SPECIAL

NATIONAL REPORT OF THE SLOVAK REPUBLIC

COMPILED UNDER
THE CONVENTION OF NUCLEAR SAFETY

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ABBREVIATIONS

AC	Alternating Current
ACRS	Secondary RHR Reduction Station
AFWP	Auxiliary Feedwater Pump
ASS	Automatic Standby Start
BC	Bubbler Condenser
BCT	Bubbler Condenser Trays
BDBA	Beyond Design Basis Accident
CDF	Core Damage Frequency
CDFM	Conservative Deterministic Failure Margin
CP	Civil Protection
CPS	Central Pumping Station
CSS	Containment Spray System
CW	Circulating Water
CWT	Chemical Water Treatment
DBA	Design Basis Accident
DC	Direct Current
DDF	Depth Duration Frequency
DG	Diesel Generator
DGS	Diesel Generator Station
DW	Demineralized Water
EBO	Bohunice Power Plant
ECC	Emergency Control Centre
ECCS	Emergency Core Cooling System
ECR	Emergency Control Room
EFWP	Emergency Feedwater Pump
EFWS	Emergency Feedwater System
EHV	Extreme High Voltage
EMO	Mochovce Nuclear Power Plant
EMO1,2	Mochovce Nuclear Power Plant Units 1&2
EOP	Emergency Operating Procedures
EPP	Emergency Planning and Preparedness
EPS	Emergency Power Supply
ERO	Emergency Response Organization
ESCW	Essential Service Cooling Water
ESTE	SW prognostic and classification tool for radiological consequences

EU	European Union
F&B	Feed and Bleed
FAIV	Fast Acting Isolation Valve
FDCT	Forced Draft Cooling Towers
FMFI UK	Faculty of Mathematics, Physics and Informatics of Comenius University
FW	Feed Water
FWT	Feedwater Tank
GFU SAV	Geophysical Institute of the Slovak Academy of Science
GIP	Professional Survey Inspection Method for HCLPF Definition
HA	Hydroaccumulator
ha	Hectare, area unit = 10E+4 m2
HC	Home Consumption
HCLPF	High Confidence Low Probability Failure (Limit for seismic resistance of structure, system and component in existing conditions)
HP	High-Pressure
HPME	High Pressure Melt Ejection
HPP	Hydroelectric Power Plant
HVAC	Heating, Ventilation and Air Conditioning
I&C	Instrumentation and Control System
IAEA	International Atomic Energy Agency
IC	Information Centre
IEP	Internal Emergency Plan
IMS	Integrated Management System
IVR	In-Vessel Retention
JAVYS, a, s,	Joint-stock company JAVYS (Nuclear and Decommissioning company)
KCHL	Control and Chemical Laboratory of Civil Protection
KI	Potassium Iodide
L&C	Limits and Conditions
LERF	Large Early Releases Frequency
LOCA	Loss of Coolant Accident
LP	Low-Pressure
LRKO	Laboratory of Radiological Environmental Monitoring
MC	Main Condenser or Monitoring Centre
MCR	Main Control Room
MDVRR SR	Ministry of Transport, Construction and Regional Development of the Slovak Republic
MH SR	Ministry of Economy of the SR

MO SR	Ministry of Defence of the SR
MPB	Main Production Building
MS	Monitoring Centre
MSH	Main Steam Header
MSK64	Macro Seismic Intensity Scale
MV SR	Ministry of Interior of the SR
MŽP SR	Ministry of Environment of the SR
NEA	Nuclear Energy Agency
NPP	Nuclear Power Plant
NRC	Nuclear Regulatory Commission
OECD	Organisation for Economic Cooperation and Development
PAMS	Post-Accident Monitoring System
PAR	Passive Autocatalytic Recombiner
PF UK	Faculty of Natural Sciences of Comenius University
PFB	Plant Fire Brigade
PGA	Peak Ground Acceleration
PORV	Power Operated Relief Valve
PP	Physical Protection
PP CC	Physical Protection Control Centre
PPE	Personal Protective Equipment
PPLC	Personnel Protection and Logistic Centre
PRZ	Pressurizer
PRZ RV	Pressurizer Relief Valve
PRZ SV	Pressurizer Safety Valve
PSA	Probabilistic Safety Assessment
RB	Reactor Building
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RHR	Residual Heat Removal
RCHBO OS SR	Battalion of Radiological, Chemical and Biological Protection of Military of the Slovak Republic
RLE	Review Level Earthquake
RMN	Radiation Monitoring Network
RMTS	Radiation Monitoring Technological System
RPV	Reactor Pressure Vessel
RUS	Reactor Unit Supervisor

SA CRG	Severe Accident Control Room Guideline
SAM	Severe Accident Management
SAMG	Severe Accident Management Guidelines
SBO	Station Black-out
SC	Secondary Circuit
SCW	Service Cooling Water
SDSA	Steam Dump Station to Atmosphere
SDSC	Steam Dump Station to Main Condenser
SE, a. s.	Slovenské Elektrárne, Inc.
SFP	Spent Fuel Pool
SG	Steam Generator
SG FW	SG Feedwater Tank
SG SV	Steam Generator Safety Valve
SL2	Seismic Level 2 (IAEA)
SLB	Steam Line Break
SLOP	Centre of Logistical Support
SMA	Seismic Margin Assessment
SR	Slovak Republic
SS	Shift Supervisor
SSC	Systems, Structures and Components
SSE	Safe Shutdown Earthquake
SSEL	List of Equipment for Safe Unit Shut-down after Seismic Event
STN	Slovak Technical Standard
SZU	Slovak Medical University in Bratislava
TC	Technological Condenser
TDS	Teledosimetry System
TG	Turbine Generator
TSC	Technical Support Centre
UHS	Ultimate heat Sink
UJD SR	Nuclear Regulatory Authority of the SR
UPS	Uninterruptible Power Supply
US NRC	U.S. National Regulatory Commission
UVZ SR	Public Health Authority of the SR
VARVYR	Warning and Notification
VHV	Very High Voltage
VÚVH	Water Research Institute

WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association
WOG	Westinghouse Owner Group

0 Introduction

0.1 Purpose of the Report

The Convention on Nuclear Safety (hereinafter as the "Convention") is the first international legal binding document in the field of nuclear safety.

The Convention entered into force on 24th October 1996.

At the 5th Review Meeting, which was held from 4 to 14 of April 2011, the Contracting Parties adopted a common declaration regarding the events in Japan - Fukushima. At the same time the Contracting Parties agreed to convene an Extraordinary Review Meeting of the Contracting Parties to the Convention in 2012, during which on the basis of special national report the measures adopted and lessons learned will be reviewed, which were made in connection with the events in Japan. The present National Report is a fulfilment of the decision adopted at the 5th Review Meeting. The content and the structure of this Report follow the conclusions of the President of the 5th Review Meeting contained in the final report from this meeting.

The following nuclear installations are subject to this report:

- Nuclear Power Plants Bohunice – V-2 Units,
- Nuclear Power Plants Mochovce – Units 1 – 4,
- Units 3&4 are under construction.

0.2 Brief description of the site characteristics and units

Slovakia is an inland country situated in a mild climatic zone of the Central Europe. There are two nuclear sites in Slovakia: Jaslovské Bohunice with 2 operating units of V-2 NPP, and Mochovce site, with 2 operating units EMO1&2 and other 2 units MO 3&4 under construction forming together the Mochovce NPP (see location of the sites on the map, and view of the sites on two photographs below – see the Figure 1, Figure 2, Figure 3).

The license holder for all these units is the joint stock company Slovenské elektrárne, a. s.

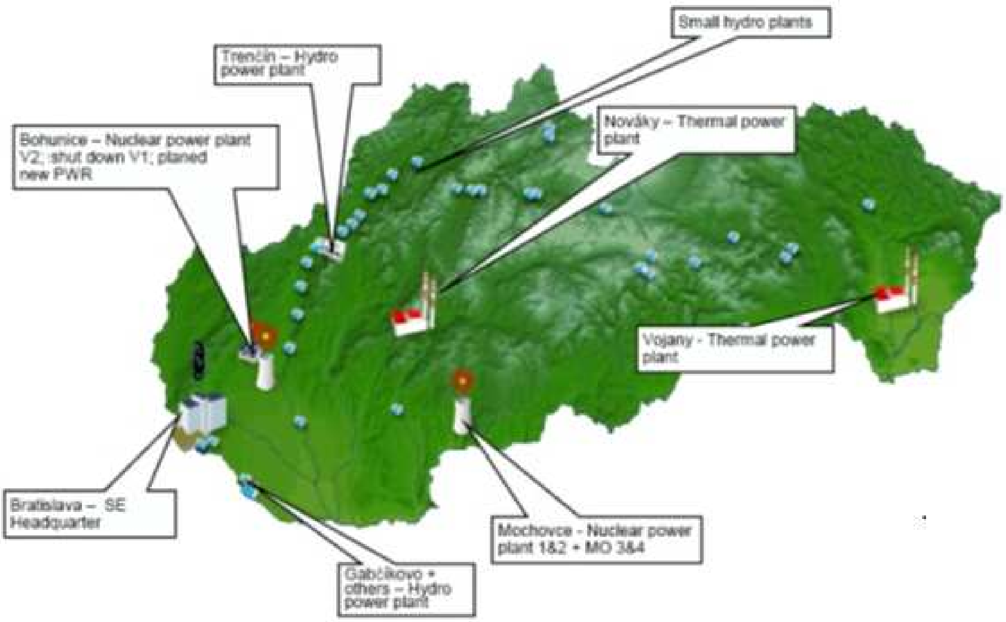

Figure 1 Location of main power plants in Slovakia

Jaslovské Bohunice site is located in West Slovakia; the nearest towns are Trnava, Hlohovec and Piestany. Cooling water for the site is provided from the river Vah, which is about 8 km east from the site with the difference in altitude is more than 20 m. On the river Vah, there is a water reservoir called Slnava with the water area of about 480 ha and the maximum volume of 12.3 million m^3. From Slnava, the NPP Bohunice V-2 units are supplied with service water through the pumping station in Pecenady. The service water off-take from the Slnava reservoir is made by four suckers to the pumping station Drahovce, from where water flows gravitationally by four pipes through a valve shaft to the suction sump of the Pecenady pumping station. From the pumping station, water is supplied by discharging pumps through two discharging lines to the NPP Bohunice V-2 raw water chemical treatment station.

