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Severe Accident Management Systems and Procedures

A nuclear power plant's safe operation involves the planning for non-standard operational emergencies, where pre-determined safety measures and damage control interventions must be taken into consideration depending on the developed event. The definition of the severe accident management cannot be explained in a single concept, it needs to be examined in detail. As a result of this it becomes necessary to specify the procedure guidelines appropriate to the nature of the event, which can be used with optimal efficiency under hierarchical organisational control. The experience of nuclear accidents in the world and the precognition of future events, the knowledge of existing guidelines for severe accident management needs to be deepened continuously, but at the same time it can be parallelly upgraded with the application of new technologies.

Keywords: nuclear power plant, reactor, severe accident, extreme circumstances, safety basis

1. Introduction

The safety policy of Nuclear Power Plants (NPP) fulfils the highest level of safety planning, with the development of protection systems and procedures that include mobile solutions in addition to multi-level redundant systems to minimise damage to human life, property and the environment, furthermore reduce the irreversible damage that has occurred. The Nuclear Emergency Response Organization (NERO) of NPPs has trained personnel and equipment capable of performing its task in all possible emergencies.

Following the serious accident at the Fukushima Dai-ichi NPP, the world's safety councils came to the conclusion that a targeted safety review is needed in the light of what has happened. The European Union Council has asked the European Nuclear Safety Regulators Group (ENSREG) and the European Commission to redefine the

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contents and methods of comprehensive risk and safety procedures in the framework of the so-called 'stress test' for NPPs in the Union.[2]

2. The serious accident concepts

The state-dependent operator's procedure instructions of the NPP, which are important for system management, have been developed primarily to avoid zone damage. If these interventions are unsuccessful, the system instructions can no longer be effectively applied to actual or former zone damage accidents, as they do not include operations designed to maintain the integrity of the physical barriers in order to be able to fulfil their basic purpose of preventing the release of radioactive materials. As soon as significant fuel-cover damage and zone geometry loss occurs, maintaining a stable state of the hermetic space becomes a primary goal, thereby emissions can still be controlled. In light of this, in some major accident situations, preserving the safety of the hermetic space or preventing the escape of fission products may take precedence over zone cooling. In a case like this, it is necessary to perform the pre-designed operations specified for the incident, which are included in the Severe Accident Management (SAM) Guidelines. According to the provisions of the Nuclear Safety Standards (NSS), a serious accident is:

'An accident condition with significant damage to the reactor zone, associated with zone melting, with more severe external effects than design- and post-design basis failures.'[3]

In case of well-planned and detailed nuclear facilities built on the basis of safety experience, major accidents are most likely to be caused by events for which sufficient information was not available at the time of design. In these special cases, faulty processes lead to an event that the NPP's security systems cannot deal with and can lead to a possible zone melting.[4]

3. Managing severe accidents

The management of serious accidents is a complex, special task the management and objective implementation of which is performed by a predetermined structural organisation temporarily formed to deal with the situation. In the event of a major disruption, the organisation must be formed and operate according to the pre-defined operational management structure until the situation requires the application of the

[2] National Report, *Targeted safety review of the Paks Nulcear Power Plant* (Budapest: National Atomic Energy Agency, 2011), 6–7.

[3] 118/2011. (VII. 11.) Korm. rendelet a nukleáris létesítmények nukleáris biztonsági követelményeiről és az ezzel összefüggő hatósági tevékenységről [Government Decree 118/2011 (VII.11.) on the nuclear safety requirements of nuclear facilities and on related regulatory activities], Appendix 10, Nuclear Safety Regulation Definitions, 145.

[4] Severe Accident Management Guidelines, *Atomerőművi reaktor és primerköri rendszerek operátori üzemeltetése* [Operation of nuclear power plant reactors and primary circuit systems] (MVM Paksi Atomerőmű Zrt, Verziószám: 2.0, 2013), 5; International Atomic Energy Agency, *Severe Accident Management.*

SAM Guidelines or a stable operating condition is established. If necessary, the managing organisation coordinates the work from a protected base of operations, from which it has a continuous view on the status of the events and the performed tasks. The mission of the management organisation and their sequence are an integrated part of the SAM guidelines, which are implementation instructions fitted in a specific hierarchical regulatory system.

