



**Requirements for the Technical Scope of the  
Targeted Safety Reassessment (TRS) of  
Paks Nuclear Power Plant**

**Version 5**

**Compiled by the Hungarian Atomic Energy Authority  
May 24, 2011**

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# Requirements for the technical scope of the Targeted Safety Reassessment (TSR) of Paks Nuclear Power Plant

## I. About the reassessment in general

### I.1 Introduction, preliminaries

In view of the accident at the Fukushima Nuclear Power Plant in Japan, the Council of the European Union invited the Commission and the European Nuclear Safety Regulatory Group (ENSREG), with the full cooperation of the Member States, to revise the scope and methods of the safety reassessment (provisionally known as “stress tests”) of all European nuclear power plants in the light of the lessons learnt from the reactor accident in Japan. This work should be carried out utilizing all available expertise (in particular, from the Western European Nuclear Regulators’ Association - WENRA). The safety reassessment shall be conducted by national authorities and the results of the reassessment, including the requisite subsequent measures, shall be shared with the Commission.

In order to better reveal the tasks to be performed in the frame of “stress tests”, the WENRA defined the task as a “**Targeted Safety Reassessment (TSR)**” and it established, on the basis of its Reactor Harmonization Working Group a Task Force to develop the TSR specifications. The Task Force has prepared its proposal which, after the necessary harmonisations, was approved by the ENSREG meeting on May 12-13, 2011.

In general, every European nuclear power plant, including Paks Nuclear Power Plant, complies with the extremely rigorous safety requirements defined by the various national and international organizations. It is pointed out that the development of safety culture is an ongoing process. Moreover, apart from the development of science and technology, experience gained from past nuclear power plant accidents (e.g. TMI, Chernobyl) has strongly justified the current high level of safety and the realization of the need for its improvement. Accordingly; every nuclear power plant and every national safety authority should learn from the Fukushima accident and take the necessary steps to enhance the present high level of safety. Consequently, the Targeted Safety Reassessment shall be conducted and those measures shall be identified which further enhance the safety level of the nuclear power plants. The reference basis of the Hungarian reassessment is provided by previously performed comprehensive and detailed analyses; primarily the outcomes of the Final Safety Analysis Report and the Periodic Safety Review Report.

Since there has been insufficient time to draw all the necessary conclusions from the Fukushima accident, it is foreseen that there will be more detailed and more comprehensive analyses. Although the issues to be assessed as identified so far have not been systematically evaluated and by no means do they cover the whole scope; they can be summarized as follows:

- The results of concurrent or subsequent occurrence of certain, not totally independent effects;
- Cliff-edge effect<sup>1</sup>;
- Deficiencies of diversity and physical separation;
- Common cause effect of severe internal events (explosion) on many items of safety equipment (active systems, pumps, measurements, etc); it is for this reason that the restoration of the operation of the installed cooling systems has not been successful up till now;
- Long term limitation of serviceability (lack of lighting, lack of measurements, radiation hazards, etc);
- Simultaneous damage to more than one unit on any given site;

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<sup>1</sup> Cliff-edge effect: a step change in the event sequence (small changes entailing severe consequences)

- Such event sequences or situations for which the personnel have not been prepared;
- Such combinations and consequences of external effects which were not assessed in the design (such an event may simultaneously affect more than one unit);
- Spent fuel pool as a source of hazard, potential provisory cooling solutions;
- Hydrogen in a closed volume out of the containment (in the reactor hall due to through wall flow or from the spent fuel pool);
- Possibilities of long term accident management (without the installed emergency cooling systems);
- Management of large volume of radioactive contaminated water.

The Director General of the HAEA, subsequent to the decision of the Council, requested the Director of the KFKI Atomic Energy Research Institute to overview, with the involvement of the leading experts of the Technical Support Organizations of the HAEA, every potential issue requiring reassessment at Paks Nuclear Power Plant and to draw up a proposal regarding the tasks to be performed.

The requirements for this proposed report were identified on the basis of the above listed issues, the specifications of the WENRA Task Force<sup>2</sup>, the recommendations of the Hungarian expert team<sup>3</sup>, and the expertise of the HAEA. It is emphasized that the WENRA specifications were strongly supported by the requirements of the Finnish Nuclear and Radiation Safety Authority (STUK)<sup>4</sup>. The Hungarian requirements also consider the ENISS proposal<sup>5</sup>.

