status?

During a severe accident, no single group is likely to have the complete information, knowledge, and skills required to manage the accident. It is therefore important to establish effective onsite communication interfaces among groups including the emergency response teams. The review shall determine whether:

- These interfaces will enable efficient integration of the information and expertise available within the operating and supporting organizations or from other involved authorities;
- Effective communication interface between the operating organization and the local county, national and other appropriate emergency organizations clearly delineate responsibilities, and specify the scope and timing of the information and the support that the local county and national emergency organization and other involved organizations will receive;
- The possible loss of power is considered in providing for communication, e.g., between the control room and the technical support centre;
- The impact of beyond-design-basis initiating events on communication is considered and provisions were made for reliable communication among different accident management and emergency response organizations, including extreme situations such as widespread onsite and offsite damage caused by severe weather conditions, flooding, earthquake, etc.;
- Measures are established to ensure the effectiveness of the emergency communication systems, including regular practice in their use.

4.5 Review of the human factor related aspects of accident management

Safe and reliable human and organizational performance is an essential part of an accident management programme. Performance under emergency situations should be taken into account during the implementation of the accident management programme to meet the expectations specified in regulatory requirements.

The conditions under which emergency actions are performed range from normal operation to the abnormal operation up to accidents exceeding the design basis accidents and include severe accidents, therefore they pose significant challenge upon the operators. This requires consideration of many human factors that might influence the development and implementation of EOPs and SAMGs. The regulatory review shall evaluate whether these factors were considered and questions such as may be addressed:

- Was sufficient verification and validation of all aspects of human and organizational performance, including EOPs and SAMGs, to execute all the identified accident management actions conducted and did it demonstrate that they can be carried out by reactor personnel under all types of conditions covered by the by the accident management?
- Is the procedures and guides location easy accessible and are the procedures and guides clearly identifiable?
- Is the EOPs format consistent with the EOPs writers guide (see also Section 4.8)?
- Is the supporting documentation easy accessible and clearly identifiable?
- In case of computerized EOPs or SAMGs computer unavailability is the completeness of paper backup assured?
- Is operator training in retrieval and use of procedures and guides provided that includes also issues of transition between procedures or between procedures and guides?
- Are there systems provided to prevent the operator from overriding any automatic protection during normal operation? However, for the case when in emergency situations the operator is allowed to control of the safety systems the automatic logic should be provided with a hardware override capability, available in the control room.
- Are administrative procedures and training in place to assure that the operator is allowed to intervene with the automatic logic only as result of EOP instructions or while executing severe accident management actions?
- Are the roles and responsibilities, to be assigned to all members of the team in charge of controlling or mitigating the accident situation, clearly defined? EOP implementation primarily involves the operations organization, with support from other organizations as needed. SAMG implementation has wider organizational implications, which require careful

considerations in terms of roles and responsibilities, personnel qualification, and interfaces with the technical support centre and the emergency support centre.

- Have been measures incorporated in the accident management programme to ensure that the personnel will be ready to carry out the appropriate roles and responsibilities? For example, certain accident events may cause damage to the facilities (e.g., the technical support centre) and provisions should be made to ensure the habitability of the facilities and an alternative is available.
- Appropriate arrangements should be identified for shift turnover and provision of food and other amenities for prolonged duty caused by beyond-design-basis initiating events.
- Have the operators been involved in the development of EOPs and SAMGs?
- Have been consideration given to the fact that reactor staff may be concerned about family and friends following a severe accident and may be under extremely high stress while executing accident management actions?
- Have been measures taken to address all of these situations when it may be impossible to increase or replace staff for a given time?
- SAM may require sufficient qualified personnel that are not part of the normal minimum staff complement, have been measures taken that qualified staff is on call?
- Have been consideration given to improvement of the accident management programme through the consideration and incorporation of relevant results from well-supported research in human performance, including decision-making?

4.6 Review of verification and validation of accident management procedures and guidelines

The regulatory review of the accident management programme shall determine whether an appropriate verification and validation of EOPs and SAMGs has been performed.

Verification and validation processes should assess the technical accuracy and adequacy of the instructions, and the ability of personnel to follow and implement them. The verification process should confirm the compatibility of document instructions with referenced equipment, user-aids and supplies (e.g., portable equipment, posted job aids, strategy evaluation materials, etc.). The validation process should demonstrate that the document provides the instructions necessary to implement the guidance.