Figure 2 General view of Bohunice site

Figure 3: General view of Mochovce site

EMO1,2 NPP is situated about 27 km far from the Nitra regional city, 7 km from town Tlmace, 12 km from Levice, and 14 km from Zlate Moravce. The Slovak Republic capital – Bratislava – is about 90 km in south-west direction from EMO1,2 NPP. The reference level of the plant ± 0.000 m is set in the altitude of 242.300 m. For Mochovce NPP cooling water is provided from the river Hron. In Hron near Velke Kozmalovce village there is an artificial water reservoir with the total volume of 2.6 million m^3.The water reservoir level is at the altitude of 175.0 m above sea level at the maximum level and 171.5 m at the minimum level. EMO1,2 NPP is supplied by service water from this reservoir. Water is pumped from pumping station Velke Kozmalovce by about 5 km long pipe to the water reservoirs 2x6000 m^3 and from there it is transported with two pipelines by gravity to EMO1,2 NPP.

The both sites are connected to the distribution grid by redundant lines. In both cases, there are 2 independent lines from the 400 kV distribution grid and 2 independent lines to stand-by unit transformers either from 110 kV and 220 kV switchyards. Similarly, in both cases there is a possibility to connect plants to a diverse power sources from hydro stations (different for each of the sites).

0.2.1 Main characteristics of the units

All nuclear units in Slovakia are equipped with pressurized water reactors of Russian VVER 440/V213 design, with relatively small reactor thermal power between 1375 and 1471 MW. The reactor coolant system is located in a large pressure suppression type containment. The units have six loops, isolation valves on each loop and horizontal steam generators with large coolant volume on secondary side of the steam generators. The reactor core is composed of 349 hexagonal fuel assemblies with 126 fuel rod positions each. 37 control rod assemblies have fuel followers underneath their neutron absorbing parts so that efficiency of scram is increased by removal of the part of fuel from the core together with the insertion of the control rods. All units use two steam turbines. Electricity is generated in main synchronous generators on a common shaft with turbine and excitation generator. Power from each reactor unit is led to the power grid through two parallel lines, always from the main generator through respective unit transformer with accessories. Both branches are connected in an outlet substation to a single 400 kV line.

VVER-440's have been conceived as twin units, in mirror spatial arrangement. Most systems and equipment belong to one unit; part of equipment and systems is common for both units. Among the common part of systems and structures there are reactor hall, refuelling machine, spent fuel storage and transport, radioactive waste handling, receipt, storage and transport of fresh fuel, vent stack, access to controlled area, demineralised water treatment system, service water system, cooling water system, diesel generator building.

Basic data about all units covered by this report are in the table.

Plant	NPP Bohunice V-2	EMO1,2 NPP	EMO3,4 NPP
Site	Bohunice	Mochovce	Mochovce
Reactor type	VVER 440/V213	VVER 440/V213	VVER 440/V213
Reactor thermal power, MWt	1471	1471	1375
Gross electric power, MWe	505	470	470
Plant status	In operation	In operation	Under construction
Date of first criticality	1984-85	1998-99	Under construction
Latest update of Safety Analysis Report	2009	2010	2008
Latest update of PSA Level 1/Level 2	2010	2010-2011	2008, update in progress
Last Periodic Safety Review	2008	2009	-

The spent fuel pit separate for each of the units is located adjacent to the reactor vessel. Spent fuel is cooled in the spent fuel pit approximately 4 to 7 years in a compact storage grid in a pool filled with borated water. Fuel is stored in a compact storage grid in vertical position enabling cooling by circulation of boric acid solution with concentration corresponding to requirements derived from neutron-physical characteristics of fuel. The storage grid consists of hexagonal absorption tubes to which spent fuel assemblies or hermetic cases (for assemblies with damaged cladding) are inserted. There are two grids placed in the pool. The lower (operating) grid is fixed, the upper grid (reserve) is removable, and common for both twin units. Both the operating and the reserves grids consist of two layers. The basic grid has capacity of 319 spent fuel assemblies and 60 hermetic cases for untight fuel (i. e. about 1 fuel loading).In case of short-term storage of fuel assemblies transported out of the reactor during inspections and repairs of the reactor internals, a reserve storage grid is used. It is placed above the basic grid, and it can accommodate 296 fuel assemblies and 54 hermetic cases.

The pool, which is open during refuelling, is connected through a transport passage to the refuelling pool (the area above the open reactor). Outside of fuel manipulation periods, the top of the spent fuel pool is covered and it is isolated from the refuelling pool by a slide gate that blocks the transport passage. This gate forms part of the hermetic confinement boundary during operation.

Status of Safety Assessments

	PSR (Periodic Safety Review)	**Licence for operation extended for 10 years**
NPP Bohunice V-2	completed	until 2018
NPP Mochovce 1,2	completed	until 2021

Generic scheme of VVER 440/V213 systems is shown in Figure 4.