The performance of the SAM assignment is based on the development of situation-specific procedures supported by preliminary survey and praxis to prove that if the organisation in charge performs the tasks according to the SAM guidelines, it will result in an appropriate outcome. This also includes the need to keep any mobile device listed in the regulations with proper maintenance ready for operation. There is a need to build up a sufficient quantity and quality of backup of the existing equipment, such as measuring instruments, communication and IT equipment. In addition, an increased number of participants in the intervention must be ensured.

A consequence of serious accident treatment is that besides properly informing the plant's operational personnel, it is also a basic requirement to inform the surrounding population. The safety of people, who must be evacuated or are confined within the operating area has to be guaranteed, regardless of how many units of the plant are involved in the emergency. According to the SAM guidelines, the evacuation should be finished even before the harmful release.

Important aspects of severe accident management measures in the event of zone cooling function loss:[5]

- Function loss assessment to initiate a prioritised action
  - external cooling of the reactor vessel by flooding the reactor shaft
  - feedback of severe accident management measurement systems
  - commissioning of the unique diesel generators for the operation of the SAM equipment
  - severe accident hydrogen treatment with passive autocatalytic recombiners
  - prevention of cooling water loss due to spent fuel pool pipe breakage
- Probability of fuel damage inside the tank and measures to deal with it
- Injury assessment after reactor damage and prevention of base-plate melting
- Maintain containment integrity, developed pressure and hydrogen treatment
- SAM differences and additional tasks on parallel blocks
- Prevention of radioactive releases after containment integrity loss or drying out of fuel stored in the spent fuel pool[6]

[5] Atomerőmű Tűzoltóság, *Primary circuit knowledge*. ATOMIX Kft., Tűzoltási és Kárelhárítási Szakágazat, Szakmai Ismeretek Oktatási anyag, ATOMIX at-me-6.2.2.-1-v2, 2013.

[6] National Report, *Targeted safety review,* 87–103; MVM Paksi Atomerőmű Zrt., *Átfogó Veszélyhelyzet-kezelési és Intézkedési Terv.* I. modul: Általános kötet [Comprehensive Emergency Management and Action Plan. Modul I: General Volume], Verziószám: 9.3, 2016, 28.

4. Sources of danger at an NPP site

In the aspect of NPPs, it cannot be said that the entire establishment is a source of nuclear danger, but it has systems and system-components that are sources of radioactive material and so they require high safety measures. In the following list, there are the main nuclear hazards of NPPs, the safety of which requires the presence of an accurate design criterion.

- Reactors: escape prevention of fissures from the reactor during heat dissipation of radioactive decay
- Spent fuel pool: cooling of stored irradiated fuels and monitoring of fuel hermeticity
- Systems that contain radioactive material: auxiliary and radioactive waste management systems located outside the hermetic space which are required for the main operation
- Spent fuel transport within the site of an NPP: irradiated fuel element transport between blocks or to the Spent Fuel Temporary Storage Facility – safety of material handling and transport route during transportation
- Hazardous radiation sources: the utilisation and storing of instruments using radiating cells applied in technological processes
- Hazardous substances that can cause a major accident: the quantity and properties of hazardous materials used for the technology in the NPP and the application of the rules both for the safe storage and handling of the materials[7]

5. Prevention and accident management

Accident management aims to prevent damage and core melting by all possible methods which can reduce even the occurrence of major accidents beyond planning. The relationships between preventive and consequence mitigation measures can be summarised in the table below.

Table 1

Accident management

Source: Severe Accident Management Guidelines, 6.

Event	**Within design basis**	**Beyond design basis**	
Goal	Zone-melting prohibition, activity retention in hermetic space		Reducing the consequences of zone-melting
Systems	Application of operational and safety systems within design limits	Usage of all available systems within their design performance values	
Form of accident management	Prevention		Consequence reduction
Instruction/ manual	Optimal recovery instructions	Function restoration instructions	Severe accident manuals

[7] MVM Paksi Atomerőmű Zrt., *Átfogó Veszélyhelyzet-kezelési és Intézkedési Terv.* I. modul: Általános kötet [Comprehensive Emergency Management and Action Plan. Modul I: General Volume], Verziószám: 9.3, 2016, 14.

During accident management, the prevention and consequence-reducing requirements are separated depending on how far the design bases extend; however, severe accident management also has operational parts that can be found in one of the prevention-related operating instructions. It can also be seen that some incident management is possible beyond the design basis according to the guidelines until the situation reaches significant damage or zone melting, from which point the tasks, which are specially designed to reduce and deal with consequences of the serious accident, are required.