## I.2 TSR objective

The Targeted Safety Reassessment aims at re-evaluating the safety margins of Paks Nuclear Power Plant and determining what actions may be necessary subsequent to the assumed loss of safety systems taking into account those issues that have already been highlighted by the events that took place at Fukushima. In addition, the TSR is aimed at identifying those supplementary measures to be implemented in order to ensure that Paks Nuclear Power Plant is able to comply with the requirements concluded from the Fukushima accident. The basis for the reassessment is provided: namely, the Final Safety Analysis Report (FSAR) and the outcomes of the Periodic Safety Reviews (PSR). Numerous analyses support these basic documents based on which the TSR can be conducted; occasionally with supplementary analyses.

A clear definition of the scope of the reassessment and its effective and targeted operation requires that **the Targeted Safety Reassessment should focus on the circumstances and experience of the Fukushima accident**. Any potential occurrences beyond the scope of this present reassessment are mentioned in Subchapter I.6 below.

## I.3 TSR scope

All four reactor units of Paks Nuclear Power Plant as well as its spent fuel pools<sup>6</sup>, all relevant equipment, facilities, documents, technical and human infrastructures will be reassessed in the framework of the TSR.

Those occurrences that present a simultaneous hazard to the reactors and the spent fuel pools and their various operating states are due to be taken into account.

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<sup>2</sup> "Stress tests" specifications. Proposal by the WENRA Task Force, May 7, 2011

<sup>3</sup> What to do in Hungary regarding the stress test? April 4, 2011

<sup>4</sup> Preparedness for natural phenomena and disturbances in power supply at the Finnish NPP, STUK, March 21, 2011

<sup>5</sup> Safety Terms of Reference – STORE, JPB V2, April 5, 2011

<sup>6</sup> Note that the hazards and the damage relate to the spent fuel pools of Fukushima Units 4-6, therefore the lessons learnt are not related to the Paks Spent Fuel Interim Storage Facility.

The technical scope of the TSR as detailed below is considered as complete by the HAEA since all other safety related issues not addressed in this present document are assessed with sufficient detail in the documents supporting the operation of Paks Nuclear Power Plant.

#### I.4 TSR method

The reassessment shall consist of the following steps:

1. Assessment of the potential occurrences of the key events considered as the most severe based on the events that took place at Fukushima;
2. Analysis of those potential causes that may lead to the occurrence of key events;
3. Description of the potential methods of prevention of and response to key events;
4. Presentation of the consequences provided that the key events cannot be prevented and managed;
5. Description of the methods as to how the on-site consequences of the key events can be mitigated.

**Besides the above analyses and descriptions, the TSR report summarizing the results of the reassessment (see Subchapter I.7) covers the identified potential weak points and the potential cliff-edge effects. The reassessment shall clearly demonstrate the extent to which the defence in depth at the power plant can withstand the extreme loads considered in the framework of the reassessment and that the existing accident management system is capable of coping with these events. In addition, the reassessment shall identify the potentially required safety improvement measures in the areas of technology, personnel and organization.**

The potential responses of the plant to certain extreme situations shall be assessed in the framework of the TSR based on the logic of defence in depth. In these extreme situations, with the application of a deterministic approach, the ineffectiveness of several subsequent layers of the defence in depth shall be assumed independently of the probabilities; however, the quantified probabilities of such occurrences may serve as complementary information during the reassessment. It shall be noted that the loss of the safety functions and the severe accident conditions may occur only if several design assumptions fail simultaneously. It should also be considered during the reassessment that the actions meant to manage such accident situations will be suddenly or gradually nullified due to the adverse external/internal conditions and limited reserves of resources.

The plant conditions assumed as initial service states during the reassessment shall represent the most unfavourable service states that are permitted under the technical specifications of the plant. The potentially degraded environmental conditions around the plant shall be taken into account in the reassessment. It is acceptable to use realistic considerations and such tools that are not qualified for severe accident sequences.

It should be assumed with regard to each assessed event sequence and conclusions, that **another unit (or all other units)** of the site might also be affected; however those existing procedures and technical solutions shall also be considered that make the support from another unit (or other units) possible. It shall be also assessed how the damage to a unit may affect the safety of other units.