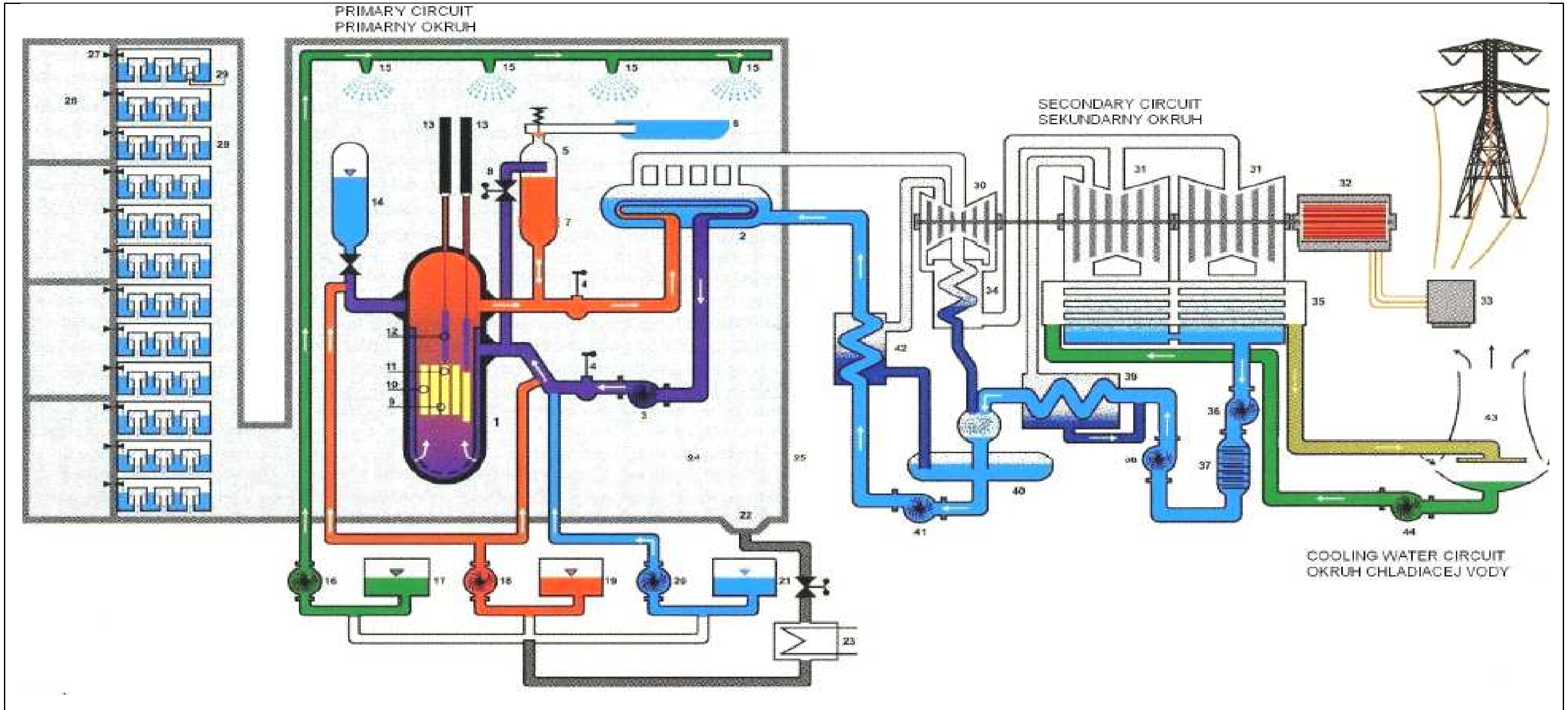

Figure 4: Generic scheme of VVER 440/V213

1 –Reactor, 2 – Steamgenerator, 3 – Main coolantpump, 4 – Main isolating valve, 5 – Pressurizer, 6 – Bubbler condenser, 7 – Pressurizer, 8 – PRZ injections, 9 – Reactorcore, 10 – Fuel assembly, 11 – Automatic control rod (ACR), fuel section, 12 – Automatic control rod (ACR), absorber section, 13 – ACR drives, 14 – Hydroaccumulators, 15 –- Spray system, 16 – Spray pump, 17 – Spray system tank, 18 – Low pressure emergency pump, 19 – LP emergency system tank, 20 – HP emergency pump, 21 – HP emergency system tank,22 – Containmentsuctionsump, 23 – Spray system cooler, 24 – Containment, 25 – Reinforcedconcretecontainmentwall,26 – Bubbler condenser tower air trap, 27– Check valve, 28 – Bubbler condenser tower, 29 – Bubbler condenser towerflumes, 30 – HP stage of steam turbine, 31 –LP stage of steam turbine, 32 –Electricalgenerator, 33 – Unit transformer, 34 – Steamseparator and reheater, 35 – Condenser, 36 – Condensatepump, 38 – Condensatepump (stage 1), 37 – Condensatetreatment, 38 – Condensatepump (stage 2), 39 – LP regeneration, 40 – Feedwater tank, 41 – Main electricfeedwaterpump, 42 – HP regeneration, 43 – Coolingtower of circulating water, 44 – Circulating water pumps

1 Executive Summary

Currently there are 4 VVER 440/213 nuclear units in operation in Slovakia, 2 units in Jaslovské Bohunice and another 2 in Mochovce site. In Mochovce there are also another two VVER 440/213 units with significantly upgraded design under construction. Total installed power of operated VVER 213 units is 1,940 MWe. The owner and operator (the holder of the operating permit) of all operating and constructed nuclear units in Slovakia is a stock company Slovenské elektrárne, a. s. (SE, a. s.).

The European Council at its meeting held on 24 and 25 March 2011 stressed the need to fully draw lessons from the Fukushima events and to provide all necessary information to the public. Recalling that the energy mix is the competence of Member States, it called for work (inter alia), to be taken as a matter of priority on the following aspects:

- The review of the safety of all EU nuclear plants on the basis of a comprehensive risk and safety assessment ("stress tests"), the scope and modalities of which should be developed by ENSREG (European Nuclear Safety Regulators Group) and the Commission in light of lessons learned from Fukushima, making full use notably of WENRA´s (Western European Nuclear Regulators Association) expertise;
- The assessment will be conducted by independent national authorities and through peer reviews, their outcomes and subsequent measures should be made public;

The European Council will assess initial findings on the basis of a Commission report.