The regulatory review shall identify whether all accident management procedures and guidelines have been verified and validated (changes made to guidelines and procedures should be re-evaluated and revalidated to maintain the adequacy of the accident management programme).
The review may address issues such as:

- Has a cross-functional safety review of the plant been performed with the objective of fully understanding all accident management implications (including a plant walk-down for assessing which kind of difficulties could exist for practical implementation of accident management measures, in particular in case of an extreme external hazards, including seismically induced fires and floods)?
- Is there a correspondence between the procedures and the control room/plant hardware, i.e., controls, equipment, and indications that are referenced are available (inside and outside of the control room), use the same designations, use the same units of measurement, and operate as specified in the procedures;
- Has all equipment needed in the accident management programme, including portable and mobile equipment, been tested, or other reasonable means used, to verify that performance conforms to the requirements? Testing should include the equipment and the assembled sub-system needed to meet the planned performance. Tests should include needed local actions, contingencies, and its proper connection to plant equipment, access to the site, off-site actions, multi-unit events, emergency lighting, etc., and the time needed for these actions.

Guidance should be provided for maintenance and periodic testing to assure proper functioning.

- Has it been verified that the procedures/guidelines represent technically correct interpretations of the high level strategies and are capable of achieving their objectives?
- Has it been verified that the instructions are written correctly, i.e., they accurately reflect the plant-specific writer's guide?
- Do the set points and the guidance as defined reflect the current plant configuration, and are they in line with systems capabilities and design limits?
- Were the guidelines and the selected level of detail tested in drills and exercises, and feedback provided to the staff that is developing the guidelines?
- Did the scenarios chosen for use in the validation cover a wide range of the procedures/ guidelines?
- Has the validation demonstrated that the instruction (procedures and guidelines are useable, i.e. they can be understood and followed without confusion, delays, errors, etc.?
- Did the validation test the organizational aspects of severe accident management, especially the roles of the evaluators and decision makers?
- Did the validation address the communications between the different teams involved?
- Was an appropriate simulation method chosen for validation (simulators, computer simulation, table top exercise, etc.)?
- Was validation assessment conducted to confirm that operator actions are possible, accounting for variables such as ease of access, possible radiation fields, presence of debris, fires or flooding, and staff complement?
    - Have the accident management procedures been tested under conditions that realistically simulate the conditions present during an emergency, including simulations of performance of other response actions, hazardous work conditions, time constraints and stress?
- Were the plant response simulation results critical to preventive or mitigative measures verified or confirmed by alternative means (e.g., other qualified computational tools or more detail calculations and experimental data)?
- Were resolutions to the critical severe accident issues such as steam explosion and hydrogen burn in containment supported by R&D or more detail calculations?
- Was the plant specific input used in the verification of procedures and guides (for example pre-analysis of accident scenarios)?
- Were the lessons learned from validation fed-back into the procedures and guidelines?
- Were the results and conclusions of the validation documented?
- Has been assured that the staff involved in the validation of the procedures and guidelines should be different from those who developed the procedures and guidelines?
- Were the plant specific procedures and guidelines fully and independently reviewed, in accordance with the applicable QA programme, during their development?
- Has there been an independent external review?

4.6.1 Review of simulator validation

The regulatory review shall evaluate whether a proper verification and validation of the simulator was performed to assure reliability simulator application for accident management training and for validation of EOPs and when applicable for evaluation SAMGs. The licensee shall provide access to documents that demonstrate that simulator verification testing was performed as a part of the initial structured design of the simulator software, and when changes were made to computer platforms, operating system, interface system, instructor stations and models.

The reviewers may evaluate the simulator validation with following questions in mind:

- Has the simulator validation been performed and there no noticeable difference exist between the simulator control room and simulated systems when evaluated against control room and systems of the reference unit?
- Was the validation performed and results are evaluated against actual or predicted reference nuclear power plant data? (Examples of simulator design data that serve to validate a simulator's performance are transient data, best estimate transient data, operating procedures, Safety Analysis Report, observed operations and startup tests) The licensee shall provide access to documents that demonstrate that simulator validation testing was performed at completion of the simulator construction, when models were changed or modified, and when changes were made to computer platforms, operating system, interface system, or instructor stations.