The reassessment shall cover the following three issues:

- design basis requirements and plant conformance with its design,
- robustness of the plant against beyond design basis events (design margins, diversity, redundancy, structural protection, physical separation, effectiveness of defence in depth regarding safety significant systems),

- any potential modifications that may improve the effectiveness of defence in depth and strengthen the independence of its levels.

In addition, the authors of the TSR report may wish to describe protective measures aimed at avoiding the extreme scenarios considered. In case of need the analyses might be supplemented by means of walkdown inspections.

The more detailed specific requirements for the analyses and evaluation are described in subsequent chapters of this document.

Since the licensee undertakes primary responsibility for the safety of the NPP plant, the reassessment is to be conducted by the licensee; the results to be evaluated and the decision on any required safety improvement objectives shall be made by the nuclear safety authority. The licensee shall deploy existing analyses during the reassessment; if necessary, complementary analyses shall be made or their need identified (see also below). If justifiable and acceptable, technical estimates may also be utilized to support the results of the reassessment.

The most important references for the analyses supporting the conclusions of the reassessment are Chapter 15 of the FSAR and the analyses made in the framework of the PSR. These analyses shall be clearly referred to in the reassessment report if the summarized results can indisputably solve an issue raised in the TSR. **Accurate and retrievable references need to be provided** in relation to additional analyses and technical estimates or, instead, a concise summary of those analyses or estimates shall be provided. The licensee is required to state whether the documents referred to are:

- approved by the authority;
- not approved by the authority, but in compliance with the quality management system of the licensee; or
- neither of the above.

Taking it into account that the technical scope is wide, complex and - to a certain extent - novel, **it is probable that the current reassessment will identify such areas where further analyses or developments will be required. The time needed for their realization may exceed the term of the TSR.** These measures shall be presented in the summary chapter of the reassessment report (see Chapter VII).

The report on the TSR and the subsequent regulatory evaluation and resolution **shall be handled as data of public interest: thus, as open information.**

## I.5 TSR scheduling

The basis for planning is that the European Commission, taking into account the time needed for the reassessment, would like to obtain an overview of the results of the reassessment as soon as possible. In line with this, in an intermediate phase of the reassessment, the Commission requests a Progress Report summarizing the results of the assessments performed up till then. The results of the complete reassessment will be compiled in the Final Reassessment Report. Accordingly; the Targeted Safety Reassessment of Paks Nuclear Power Plant shall be conducted in accordance with the undermentioned schedule:

1. Submittal of the Progress Report to HAEA; deadline: August 15, 2011; responsible: Paks NPP Ltd general manager;
2. Preparation of National Report based on the Progress Report; deadline: September 15, 2011; responsible: HAEA director general;

3. Conduct of the Targeted Safety Reassessment, preparation of the Final Reassessment Report; deadline: October 31, 2011; responsible: Paks NPP Ltd. general manager
4. Regulatory review of the reassessment report, decision on safety improvement measures to be implemented by the licensee, preparation of the final version of the National Report; deadline: December 31, 2011; responsible: HAEA director general.

It should be noted that the Council will invite an international "peer-review" team to evaluate the National Report.

### I.6 Additional tasks beyond the scope of the present TSR

It should again be emphasized that the Targeted Safety Reassessment is the reassessment of Paks Nuclear Power Plant in the scope justified by the lessons learnt from the accident that took place at Fukushima until the issuance of these requirements. It may well be that other conclusions can be drawn later, as well as the further reassessment of the power plant, and such conclusions and other reassessments may lead to additional thoughts, concepts and analyses. In this respect, the following might be considered:

1. Other extreme events, phenomena, interventions endangering the safety of the plant;
2. Behaviour and compliance of other nuclear facilities under the here-assessed extreme conditions;
3. Adequacy of the nuclear-safety-relevant legal and regulatory environment in the light of the measures induced by the reassessment;
4. Adequacy of the national nuclear accident response system to manage such extreme situations.

These issues and any additional problems that may arise later, even if they may subsequently be considered justifiable and timely, shall not be interrelated with the Targeted Safety Reassessment outlined in this present document; they must be handled in other targeted assessments with well-defined scopes.

### I.7 Content of the reassessment reports

The outcomes of the Targeted Safety Reassessment are due to be summarized in a Progress Report and a Final Reassessment Report prepared by the licensee. The reports shall consist of two parts. The most relevant specifics of the site and the plant are to be summarized in the first part of each report as follows:

- Location, environment;
- Number of units;
- License holder;
- Type and power of reactors;
- Dates of commissioning;
- Specifics of the spent fuel pools;
- Connections to the external electric network;
- Differences between the blocks that are relevant with respect to safety or to the reassessment.
- Scope and main results of PSA analyses.