In view of the lessons learned from 11 March 2011 Fukushima accident the owner performed so called stress tests on all units in operation or under construction. The task was further specified and its scope outlined in the letter of the regulatory body and several subsequent meetings between the operator and the regulator. The results of the stress tests as an adopted measures, serve as basis for preparing the national report.

The state regulatory authority performing the state supervision upon the nuclear safety of nuclear installations is the Nuclear Regulatory Authority of the Slovak Republic (UJD SR). The state supervision over nuclear safety is performed in accordance with the Atomic Act (No. 541/2004) and subsequent set of regulations, in particular Regulation No. 430/2011 on laying down details of the requirements for nuclear safety. The whole set of legislative basis has been updated quite recently (in the period 2004-2006), in line with the progress in the development of the IAEA Safety Requirements and established WENRA Reference Levels. The legislation reasonably covers also the issues relevant for the European stress tests. In addition, a new revision of the atomic act is under development. Lessons learned from the stress tests and their peer review is going to be evaluated and the legal framework will be amended if it is necessary.

Relevant Safety Analysis Reports updated in line with the regulatory requirements and accepted by the regulatory body are available for all plants. PSA studies Level 1 and 2 are also available, demonstrating compliance with internationally established safety objectives. The latest update of the SAR for NPP Bohunice V-2 was performed in 2009, for EMO1,2 in 2010. For EMO3,4 units the Preliminary SAR was issued in 2008, preparation of the Preoperational SAR is currently in progress. Similarly, the latest update of PSA Level 1 and 2 was done in 2010 for NPP Bohunice V-2 and in 2011 for EMO1,2. It is expected that parts of safety documentation specific for rare extreme external hazards will be further updated and extended in accordance with lessons learned from the stress tests.

In accordance with the Slovak national legislation all plants in Slovakia are subject to Periodic Safety Reviews with 10 years periodicity. The latest periodic review in NPP Bohunice V-2 was completed in 2008, in EMO1,2 in 2009. Based on the results of the review the UJD SR issued operational permit for subsequent 10 years of operation. The permits are associated with approval of safety upgrading programme of the plants aimed at closer compliance of the safety level with contemporary safety standards. The programmes include also implementation of comprehensive severe accident mitigation measures.

All operating units in Slovakia have been subject of a number of international missions performing independent review of their safety level. Since 1991 there were in total about 20 IAEA missions (site review, design review, OSART, IPSART missions), 6 WANO missions, 2 RISKAUDIT missions and 1 WENRA mission.

Based on WANO recommendations during the period from April to October 2011 the non-standard tests and inspections of equipment important for coping with extreme conditions exceeding the basic design were successfully performed on the operating units. The tests included verification of the long-term run of diesel generators, the possibility for delivery of cooling water from the bubbler-condenser to the spent fuel pool, for feedwater supply to steam generators from a mobile source, for supplying of water from cooling towers to essential service water system, connection of a back-up power supply from the hydro power plant, and others.

For determination of safety margins in nuclear units a systematic approach called Configuration Matrix Method was developed. The approach is based on verification of performance of the fundamental safety functions for occurrence of events during operation at power as well as during shutdown modes, taking into account both fuel in the reactor as well as in the spent fuel pools. The approach identifies all feasible configurations of plant systems, both safety and operational, capable of maintaining safety functions with consideration of all possible connections available according to the design as well as those that can be set-up by personnel under given conditions in available period of time. The approach verifies presence of all conditions for functioning of the systems (i. e. power supply, working medium, instrumentation, environmental conditions, accessibility by operators, availability of procedures) and assesses how eventually these systems will be disabled in their turn with increasing load induced by the external hazards. The evaluation includes consideration of the human factor, logistic and administrative provisions for staff response in case of events initiated by unlikely extreme external conditions. All relevant information was arranged in a special database containing approximately 2,500 structures, systems and components, which will remain available for future plant safety assessments. The Configuration Matrix Method was subsequently adopted by the IAEA as one of the approaches for IAEA independent reviews.

In the text below, the main results for the different areas of the assessment performed within the stress tests are summarized.

Earthquakes

There are no tectonic structures located on the territory of the Slovakia and adjacent territories that could cause extremely strong earthquakes comparable to catastrophic earthquake in Japan. Nevertheless, the seismicity is an issue which was seriously considered in design, operation and safety upgrading of the plants and covered by the stress tests. The seismic monitoring system has been implemented and is currently in use around the nuclear sites for early identification of any seismic activity potentially affecting the NPPs.