Primary consequence reduction to be implemented during severe accident management:

- Restoring a controlled and stable Zone
- Restoring and maintaining a controlled and stable Hermetic space
- Avoid damage to the reactor vessel at high pressure
- Reduction or elimination of radioactive release

Operating manual procedures assume that zone damage can be prevented by performing the tasks contained in it, and therefore includes recurring task sets for zone damages that cannot be fully performed until the zone is restored or stabilised. Consequently, the forecasts of the expected effectiveness of interventions will no longer be applicable. Operator instructions focus tightly on avoiding zone damage by performing operations that are also able to prevent fission material escaping from the hermetic space. At the same time, for each task in the instructions, the risk of the event must be recognised, so the possibility of zone damage must be assessed depending on the effectiveness of the preventive tasks already performed. It should be noted that by using the tasks of the manuals, zone damage can be successfully prevented in the majority of the analysed cases. In recognition of predictable failure of the preventive measures, the change to the SAM procedures should begin in parallel with the suspension of the tasks set out in the prevention manual. After that, it is no longer possible to return to the procedures of the operational treatment assignments, as the SAM guidelines are implemented as fully self-contained, separate complex units, covering all areas needed to prevent an accident and stabilise the zone.[8]

6. Severe accident management manuals

The complex accident management procedures for critical damage and zone-melting are containing guidelines unlike the mandatory actions of the sorted preventive procedures. That is the reason why during the specific steps of the manual, the entire accident management process must be interpreted and analysed and, depending on its current state, a decision must be made to implement the steps of the comprehensive processes to properly manage the accident situation. During the processes, the primary importance is to preserve the integrity of the hermetic space and prevent the escape of fission products, even against the implementation of zone cooling, because

8 Severe Accident Management Guidelines, 6–7.

at this point the condition of the blocks is beyond the original safety levels that are included in the design bases. The SAM Guidelines are built of several separate sections that include parallel procedures and enforcement steps for each involved technician crew. To justify and support decisions, it is necessary to track them continuously, for which the so-called Diagnostic Flowchart of the systems and the event-formed Accident Status Tree can provide the necessary supporting information. These are accompanied by the instructions for the professional crew that is involved in the accident management. A support centre with professional staff should be set up to analyse the data and make the decisions. In the diagnostic flowchart, all the aspects of the serious accident must be taken into account that endanger the integrity of the physical barriers and the prevention of the release of radioactive materials.

Diagnostic flowchart parameters:

- Reactor condition and primary circuit pressure
- Hermetic space water supply and flooding parameters of the reactor shaft based on the water level
- Supply to the main water circuit system based on zone temperature
- Radioactive release reducing procedures
- Steam generator supply based on water level and inner pressure
- Condition control of the hermetic space depending on its pressure
- Hydrogen reduction inside the annulus
- Level and stability of the spent fuel pool

Based on the results of the performed implementations of the parameters, the increase or decrease of the zone stability can be determined. The condition assessment includes the actual water levels, pressures, radiation levels and information about the open state of the reactor. The results of the flowchart can be used to determine whether there is a major, direct danger parameter that can be classified into the Severe Accident Status Tree model and inheres the need to implement guidelines for the immediate emergency. According to this, the reduction of radioactive material release, decreasing pressure in hermetic space, evaluation of hydrogen control (autocatalytic hydrogen burning via recombiners) and the related appropriate procedures are performed. The Diagnostic Flowchart and Severe Accident Status Tree assessment should be monitored and evaluated in parallel, prioritising the necessary implementation of the status tree guidelines either to achieve or to maintain a stable state.[9]

7. Severe accident management systems

7.1. Accident situations related to the cooling water

To run the technology by the operating nuclear units, the feed-water system implements continuous refrigerant supply. In the case of a malfunction of the service

[9] Severe Accident Management Guidelines, 9–16; Atomerőmű Tűzoltóság, *Primary circuit knowledge.*

feed-water system, its role is taken over by the emergency water-supply system. Their power supply is provided by diesel generators even by the loss of normal power supply. In accordance with the multi-level protection design used in the NPP, the feed-water system was built from such a safety point of view that it was designed for the possible failure of the supply and emergency feed-water system. Therefore, in accordance with the parameters of the emergency water-supply system, an additional emergency water-supply system has been built to ensure the feed of water to the steam generators.