Control room simulators are usually not validated for beyond design basis accidents, and great care is required in their use for the training of operating personnel in beyond design basis accidents. The simulators could be used in exercises for initial accident classification and decision making. Consideration should be given to using workstations and other advanced computer applications to simulate accident evolutions after core damage has occurred.

4.6 Review of the maintenance programme for accident management procedures and guidelines

The regulatory review shall determine whether the licensee has established a accident management maintenance process. The need of the accident management programme update should be assessed as new information becomes available which may indicate potential for new accident scenarios, phenomena or challenges to physical barriers or any other significant effect on accident management that had not been fully considered previously. The reviewers will have to evaluate this process developed by the plant to guarantee that the impact of any significant modification is correctly addressed in the accident management procedures and guidelines, and training documents.

The review may include questions such as:

- Is there a formal process for making changes when such changes are deemed necessary (the effect of any changes in the plant design including the available portable equipment or the operating organization on the accident management programme should be evaluated) ?
- Does the process consider that the accident management actions may be affected through new insights from research on accident phenomena or industry operating experience including lessons from events?
    - When new information is received that challenges the basis of current design assumptions, does the maintenance process include evaluation of the capability of installed equipment and accident management procedures and guidelines to determine if safety functions could be compromised? Based on this evaluation, measures for updating the accident management programme commensurate with the impact should be identified.
- Does the maintenance programme address new information that has been derived from drills, exercises, training programs, safety analyses, etc?
- Are in the accident management reviews at least the following changes considered?
    - In the control room: Specific displays defined for continuous monitoring, installation of new/improved instrumentation, using labels in the control room to identify the qualified instrumentation which can be used during an accident;
    - In the operating documentation: Effect of the interface with normal and AOPs, required modification of the alarm sheets that address orientation into an EOP, addressing specific requirements in limits and conditions/ technical specifications to ensure required instrumentation availability;

- In other plant documents: The emergency plan and the procedures for the groups in emergency response as the TSC and/or the radiological group;
- In the plant systems: Modifications to allow timely operation of equipment used in the strategies (e.g. exchange of locally operated valves for control room operated valves).

For a multi-unit plant, differences between the units should be addressed and the review team should verify how these differences have been considered in the development of the accident management procedures and guidelines.

4.7 Review of the accident management programme documentation

The documentation that supplements the plant specific EOPs and provides justification for the EOP development programme can be divided into two groups, the technical documents and the administrative documents. There is no fixed requirement as to what type of documents should be available. It is up to the nuclear power plant to decide which specific documents will be added for the review, for licensing or QA purposes or any other reasons. The agreement on which documents shall be used for the regulatory review must me reached in the first phase of the review project. The technical documents usually contain the EOPs, the technical basis documentation, some additional reference documents and other general documents that might be relevant to the development and implementation of EOPs. The Administrative documents may include EOP writing guides, user guides, verification and validation guides, licensing requirements and QA requirements.

4.7.1 Technical Documents

a) EOPs:

The review shall determine whether:

- A self-sufficient full set of documents providing the EOP instructions exists and is available in the control room. These instructions can be either computerized or in paper form. The EOPs shall contain all the information necessary for the operator to do his job. Not only do they need to contain the instructions themselves, but also all the diagnostic tools, the monitoring tools as well as the administrative and technical notes and/or warnings. The information can be in different formats: text, charts, flow diagrams, figures, tables of values, etc.

b) The technical basis and background documents

The review shall determine whether:

- The available documents provide a detailed explanation of the overall organization, purpose and structure of every procedure and its links with other procedures;
- They provide details on each action, instruction and element of each procedure, including:
  - the technical basis for each element of the EOP package (the availability of this information is mandatory when developing EOP training materials)
  - the history and reason of each element for every EOP procedure (during procedure revision these documents provide the required information to evaluate whether a particular element can be modified and, if so, how it should be modified)
- Included are the analyses performed during EOP development of the proposed strategies and actions (for optimization and validation the operating strategies before transcribing them into specific operator instructions) including:
  - Specific EOP analysis reports (thermal-hydraulic, structural mechanics, experiment reports, etc.);

- Set points calculation report;
- Final EOP validation report;
- Description of generic principles used for the development of the EOPs. Also, during the documentation and implementation phase additional representative analyses may be incorporated to augment staff and operator training. These best estimate analyses include operator actions, as they are required in the EOPs.

c) Additional reference documents.