The assessment of the seismic level of the sites was developed in accordance with IAEA recommendations. It is reflecting the current state of the art and was accepted by several international missions. In subsequent safety upgrading steps, capability of all nuclear units to maintain fundamental safety functions have been strongly increased since the original design. For NPP Bohunice V-2 the initial design basis value of horizontal acceleration at ground level (PGA) 0025 g has been increased through PGA=0.25 g (upgrading performed in 1995) up to the current value PGA=0.344 g, with corresponding upgrading completed in 2008. Similarly, in Mochovce the initial site value PGA=0.06 g was increased (based on the IAEA recommendation) to 0.1 g, which was used for the plant construction. Recently using the state of the art method the site seismic level has been raised to 0.143 g. Subsequently the regulatory body has set up the value PGA=0.15 g as a design basis for construction of EMO3,4 and for safety upgrading of EMO1,2 units. Since the upgrading was largely based on conservative approach considering mainly elastic behaviour of the structures, there is a margin even above the increased PGA values. Taking into account properties of materials used for individual safety system components, with increasing loads first the occurrence of plastic deformation should take place and only after exceeding the structural limit values the component damage will occur. However, such assessment is beyond the current regulatory requirements and international standards, and the margin was not quantified yet. More refined analyses are in progress in order to define the extra margin embedded in the original conservative design assumptions. The preliminary estimates indicate that safety margins are well beyond the design values. These margins are expected to be quantified by further evaluations.

In spite of the fact that robustness of the plant against earthquakes has been significantly increased recently and it is considered adequate in accordance with the current requirements, there are additional safety upgrading measures envisaged including in particular quantification of margins of key SSCs for earthquakes beyond the design basis earthquake and development of a seismic PSA.

Flooding

Floods from surface water sources, failure of dams, effects of underground water and extreme meteorological conditions as potential sources of flooding were thoroughly analyzed. Internal flooding due to rupture of pipelines following the earthquakes was considered in the assessment, too. Due to the inland location of the sites, their distance from the sources of water and the site topography and plant layout conditions, flooding of the site due to the sources of surface water from rivers or lakes can be screened out, similarly as from the ground water. Analysis of potential failures of dams on the rivers Vah and Hron has shown that the induced flooding wave can temporarily disable pumping stations which provide raw water to the plants. These events are conservatively addressed in the stress test report as long-term losses of the ultimate heat sink.

The only meaningful sources of the site flooding are extreme meteorological conditions (strong rain, snow, combination of rain and snow melting). Recently (2011) updated study of extreme meteorological conditions for the Mochovce site was used for the assessment. Flooding of the site due to extreme precipitation is very unlikely; only if extreme precipitation is conservatively combined with blockage of the sewer system and with neglecting any recovery staff actions, up to 10 cm site water level was conservatively estimated for the return period of 10,000 years.

Electrical components/systems are the most vulnerable to flooding, depending on their location/elevation in the relevant civil structures. Proper sealing of the buildings and sufficient elevation of the entrance doors provide an adequate protection against flooding. Detailed verification has demonstrated that in both Mochovce plants large margins (more than 2-times) are already available. In Bohunice, adequate temporary fixing has been implemented and the final permanent protection is in its pre-design stage. In addition, for the situations without any fixing time for flooding safety important components/systems was estimated demonstrating that the time margin to flooding of essential power supply is more than 72 hours. It is important to state that flooding due to precipitation does not occur suddenly and it is not associated with damaging hydrodynamic wave, therefore time margins exist and damaging impact is much less significant.

The measures for further improvements of the current situation include updating the procedures for prevention of the blockage of inlets to the sewer system, development of an updated meteorological study also for the Bohunice site, completion of the on-going implementation of preventive measures against water entering into the buildings and providing additional fire brigade pumps for removal of water from the flooded area. In addition it is required that the comprehensive assessment of the extreme meteorological conditions will be performed and corresponding parts of the SARs will be updated in order to take into account new meteorological data, ongoing plant upgrading measures and state of the art methodology.

Extreme meteorological conditions (other than extreme precipitation)

Assessment performed within the stress tests included meteorological events and their combinations, such as extreme temperatures and humidity, extreme drought, ice and snow impact, extreme direct and rotating wind. Feasibility of logistics needed for the emergency preparedness was also evaluated.

Due to location of Slovakia in the mild meteorological region of Europe, extreme conditions were not considered as a major issue in the past, resulting in some cases in limited design information regarding resistance of plant systems, structures and components. Subsequently the evaluations of the effects of extreme meteorological conditions in the stress test report are mostly qualitative (in particular in NPP Bohunice V-2), based on operating experience and on engineering judgment. Nevertheless, the performed assessment and operational experience has proved that the resistance of the plant against meteorological extremes is acceptable. Extreme drought does not represent serious safety issue since it is a slowly evolving process and the site water inventory is sufficient for more than 10 days of residual heat removal. In addition the upgrading measures implemented with the primary aim to increase seismic resistance contribute also to improved resistance against the wind. Since development of extreme meteorological conditions (except very strong wind) to severe loads on the plant requires certain time, the evaluations also show sufficient time margins for adoption of countermeasures in extreme conditions.

As already stated a new meteorological study has been developed for the Mochovce site and will be completed soon also for Bohunice. These new site data as well as ongoing plant upgrading measures and state of the art methodology will be taken into account in updating of the corresponding parts of the SARs also regarding extreme weather conditions (i. e. extreme wind, temperatures and humidity, snow amount, freeze and icing, and their combinations). This should include the detailed assessment of impact of extreme meteorological conditions on the vulnerability of high voltage line at the Bohunice and Mochovce sites. Among the prepared operational measures there are changes in plant operating procedures and preventive arrangements including increased frequency for plant walk-down to diesel generator stations during period of low temperatures, snowing and icing, and preventive measures at ambient temperatures bellow design values to maintain the functionality of the required equipment.