The findings of the reassessment together with the conclusions are to be presented in the second part of each report in line with the method described in Subchapter I.4 and the technical scope requirements. Both reports shall be divided into chapters in accordance with the scope requirements and the chapters below. **The closing section of each chapter shall summarize the conclusions of the assessments described in that chapter and shall determine the measures to be taken. The reassessment shall refer to the status of the units as on June 30, 2011.**

The reports shall refer to those relevant safety improvement measures and modifications that are currently in progress, or summarize them in a separate annex.

The executive summary and the closing section of the chapters shall be in English as well as in Hungarian.

## II. Key events – the most severe TSR relevant situations and their internal causes

### II.1 Key events

The most significant characteristic of the accident at Fukushima was that the extreme natural events some of which were beyond the design basis led to such a severe situation that could not be caused by events within the design basis. The most relevant aspects of these severe situations are as follows:

1. Long term (i.e. several days) loss of electric supply;
2. Long term loss of the ultimate heat sink;
3. Occurrence of major radioactive release or extreme radiation conditions.

As a common name, these specific events will be referred to as *key events* in subsequent chapters of this document.

### II.2 Assessment of the internal causes of key events

**It shall be assessed** in the framework of the TSR how these key events may occur at Paks Nuclear Power Plant with respect to the following:

- a) equipment that has become degraded due to (existing or permanent load induced) technical condition degradation, false design or other reasons;
- b) occurrence of beyond design basis accidents.

The direct, technical (e.g. operational, maintenance), human, documentation or organizational (altogether, i.e. internal) causes of the occurrence of key events shall be considered in this part of the reassessment; the next chapter refers to external causes.

It should be noted that the key events are not independent of each other; the occurrence of one or more key events may induce the occurrence of another. It is intended that the reassessment should reveal such relationships.

**As general but not exclusive examples** the following shall be assessed:

- performance of safety systems designed to prevent the occurrence of key events, the robustness of engineering barriers as a function of time (*e.g.: no-failure operation of diesel generators, core cooling pumps, AEFW pump*); *interval during which the containment pressure will reach 3.5 bar absolute pressure (the loss of containment integrity shall be assumed in this case); the interval after which the amount of radioactive material that is sufficiently high to limit emergency response actions will be released due to the leakage of the containment,*
- time and space limitations in fuel, cooling medium and lubricant supply for safety systems and emergency/reserve systems;
- expected limitations in availability and serviceability of necessary measurements, actuators (including supplies and operating conditions) and intervention locations (control rooms, emergency command post).
- potential effects from the operation of other units on the site.

### II.3 Specific potential internal causes

The causes identified during the preliminary examinations in relation to the specific key events are listed below. In the TSR, those potential events (including but not necessarily limited to the list below) **are due to be analysed and evaluated systematically**, which may lead to the occurrence of any of the key events.

### II.3.1 Potential internal causes of long term loss of electric power supply

- Collapse of electric network after concurrent loss of all four units;
- Loss of operability of diesel generators;
- Loss of every other diverse backup power supply;
- Sequences started by such initiating events that have been taken into account in former analyses, which lead to long term loss of electric power supply with the assumption of cases listed in Paragraphs a) - b) of Subchapter II.2.

### II.3.2 Potential internal causes of long term loss of ultimate heat sink

- Accidental failure of component cooling system;
- Loss of cooling function of spent fuel pool due to failure in cooling system or leakage from the pool;
- Sequences started by such initiating events that have been taken into account in the former analyses, which lead to concurrent loss of normal operational and emergency heat sink with the assumption of the cases listed in paragraphs a) - b) of Subchapter II.2.

### II.3.3 Potential internal causes of a major radioactive release or occurrence of extreme radiation conditions

- Containment failure due to overpressure ensuing from the long term loss of ultimate heat sink or other internal causes;
- Sequences started by such initiating events that have been taken into account in former analyses that lead to containment failure with the assumption of the cases listed in Paragraphs a) - b) of Subchapter II.2;
- Sequences started by such initiating events that have been taken into account in former analyses that lead to release without containment failure with the assumption of the cases listed in Paragraphs a) - b) of Subchapter II.2. Failure of liquid radioactive waste storage facilities shall also be covered;
- Fuel damage due to loss of coolant from the spent fuel pool, also taking into account the effect of the disappearance of the water shielding.