7.2. Reactor shaft flooding

Due the technical design, it is possible to cool the reactor vessel externally so that the melted material is kept inside the tank preserving the structural integrity of the reactor vessel, thereby preventing the reaction of the concrete and the corium. The system provides an adequate amount of water for the hermetic space and the reactor's concrete shaft where it maintains sufficient cooling for the reactor vessel's external surface. In this case, by the conservative assumption the Zone emergency cooling systems are also out of order.

7.3. Combustion of hydrogen accumulated in the hermetic space

According to the analysed processes, during the zone melting, a significant amount of hydrogen is evolved from the reaction of the concrete and the corium, which threatens with an explosion, endangering the hermetic space integrity. To ward this off, passive hydrogen recombiners have been installed to provide catalytic combustion of hydrogen accumulated in the hermetic space.

7.4. Spent fuel pool water depleting and preventing the failure cooling circuit

A special procedure elaboration has become necessary to prevent an accident of the spent fuel pool's cooling failure and due to the damage of the used fuel rods. It has been identified that the damage of the non-excluded parts of the spent fuel pool's pipelines can result a loss in the refrigerant, which can lead to a spent fuel injury without the adequate alternate cooling water.

7.5. External refrigeration supply

The nuclear power plant's heat absorption safety function maintenance systems were designed to monitor and prevent the cessation of heat dissipation. During the external refrigerant supply, alternative water sources are exploited, from which the amount of cooling water can be provided by mobile devices through the constructional connection points to the steam generators.

The management of an extraordinary event is based on the fact that the power plant's safety heat absorbing systems cannot provide heat dissipation, so an alternative supply is required. That is implemented through a connection point on the pre-determined supply line to achieve long-term heat dissipation indirectly through the steam generators.

For the supply of external refrigerant, it is important to determine the primary water extraction point, because it must be selected depending on which installation's connection point the equipment is connected to and operated by. Relevant aspects of consideration are distance, accessibility, water quality and quantity. The experts of the response team need to have exact information within critical time to begin the preparation of the feed and the building of the mobile supply system on the pre-determined route. The dismantling of the pumps and the hose system takes time, and by an event of a factual nuclear emergency, relocating it to another water source would take much longer than the first installation of the system.

7.6. Power supply accident situations

7.6.1. Assumed electrical failures in a severe accident situation

- Complete voltage loss
- Power sources for emergency power-supply systems become inoperable (both diesel generators and battery packs)
- Lack of external electrical network supply

7.6.2. Independent power supply

Safety systems must have an alternative power source beyond the normal operating intake that can maintain the following systems:

- The electrical fittings for reactor shaft flooding
- Operation of the severe accidents' measurement systems
- Operation of the volume compensator safety and pressure relief valves to avoid zone melting
- Power intake of the Spent fuel pool's drain protection fittings

7.6.3. Elements of the SAM's independent power supply system

- Mobile diesel generator:
  - Power support: one mobile diesel aggregator applied to a trailer for each installation

  - Output: 96 kW
  - Maximum operational time: 40 hours (≈ 900 l fuel)
  - Connection to the electricity network: box constructed outdoor connection
  - Firefighters deliver the diesel aggregators to the chosen point
  - Operation and connectivity: performed by maintenance and electrician specialists
- Outdoor electrical connectors
- Network switch cabinets and the associated connecting cable network
- Uninterruptible power supply for the accident measurement system[10]

8. Extraordinary circumstances causing and affecting a serious accident

8.1. Earthquake

The installation of an NPP follows the industrial custom practice of the given age. During the technical design, the establishment sites were classified on the basis of the current seismological and geological characteristics of the last decades. With today's technological solutions, there are more options for site inspections and the recorded history also helps the qualification. As a result of the test, the expected value of the maximum free-surface horizontal and vertical acceleration force during a possible earthquake is determined, taking into account the vibration transmission of the loose sediment layer covering the surface. The analysis is supplemented by the examination of possible soil liquification, which is the permanent displacement on the surface. The creation of a geological-structural model contains geological, geomechanical, geophysical, tectonic, stratigraphic, hydrogeological, evolutionary and zone divided seismological studies. In case of some particular earthquakes, the tasks of plant operators must be regulated by special preventive emergency instructions. The nuclear power plant is able to withstand seismic activity that does not reach the level of the so-called safety earthquake, which means a level of the planned earthquake that does not exceed a tolerated amount by the units, without significant radioactive release. However, additional damage, fires and other failures may occur in unconfirmed parts or service areas. Indirect effects due to earthquakes may also occur, which do not directly cause the failure in system components that ensure nuclear safety, but it can happen, that other parts of the installation are damaged, which may affect the parts that perform effective safety functions. The possibility of additional refrigerant or electrical supply loss due to an earthquake should be considered by the SAM Guidelines and in every case there must be an alternative source of mobile intake that can guarantee nuclear safety.[11]

[10] Severe Accident Management Systems, *Operation of the primary circuit systems.* MVM Paksi Atomerőmű Zrt., Verziószám: 1.0, 2018.