Loss of electrical power and loss of ultimate heat sink

Regarding the risk of loss of power supply it may be taken into account that in both sites there are 8 different options (with different vulnerability to external hazards) for providing power supply to plant home consumers (in addition to their redundancies); 5 of these options are independent on the electricity distribution grid. These various options can be activated either automatically or by plant staff within few tens of seconds up to two hours. There are back-up power sources capable to provide power supply for unlimited period of time. The same possibility is offered by connecting the NPPs to the preselected hydro plants. Internal power sources in the plant not dependent on the external grid include 3 x 100 % redundancy emergency DG with fuel reserves for 9 - 10 days. A decision on installation of DG dedicated to management of severe accidents has been made as a result of the conducted PSRs already before the Fukushima accident and implementation is currently in progress. In addition mobile DGs for recharging the batteries in case of a long-term SBO and loss of all other AC power sources are being procured. Capacity of batteries was demonstrated to be sufficient for 8 - 11 hours and further margins exist in optimization of their use and possibility of their recharging from a DG currently being purchased.

Time margins to irreversible losses vary according the operating regimes and success of individual measures. Large number of combinations were analysed and addressed in the stress test report; only some of them are presented below. It was confirmed that there are inherent safety features of VVER 440/V213 contributing to significant time margins in case of loss of electric power and loss of ultimate heat sink, which include the large thermal inertia due to low power and comparably large amount of water both in primary and secondary system, as well as large volume of water inside the containment stored in the pressure suppression system potentially available for cooling of fuel.

Time margins in case of SBO occurring at full power, using only coolant inventory available in primary and secondary circuit is about 32 hours, using a mobile emergency source would extend the margin to more than 10 days, without any off-site assistance. For shutdown regimes this time interval is extended at least to 2.7 days, and with use of demineralised water emergency tanks up to 13 days. For loss of heat removal from the spent fuel pool, time margins without any operator actions are more than 30 hours for the most conservative case with complete off-loading of the core into the pool, or more than 150 hours for more realistic situations (for partial core unload). These margins can be further extended by about 4-14 hours using coolant from the bubbler condenser trays. Staff interventions by means of the fire trucks would resolve the issue for the unlimited period of time. Containment integrity in case of a complete loss of heat removal will be maintained (without staff actions) for at least 3 - 5 days.

For NPPs in Slovakia the external atmosphere serves as the primary ultimate heat sink, steam dumping to the atmosphere is an alternate mode of heat removal. Although this UHS in principle cannot be lost, the transport of heat to the UHS can be disabled. Such situations were subject to assessment within the stress tests. If normal plant cooling through the secondary circuit and cooling towers is not available, remaining options include direct release of steam from steam generators to atmosphere through the steam by-pass stations, or by primary circuit feed and bleed, or by heat removal through the essential service water system, the last one being qualified also for emergency conditions. Since failure of all essential service water systems could have serious consequences regarding heat removal from the core, from the spent fuel pool and from the containment, this case was analysed in detail in the stress tests as the most conservative one. If the loss of essential service water is not caused by the station black-out discussed above, loss of raw water supply should be considered. However, large water inventory of cooling water in each unit is sufficient for heat removal for about 8 to 16 days and on-site inventory for about a month. The case of a combined station black-out and loss of ultimate heat sink in case of VVER 440/V213 design is in fact covered by the station black-out only, since the station black-out is always connected with the loss of ultimate heat sink.

As described above, the evaluation of safety margins at station black-out proved the ability to ensure protection of safety barriers during considerably long time, thus providing sufficient time for accident management actions for recovery of the plant power supply. Despite the robustness of the current plant design, the following improvements are still being considered:

- To increase resistance and reliability of AC emergency power supply for beyond design basis accidents by installation of new 6 kV emergency DG for severe accidents,
- To provide 0.4 kV DG for each unit for charging batteries and supplying selected unit consumers during SBO including modifications of the pumps of borated coolant system enabling their use during SBO,
- To provide technical solution and cable pre-preparation in order to facilitate mechanical interconnection of batteries between systems,
- To provide lowering the need for emergency illumination in order to extend life time of batteries (subdivision into sections with the possibility for switching off unnecessary consumers, use of energy saving bulbs),
- To provide monitoring system of capacity of batteries (for NPP Bohunice V-2),
- To provide mobile measuring instruments able to use stabile measuring sensors without power supply,
- To provide vital power supply for containment drainage valves and hydroaccumulator isolation valves (for EMO),

- To consider possibility to control selected valves without vital power supply by means of small portable motor 3-phase generator 0.4 kV,
- To develop operating procedure for possible use of diesel generators installed in Levice switchyard for SBO event (for EMO),
- To assure long-term serviceability of communication means for MCR operators and shift service staff,

For enhanced resistance of the plant in the case of loss of UHS the following modifications are planned:

- To provide additional mobile high-pressure source of SG feedwater for each site, and to ensure logistics of supplies for the mobile source, with possible use for both EBO and EMO (the same nozzles),
- To establish the logistic system for provision of emergency feedwater to suction of mobile emergency pumps from external pure (potable water) water sources after exhaustion of demineralized water inventory,
- To modify connection of emergency mobile source of coolant to the emergency feedwater system suction and discharge with accessibility from the ground level (in EMO) in order to ensure availability of the source in cases of internal and external floods and fires,
- To construct a fixed line for maintaining the coolant inventory in SFP from a mobile source (fire pumps),
- To consider modifications providing for removal of steam from the SFP to the reactor hall and to the atmosphere is case of coolant boiling,
- To document behaviour of the reactor coolant pump seals at long-term failure of cooling (more than 24 hours) in the UHS loss regime.