The review shall determine whether other documents generated during or supporting the development of EOPs and of their technical basis are available. These documents may include:

- The safety analysis report
- Limits and conditions/technical specifications
- Detailed system descriptions
- Operating procedures;
- Equipment specifications and operating manuals
- Sensitivity studies on various approaches
- Review of applicability (and its limits) of the reference system to the plant, if used.

d) Other general documents that are relevant to EOP development and implementation

The review shall determine whether other general documents supporting the development of the EOPs especially related to scientific basis, operational experience, regulations, etc. are available:

- Literature (scientific articles, technical reports, conference proceedings,
- Official guideline documents (IAEA guides, World Association of Nuclear Operators (WANO) reports, Institute of Nuclear Power Operations (INPO) reports, etc.);
- Legislative documents (regulatory requirements, legal provisions, etc.).

4.7.2 Administrative documents

The review shall determine whether a logical and comprehensive process was applied to the development of EOPs and whether this process including the rules and requirements is properly prepared and documented. Specifically the review shall determine whether

- A plant specific EOP writer's guide was prepared that provides the rules to assure the consistency from procedure to procedure and within the individual procedures themselves (Such rules are necessary because the procedures are a structured document which contains looping of steps, procedural transitions, conditional requirements, etc);
  - Consistency between the intentions of the procedure writers and the understanding of the procedure users is ensured by clearly defining all potentially ambiguous structures and through the adoption of a limited mandatory vocabulary (action verbs) with the goal of reducing the probability of operator misunderstandings and/ or errors;
  - The rules shall include but are not limited to:
    - Defining the procedure format as a whole,
    - Defining a limited set of action verbs that will be used consistently throughout the procedures,
    - Formatting of condition statements;
    - Structuring of steps,
    - Transfer between columns in a two column format,
    - Looping;
    - Rules for links within and between procedures;
    - Creation of links to reference documents and set points database;

        - Use of graphic symbols, tools, tables and diagrams,
        - Indication of strategies,
        - Indication of communication points for team coordination,
        - Definitions of principal terms and abbreviations used in EOPs.
    - The writer's guide defines the general philosophy regarding how much detail should be provided in the procedures.

      In general, whatever is obvious should not be expounded upon in the procedures (for instance the location of the reactor trip control). Conversely, items that are not normally operated or are being used for out of the ordinary actions should be detailed in the procedure. For example, sufficient detail should be provided in the procedure for a seldom used valve so that no time is lost while an operator refers to a plant drawing or a system description for information. Operator guidance is not only required in the control room EOPs but also for local actions by the field operators. The writer's guide must be consistent with the user's guide. The writer's guide can also define the QA process to be followed for the development and validation of the EOPs.

- A plant specific EOP user's guide is available that establishes the rules on how to use the procedures that were written according to the writer's guide. Because the user's guide is written mainly for the operators it also defines rules on how to use the EOP package as a whole. The rules shall include at minimum:
    - Entry conditions,
    - Distribution of roles between control room personnel,
    - Communication protocol in the control room,
    - Priority rules for transitions between and within the scenario dependent and scenario independent parts of the EOP package,
    - Progression rule through the procedures,
    - Evaluation of CSF status trees/safety function status (when necessary for priority management);
- There is a plant specific EOP verification guide and EOP verification report which includes the verification criteria, documentation of findings, resolution of findings, etc.;
- There is plant specific EOP validation guide and final EOP validation report which establishes all the administrative rules for validation and documents the findings and resolution of findings;
- A document addressing the fulfillment of licensing requirements demonstrating compliance with a number of administrative and/or technical rules;

The regulatory review shall determine whether appropriate documentation of and for the SAMGs was prepared and whether it contains:

- Goals and principles used for development and implementation of the SAM program and provisions;
- Results of probabilistic, analytical, and design studies conducted in support of SAM;
- Results of assessments of the efficiency of preventive and mitigating actions;
- Documented plant modifications and associated changes to SAMGs
- SAM guidelines and procedures;
- Performance capabilities for the systems and equipment that can be used in support of SAM procedures;
- Information requirements for effective accident management;
- Responsibilities of persons and organizations involved in SAM;
- Requirements for personnel training; and
- Results of SAM validation and reviews.