[11] National Report, *Targeted safety review,* 34–52.

8.2. Flooding, external overflow

Flood protection is the process of the weather, where the properties of the water area and the factors influencing them can be considered parts of the whole, which can be broken down into protection levels. The flooding protective structures established on hazardous water sections are preventive interventions that are designed to be sufficient to protect the specific areas close to water. This is complemented by procedures that provide additional temporary defence walls and mobile response. The location, length and height of the defending structures, as well as their structural properties, are established depending on the water ditch, floodplain and water movements.

Flood protection does not end with the presence of defence. Continuous inspection and control is required depending on the actual level of flood protection. When the flooding water reaches a specified water level on the watercourse meter, flood protection preparedness takes effect, which lasts until this water height is reduced to a safe level and the restoration work of any damaged primary defensive structure is completed. In the event of a flood, rivers leave their riverbed, which can threaten with the inundation of potentially useful areas. Therefore, these useful areas must be artificially separated from the specified water areas and such special designs must be done that further interventions can be taken if necessary, to strengthen the defence. The primary defence-structures should be upgraded, if necessary, with procedures to be applied depending on the current situation. The availability of mobile resources and an adequate size of operational staff is essential to execute an effective defensive implementation. In addition to this, the field experts should take appropriate preventive action so that the defence walls do not weaken the existing primary or pre-built defensive constructions. Reducing the faster course of a flood, dividing it, reducing the amount of water that flows away, or applying a reduction in the area at risk of flooding are the ways in which flood management can intervene effectively. One of the methods based on the area reduction includes the application of protective embankments on the coastline at variable distances. The mobile equipment of the exemption requires the accumulation of adequate quantities and the regularisation of such transport vehicles that are suitable both for carrying and for use in the appropriate terrain.[12]

8.3. Extraordinary weather situations

Extreme weather conditions affecting nuclear safety under the NSS may be the following:

- Powerful wind blasts
- Extreme amount of rainfall

[12] National Report, *Targeted safety review,* 53–56; J Nagy, *Az árvízvédekezés folyamata, feladatai az MVM Paksi Atomerőmű üzemi területén* [The process and tasks of flood protection in the operating area of MVM Paks Nuclear Power Plant] (Oktatási jegyzet [Teaching material], 2019).

- Accumulated ice and snow barriers
- Lightning
- Extreme high/low temperature
- Drought

Drought, as an extremely persistent dryness, affects the NPP through a critical reduction in the primary refrigerant source. The design basis of an NPP shall include each category of event and its effects for nuclear safety and we have to calculate with them in terms of their frequency and magnitude. However, low frequency does not mean that the effects of a certain event can be ignored. In order to make a meaningful reference to design basis, it is necessary to have information about the local natural hazards together with vulnerability data, given effects relevant to load specifications and associated occurrence frequencies.

To define the occurrence and extent of extreme weather events, that are usually estimated by the internationally accepted Gumble approximation, mainly because extreme weather observation consists only of the data collection of limited duration, which results in a pattern loaded with uncertainties. Based on these 10,000 year-periodical-return time events, the values of the wind blasts, daily precipitation, snow thickness and extreme temperatures are determined.

The effect of the persistently low water level of the cooling water supply source must also be taken into account even if the NPP is operating with offline units during a drought period as the cooling water shortage or its extreme fluctuations cannot be tolerated permanently in any operating condition.

In case of lightning strikes, a different method should be used from other meteorological event models, because this phenomenon cannot be described by a single value. Therefore, lightning protection can be justified by compliance with the relevant standards in the design basis. Therefore, the lightning strikes are part of the design basis for safety-class buildings and outdoor technological equipment in an NPP, while the electromagnetic effects of lightning must be taken into account in accordance with the control equipment design basis.