The reassessment report **shall describe the results of the above evaluations separately and in a well defined manner.**

## **III. Potential external causes of key events**

### **III.1 Assessment of external causes of key events**

The issues listed in the subchapters below **shall be assessed and described** for each case, if relevant:

- a) Design basis events, justification of choice of design basis, method of evaluation of events in the design basis (frequency, preceding occurrences, reason for choice, margins), evaluation of adequacy of development of design basis;
- b) Protection against design basis events in the plant [actual condition of systems, structures and components relevant from the protection aspect, compliance with design expectations, redundancy, diversity, physical separation, operating conditions (procedures, mobile equipment, ...) other potential contributing events (loss of important tools, damage to buildings due to the phenomenon, inaccessibility, loss of electric power supply, effect of external events)];
- c) Robustness of the plant beyond its design basis: robustness of safety-relevant systems, structures and components influencing the consequences of the event; available design margins, diversity, redundancy, physical separation, structural protection; analysis of potential for cliff-edge effect.

During the reassessment, evaluations shall be carried out to determine which external causes and which conditions might lead to the occurrence of key events at Paks Nuclear Power Plant. The reassessment report **shall describe the results of the above evaluations separately and in a well defined manner.**

### III.2 Earthquake

Issues a)-c) above shall be described for earthquakes potentially affecting Paks Nuclear Power Plant. First of all, it will be considered and evaluated whether or not **the seismic safety assessments and analyses are appropriately wide in scope.** (Note: Even so, this evaluation shall by no means claim that the Paks site should be reassessed because of newly-considered seismic threats to the site.) The implemented safety improvement measures and the conclusions shall be described briefly, clearly and in a convincing form. Protection against beyond design basis earthquakes, any deficiencies and any additional analyses shall be included. Specifically (but not limited to), the following issues shall be addressed:

- Anchorage of principal maintenance components, fuel-manipulation and other technical equipment, maintenance discipline;
- Adequacy of procedures to be applied in case of an earthquake, preparedness of personnel;
- Preservation of accessibility after various earthquakes, potential for concurrent loss of control room, backup control room, dosimetry control room and crisis centre, conditions in this situation, adequacy of crisis centre;
- Assessment of potential serious consequences of a beyond design basis earthquake (including soil liquefaction);
- Potential for ATWS in consequence of a beyond design basis earthquake;
- Seismic protection of Component Cooling Water Tank;
- Potential impacts of buildings or other structures damaged by the earthquake on the equipment used for preventing key events (e.g. stack collapse, damage to waste storage and auxiliary buildings, collapsing of bridge crane);
- Determination of the operating state most sensitive to an earthquake;
- State of spent fuel pools and their cooling systems from the aspect of withstanding earthquakes of various (but reasonably assumed) strength;
- Potential impact of an earthquake on the water intake supply, overflow weir and cooling water supply;
- Potential and consequences of beyond design basis fires caused by an earthquake.
- Potential internal flooding due to pipeline breaks caused by an earthquake.

### III.3 Low or high water level

Issues a)-c) above shall be described for floods potentially affecting Paks Nuclear Power Plant. It shall be evaluated whether it is realistic to assume floods with lower frequency than that considered in the design basis.

Similarly, possible consequences of earthquakes (within the design basis) occurring at extremely low or high water level shall be evaluated. The potential for low water level caused by beyond design basis earthquakes shall be analysed, and the operability of pumps at low water level after loss of electric power supply will be considered.

### III.4 Other extreme environmental effects

Preparation for extreme weather conditions shall be addressed in this part (storm, strong precipitation, lightning, ice and snow blockage, extreme temperatures and realistically assumable combinations of these) in accordance with the specification of paragraphs a) - c) of Subchapter III.1, but the loss of external electric power supply shall be taken into account for specific external causes (e.g. network collapse due to malfunction, malevolent human interaction). The following items shall specifically be addressed:

- Preparedness for the combination of phenomena (also including events per III.2 and III.3) within and beyond design basis;
- Weak points, and buildings and other structures impacted by potential cliff-edge effects;
- Failures that might lead to unsafe conditions;
- Identification of envisaged measures and accident management procedures.