Also it needs to be determined whether hardcopy backups for the procedures, guidelines and supporting background documentation stored in electronic form, are available in all evaluation and decision making locations, such as main control room, supplementary control room and technical support centre, so that they can be used when necessary.

4.8 Review of training and qualification programmes in support of accident management

The objective of the review of the training and qualification programme is to evaluate whether appropriate levels of training were provided to the operating personnel and responsible organizations that ensure their competency in using all procedures, instructions and actions specified for accident management.

The review shall identify whether a comprehensive training programme for accident management has been prepared and implemented and whether this training programme includes a combination of education (classroom training), exercises and drills, supported by appropriate means, such as desktop training or adequate simulation tools.

Personnel responsible for performing accident management duties should be trained to acquire the required knowledge, skills, and proficiency to execute their roles.

The review may address questions such as:

- Was the training programme developed using a systematic approach: Were the training needs and objectives clearly specified early in the accident management programme development and was the training programme established and deployed before the accident management programme was implemented?
- Is the training programme comprehensive and realistic consisting of classroom activities and use of simulators? Plant accident management using EOPs should be practiced in the simulator, to provide operating personnel with the necessary knowledge and skills to demonstrate competent emergency actions.
- Has the training been established and implemented for each on-site group and off-site group involved in accident management? Has the licensee established the roles and responsibilities of the following participants:
    - Control room operators;
    - Field personnel;
    - Shift supervisors and shift managers;
    - Station emergency response groups;
    - Station management;
    - Advisory and supporting groups; and
    - Corporate utility emergency centre personnel.
- Is the training commensurate with the tasks and responsibilities of the participants, taking into account appropriate technical level needed for each group, to enable them to
    - understand their roles and responsibilities within the AMP,
    - learn about accident phenomena and processes ,
    - become familiar with the activities to be carried out ,
    - enhance their ability to perform in stressful conditions,
    - verify the effectiveness and improve the clarity of procedures and guidelines?
- The decision makers were trained for understanding the consequences and uncertainties inherent in their decisions; the implementers should ensure that they understand the actions that they may be asked to take; and the evaluators should ensure that they understand the technical basis upon which they will base their recommendations.
- Does the training provide for understanding of the conceptual basis and terminology and

structure of the EOPs and SAMGs and the personnel own roles and responsibilities in the implementation of the accident management procedures and guidelines and does it enable the operators to acquire the knowledge, skills and proficiency to execute their roles and to use EOPs when required to bring the plant to safe and stable conditions?

- Are the operators aware of and trained in fundamental physical concepts and are able to apply this knowledge to the AM?
- Is the training programme, including periodic exercises and drills, sufficiently realistic and challenging to prepare personnel responsible for accident management duties to cope with and respond to situations expected to occur during an event, including accidents occurring simultaneously on more than one unit, from different reactor operating states and in the spent fuel pool?
- Does the training include insights in industry experience, guidance on AM philosophy, usage, technical bases and on all procedures contained in the EOP set?
- Has been exercise guidance prepared for simulator training?
- Does the training and exercises include events occurring simultaneously in multiple units?
- Are the operators trained in plant equipment or configuration changes that affect AM? (This training can be either classroom based or simulator based, depending on the scope of the change)
- Is a specific in depth training in AM provided to overcome the degradation of operating personnel's performance that can occur in stressful situations?
- Has been a training refresher programme developed and implemented? Emphasis should be placed on exercising procedures dealing with the most probable and complex accidents.
- Is there a mechanism in place allowing the operators to provide feedback to the AM development based on experience with simulator training? Involvement of operators and other operating personnel in the development of the EOPs in the framework of reviews, EOP verification, etc., provides valuable initial training as well as feedback to the development team.
- Are unconventional line-ups of the plant equipment, use of portable equipment (such as diesels or pumps) as well as repair of the equipment considered in the training?
- Does the training material address implementation of strategies under adverse environmental conditions, including those resulting from external hazards, under potentially high radiation situations and under influence of stress on the anticipated human behavior?
- Are the drills design so that they extend over a time period long enough not to unacceptably distort plant response, and allow to test transmission of information during shift changes?
- Were special drills/exercises developed to practice operating shifts and TSC staff changeover and information transfer between different teams?
- Do the accident management exercises and drills periodically challenge responders by making unavailable information sources (such as the safety parameter display system), equipment, and facilities that potentially could be damaged in the accident?
- Are there drills implemented that purposely include sources of inaccurate or miscommunicated information to personnel and can be used as a way to exercise their questioning attitude, teamwork, and diagnostic skills? However, caution should be used so that misinformation does not contribute to negative training.
- Are the exercises and drills based on scenarios that require application of a substantial portion of the overall accident management programme in concert with emergency response and in realistic conditions characteristic of those that would be encountered in a severe accident? Large scale exercises providing an opportunity to observe and evaluate all aspects of accident management should be undertaken.
- Do some scenarios used for exercises and drills include the core damage domain with failure of reactor pressure boundary (RPV, pressure tubes) and containment?
- Were the training materials developed by subject matter experts and qualified trainers?