Extreme wind-blows can have an impact on nuclear safety by a disruption of the outdoor power grid cables, and it is necessary to count with additional effects such as the mass of sand and dust stirred up by the wind, which can endanger electrical devices. To avoid this, critical system protection and safety system elements are protected against dust. In case of damage to any classified dust-protection, it is necessary to proceed in accordance with the relevant enforcement instructions.

The important system protection units including the power supply interiors are also air-conditioned. If the cooling of these rooms was left out, significantly high temperatures could develop. The magnetic-switches and circuit breakers in these rooms are able to fulfil their intended function for some time even at elevated temperature, and the battery packs are capable of upholding their discharge capacity. However, this status cannot be maintained for a long time without the failure of electrical systems. But you can prepare for the effects of the extreme high temperature with mobile controllers. Heating the functional areas, which are performing safety roles can also be planned to offset the effects of extreme low temperatures. Attention must be paid to management measures to be implemented for the temperature protection of all critical systems.

For treatment of the effect of extreme quantity and duration rainfall, the design basis must count with an adequate quality and permeability of drainage, based on the site-specific increased rainfall efficiency model, including the identification and emergency measures for critical overflow areas.[13]

9. Losing electrical supply and final heat absorption

For the operation of the safety systems an NPP adequate cooling water is needed, which is provided by electrically powered pumps. So, the two types of security sources are closely connected to each other and the loss of any function of one of the systems cannot cause a loss of security operation on the other side. According to this, the cooling water sources and the transmitting electrical supply pumps can be ensured by establishing several redundant systems.

By the event of an electricity supply loss, it is an important aspect which category of the NPP's consumers must be supplied with electricity and for how long the primary reserves can maintain this. Depending on the power demand, if necessary, power supplies that can maintain electrical replacement properly for longer periods should also be put into operation. To operate alternative sources, planned safety criteria for earthquakes, floods and extraordinary weather must also be calculated with. In addition to the establishment of safety systems, mobile power supplies must be provided as part of the severe-accident prevention strategy so that additional alternative units can be used in the event of the safety power loss of the supply systems.

In case of final heat absorption loss, all heat removal systems from the reactor shall fail, which means that due to the failure and dropout of the redundant safety heat absorption function providing systems, the heat removal performance will be unsatisfactory. Examining the roles of the systems, their operational structure, performance, the resistance of technical barriers as a function depending on the elapsed time, their electrical supply implementation, fuel and lubricant limits, a well-established additional safety procedure is required to achieve the heat subtraction of the reactor in an alternative way as soon as possible. In an extreme case, such as the heat abstraction from the primary circuit and the containment cannot be ensured through the secondary circuit systems, the water supplied from the external source can also be injected into the hermetic space through the special feed-water side purge valves of the secondary circuit steam generator. Safety-critical cooling water and electrical systems include realisations that can independently provide the necessary replenishment on an alternative route without function loss. In addition to these, there are other mobile replenishments that can be found in the SAM guidelines.[14]

[13] National Report, *Targeted safety review,* 57–62.
[14] National Report, *Targeted safety review,* 63–86.

10. Summary

One of the most basic aspects of the efficiency and development in the SAM guideline is the comprehensive knowledge of preparedness and prior professional science. In addition to the technological and safety parameters of NPPs, an accurate knowledge of the existing equipment and the possibilities of intervention in the necessary situation can provide the basis on which nuclear safety can be built. This requires professionals who meet all the mentioned criteria. To meet this standard, the transfer of expertise is needed for the staff involved in remediation at any level. The flow of information in an emergency situation must have a real-time communication channel, the availability and content of which cannot be limited by any external or technical circumstance. This means, that the operating management team and the technological control systems must be in accordance with the current status of information and must use real time communication channels.

The personnel performing tasks under the authority of the organisation responsible for the Severe Accident Management of an NPP are obliged to meet the requirements not only in terms of their preparedness, but also in terms in their quantitative factor. Safety bases should also be designed for the occurrence of another serious accident developing in parallel or arising from an existing nuclear accident, since the resources deployed for one incident cannot discharge the global nuclear resources in such an extent that they cannot manage a corresponding event.

It can be seen that Severe Accident Management is a complex and elaborate task that requires careful planning to manage with it effectively. To this purpose, in addition to all possible hazards for NPPs and their emergency management, a bastion of protection must be provided, which besides the known dangers, has such an additional source that can be used at any time to strengthen the defence or even stand in their place completely instead of the original protection protocols.

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