#### ***IV. Possible methods for the prevention of and/or response to key events***

##### **IV.1 General issues of prevention and response**

The following issues of prevention methods (if relevant) **shall be assessed and described** with respect to external and internal causes of key events:

- a) Compliance of the plant with the design basis, general configuration management process run by the licensee to maintain the design basis state; demonstration that mobile equipment considered in the emergency procedure remains operable; description of any known deviation from the design basis;
- b) Based on available information and analysis, that level of causes of key events beyond which the loss of fundamental safety functions or severe damage to the fuel or major radioactive release turns out to be unavoidable; weak points and potential cliff-edge effects, provisions to prevent them (technical modifications, procedure modifications, organizational modifications);
- c) Based on available information and analysis, that level of causes of key events under which the containment preserves its integrity;
- d) Possible methods for repair of safety barriers to prevent or respond to key events (to improve the resistance of systems, structures and components and to increase the independence of safety barriers).

##### **IV.2 Specific issues of prevention and response**

Prevention of key events shall be assessed specifically (but not limited to) the particular possibilities listed below. Potential for gradual and subsequent loss of safety systems used to prevent key events shall be considered. **After the separate assessment of loss of electric power supply and loss of ultimate heat sink (see Subchapter IV.2.1 and IV.2.2 below), the analysis shall be repeated by assuming concurrent occurrence of two key events.**

The analysis shall take into account the situation when the site **cannot be approached** by heavy vehicles within 72 hours and when light mobile equipment cannot approach the site and cannot be operated within 24 hours.

Potential damage to, and unreliability or complete loss of **the IT & measuring networks** shall be taken into account as well as the loss of data and the means required for control and technical support activities.

###### **IV.2.1 Prevention of long term loss of electric power supply**

- Management of this situation in the design basis, taking into account internal backup power sources, maximum interval of operability, fuel supply of generators;
- Application of mobile (backup) diesel generators, method of their deployment (including time necessary to operate, fuel supply, necessary contributors and documentation);
- Other available AC supply;
- Distant gas turbine accessible via network or utilization of any other means as backup electric power supply;
- Need for installation of any nearby gas turbine or other electric energy supply;
- Possibilities for use of other mobile facilities (Hungarian Railways, Hungarian Defence Forces, Disaster Management, etc.);

- Opportunities and timing of recovery after total loss of electric power supply.

#### IV.2.2 Prevention of long term loss of ultimate heat sink

- Available alternative cooling water sources (emergency water supplies, reservoirs, drilled wells, intake from Danube, mobile water supply, condenser cooling water);
- Period during which the plant can withstand the situation with the available cooling means without severe fuel damage;
- Alternative possibilities of heat removal (decay heat, vessel cooling, secondary side cooling, application of auxiliary emergency feed-water system, alternative spent fuel pool cooling);
- Supply of available water to the location to be cooled (reactor, containment, spent fuel pool) in an emergency situation;
- Availability of resources required to implement alternative cooling provisions (personnel, equipment, energy, fuel); feasibility of these provisions (e.g. as a function of radiation conditions), necessary procedures and documents;
- Opportunities for recovery after loss of ultimate heat sink.

#### IV.2.3 Prevention of a major radioactive release

- Prevention of re-criticality, alternatives for boric acid supply to the vessel and make up for boric acid in the spent fuel pool, prevention of criticality in the fresh fuel store due to flooding
- Prevention of containment over-pressurization (cooling, filtered or unfiltered venting);
- Removal of hydrogen generated in the spent fuel pool;
- Provisions to prevent processes leading to vessel failure, and their management;
- Blocking of release routes bypassing the containment.

### *V. Potential consequences of uncontrolled key events*

**Based on the severe accident analyses, assessments are to be made and briefly described** as to which scenarios and under which conditions these may lead to severe accident consequences and how they can be mitigated if a key event occurs and the response is ineffective. The occurrence of a severe accident shall deterministically be assumed even if its probability is low. Severe accident management, as the last line of protection of defence in depth, shall be in harmony with the measures aimed at avoiding core melt and maintaining plant safety as a whole.