Experts could assist in answering questions that are beyond the capability of professional trainers, and operation of field/local equipment, operation under adverse condition, including operation of portable equipment.

- Was the initial training as well as refresher training developed for all groups involved in accident management?
- Was the frequency of refresher training established based on the difficulty and importance of accident management tasks and a maximum interval for refresher training defined?
- Was replacement staff was trained appropriately?
- Are mechanisms in place for systematic evaluation of results from exercises and drills to feedback into the training programme and, if applicable, into the procedures and guidelines as well as into organizational aspects of accident management?
- Are criteria for evaluating the effectiveness of a drill or an exercise are established? Such criteria should characterize the ability of the team participating in the drill or exercise to understand and follow the evolution of plant status, to reach sound decisions including in case of unanticipated events and initiate well-founded actions, meet job performance criteria and drill objectives.

Specifically for or severe accident management it necessary to ensure that the SAMGs user team is appropriately constituted and qualified to perform accident management functions under severe accident conditions. The training review may address

- Has it been shown that the staff can perform their assigned accident management functions under the conditions anticipate during an emergency (stress, time, heat, radiation, live steam, lifting, climbing, etc.)?
- Has it been shown that there will be sufficient equipped staff available to perform the accident management functions in time during an emergency?
- Have possible conflicts with other response functions (e.g. search and rescue, security, firefighting) been considered and resolved?
- Have provisions been made to effectively utilize the emergency services (e.g. fire fighting) available from off-site to include providing them with prompt access to the site, appropriated training and radiation protection?
- Has a review of the capabilities of the technical support centre (TSC) (or that part of the organization responsible for SAMGs) been performed to ensure that it is appropriately staffed and that staff have the appropriate qualifications?
- Have the functions inside the emergency arrangements organization been properly described?
- Do the decision maker and other people involved in the decision possess adequate technical knowledge of severe accident phenomena and accident management?

The review shall verify that the training programme is documented, and detailed training records are held.

5. DOCUMENTATION OF THE REVIEW RESULTS

The review of the accident management programme and its implementation (EOPs and SAMGs) needs to be thoroughly documented. It is recommended that the regulatory review team initiate the report during the review process and does not wait till the final stage of the evaluation. Particularly sections on the objectives and scope of the review need to be prepared early on.

During the course of the review each team member writes technical notes describing the situation in each of the review areas. These notes contain experts' observations, including any recommendations and suggestions. Good practices or good performances are reflected as well. Technical notes form the basis for a draft review report.

After completion of the review the team leader prepares the final review report based on the draft report. This is a record which summarizes the team's main observations and conclusions including all recommendation and suggestions. Before the text is finalized the licensee is given the opportunity to comment.

The review report should contain specific findings, as well as conclusions, supported by several related findings. Recommendations shall be made to the licensee to address any potential shortcomings in a way meeting the regulatory expectations.

Review findings, in general, are defined as results of the evaluation of the objective evidence found during the regulatory activity against relevant criteria. A finding can indicate either conformity or non-conformity with the criteria, based on consensus of the review team, rather than individual, assessments.

The complete set of findings of the accident management programme will allow developing a statement on how well the reviewed accident management program has been developed and implemented at the NPP, in terms of meeting the identified review criteria. The review team may recommend that the licensee provide further information on specific topics or issues, or undertake additional actions/activities to address potential shortcomings in the accident management programme.

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