The minimum list of severe accident phenomena to be considered is as follows:

1. Core melt (including high pressure core melt, vessel breach, corium--concrete interaction, time sequence);
2. Hydrogen generation or steam generation (explosion) in the reactor core, in the reactor shaft, in the spent fuel pool, hydrogen release to an oxygen-rich space, possible hydrogen processes (radiolysis + zirconium reactions + molten core--concrete interaction); possibility of accumulation of hydrogen in the containment or in surrounding buildings, and management of hydrogen under severe accident conditions if the reactor and/or the containment is open;
3. Failure related to spent fuel pool (boron dilution, core melting, releases, hydrogen generation, timing);
4. Containment failures (time scale).

### *VI. Management of consequences of key events*

#### **VI.1 General issues of severe accident management**

- a) The actual procedures developed for the various phases of the management of the loss of core cooling accident **shall be described**, such as:

- phase of in-vessel prevention of core damage (ultimate possibilities to prevent fuel damage, prevention of high pressure core melt);
  - in-vessel post-core-damage phase;
  - post-vessel-breach phase.
- b) Those design features and management procedures **shall be described** which provide for maintaining the containment integrity after fuel damage, such as:
- prevention of hydrogen deflagration or hydrogen detonation;
  - prevention of containment over-pressurization, if release is assumed for that purpose, it shall be assessed whether filtration is necessary. If yes, the method how the amount of release is estimated shall be described;
  - prevention of re-criticality;
  - prevention of basement melt through;
  - provision of necessary AC & DC electric power supplies to equipment maintaining containment integrity;
  - management of open reactor and open containment.
- c) Actual management procedures relevant for various phases after loss of coolant from the spent fuel pool **shall be described**, such as:
- before/after losing adequate shielding against radiation;
  - before/after uncovering of fuel elements;
  - before/after damage to several fuel assemblies.

In each of the three cases, i.e. a) – c) above, the following issues shall be addressed:

- Potential cliff-edge effects and time available before their occurrence;
- Adequacy of existing management measures and means; completeness of scope of scenarios taken into account and the need for introducing further ones, including:
  - suitability and availability of the required instrumentation;
  - accessibility and operability of vital compartments and locations of the plant (control rooms, emergency response rooms, local intervention and sampling locations, possibilities to repair);
  - accumulation of hydrogen outside the containment rooms;
- Specific problems of sustained (i.e. several weeks long) response;
- Possibility of revitalization of I&C system which previously lost electric power;
- Possibility and methods of recovery of damaged engineered barriers.

## VI.2 Specific issues of severe accident management

In addition to general attributes of severe accident management, the specific and additional conditions listed below shall also be described. Favourable and unfavourable features of Paks Nuclear Power Plant as compared to the Fukushima NPP shall also be included.

- a) Maintenance of operability of severe accident management system, with special attention to the following items:
- Organizational preparedness to manage the situation (personnel and shifts, resources, procedures, training and exercises);
  - Assistance from off-site;

- Applicability of existing tools;
  - Applicability of mobile equipment (availability, time to deploy);
  - Possibility of supply (fuel, water, food, etc.);
  - Limitation and management of radioactive releases;
  - Control and limitation of radiation exposure of workers;
  - Communication and information systems (internal and external);
  - Long term post-accident operations.
- b) Operability of severe accident management system in abnormal situations
- When infrastructure and communications are severely impaired or destroyed;
  - When working conditions have deteriorated (including accessibility and habitability of control room, backup control room, protected crisis centre) due to major radiation/contamination or destruction;
  - Under extraordinary environmental impacts;
  - When electric power supply and/or measuring instruments are lost;
  - In relation to potential negative impact of other units;
  - When sustained (i.e. several weeks long) response is required;
  - Solution to problems related to lack of accessibility, supply and personnel.
- c) Operation of on-site emergency response system
- Capability to respond when more than one block (unit) is out of action, based on limited information, with transport difficulties, high radiation levels and unusual off-site difficulties;
  - Preparedness, skill and resources of the Emergency Response Organization (personnel, tools, data, documents);
  - Involvement of off-site services (fire brigades, emergency medical services, off-site technical support);
  - Effectiveness and operability of decision-making;
  - Operability after loss of electric energy supply, including crisis centre.

## ***VII. Possible measures to improve management of severe accident situations***

A separate part of the TSR report shall summarize the projected safety improvement measures intended to eliminate the possible deficiencies revealed in the various reassessed areas.

The main advantages and the expected results of the planned measures shall be described. A preliminary assessment shall determine the schedule of the measures to be taken. The consequences (i.e. drawbacks) if any given measure is not implemented shall be clarified.