Severe accident management

Development and implementation of the accident management programme including mitigation of severe accidents has been an on-going process in all nuclear units in Slovakia independently of the Fukushima accident. Symptom-based emergency operating procedures (EOPs) addressing design basis accidents and preventive part of severe accidents were fully implemented in NPP Bohunice V-2 and EMO1,2 in 1999 (for events initiated during power operation) and in 2006 (for events initiated in the reactor under shutdown or in the spent fuel pool). Plant specific severe accident management guidelines (SAMG) were prepared for NPP Bohunice V-2 and EMO1,2 during the period from 2002 to 2004. In 2004-2005, an overall study defining technical specification of modifications and extensions of the VVER 213 basic design needed for implementation of SAMG was prepared. The project of implementation of modifications to support the severe accident management on the basis of SAMG was proposed in compliance with all the requirements and recommendations in Slovak legislation in 2006 - 2007. The SAM implementation project was initiated in 2009 as the common NPP Bohunice V-2 and EMO1,2 project with deadline in 2013 in EBO and the follow-up implementation in EMO1,2 (implementation accelerated after the Fukushima, with the new deadline 2015).

The measures being implemented include dedicated means for the primary circuit depressurization, hydrogen management using passive autocatalytic recombiners, containment under-pressure protection, in-vessel corium retention by strengthening of the reactor cavity and providing for its flooding, dedicated large external tanks with the boric acid solution with dedicated power source and pump aimed at possible spent fuel flooding, and serving as a supplementary source of coolant for the reactor cavity flooding and for washing out the fission products from the containment atmosphere, modifications enabling coolant make-up to the reactor cavity, spent fuel pool and external source tanks using mobile source connected to the external connection point on walls of the reactor building and auxiliary building, and associated I&C needed for severe accident management. The measures are being implemented for possible use of large amount of coolant from the water trays of the bubbler condenser as an additional source of coolant. Implementation of reliable in vessel molten corium retention prevents complicated ex-vessel phenomena associated with core-concrete interaction, direct containment heating, production of non-condensable gases leading to containment over pressurization, etc.; all these phenomena are associated with large uncertainties.

Large part of the required plant modifications has been already implemented (e. g. installation of autocatalytic recombiners, measures for flooding of the reactor cavity). The long term heat removal from the containment is in the current scope of the SAM project ensured by recovery of service ability of the design basis equipment – the containment spray system.

SAM project being currently implemented in both NPP Bohunice V-2 and EMO1,2 is based on originally defined scope with assumptions for occurrence of a severe accident on only one of two units. In view of the lessons learned the project completion will be followed by evaluation of a possible extension to management of a severe accident on both units at the same time. Further SAMG improvement and preparation of additional supporting documents for decision making by SAMG and main control room teams will be adopted based on results of validation at the project completion.

Regulatory approach

The available legislation provides for sufficient power and flexibility for the regulatory body to address situations like the Fukushima accident. In particular, the Atomic Act among other requires to reassess the safety level of nuclear facilities and to take adequate countermeasures after obtaining new significant information about the associated risks. The obligation to perform the relevant assessment and implement the countermeasures is put on the licence holder.

As already explained the regulatory body gradually updates the relevant Slovak nuclear safety legislation in accordance with the progress harmonized under the WENRA framework and IAEA Safety Requirements. The plants are being upgraded towards closer compliance with the new requirements within the Periodic Safety Review processes.

After Fukushima, several meetings have been held between the operator and the regulatory body in order to provide for common understanding of the issues. The regulatory body supports commitments of the operating organization to comprehensive assessment of plant vulnerabilities and margins against external natural hazards as well as implementation of additional measures for further safety enhancement of the plants.

The regulatory body is convinced that the process should not be finished by implementation of several individual actions and requires that new challenges as well as required upgrading will be comprehensively evaluated and reflected in the updated Safety Analysis Reports. This requirement applies in particular to the need of updating the Safety Analysis Reports in the area of site characteristics relevant for external and internal hazards as well as plant vulnerabilities and resistance against such hazards. It is specifically required that the comprehensive assessment of the extreme meteorological conditions will be performed and corresponding parts of the SARs will be updated in order to take into account new meteorological data, on-going plant upgrading measures and state of the art methodology.

In addition to existing studies taking into account limited time frameworks the regulatory body will ask for further systematic and comprehensive assessment of plant resistance to the station blackout and loss of ultimate heat sink taking into account the measures for increasing robustness of the plants. Similarly, adequacy of already available analyses for the progression of severe accidents should be assessed. All the assessment should be followed by the evaluation of adequacy of hardware, procedural and organizational provisions for addressing such situations and corrections implemented, as necessary. In particular, occurrence of severe accidents in parallel at several reactors (up to all of them) in the given site under conditions of severely damaged area infrastructure should be considered. It is recommended to harmonize the approaches with the operators of similar reactor types, taking into account all relevant lessons learned from the stress tests. Completion of such works is preliminary expected in about 3 years. The final scope and schedule should benefit and preferably be harmonized within Europe with the use of the peer review of the stress tests.

National Organization on Emergency Preparedness

Acting under its material competence as the executive body of the Slovak Government, the Central Crisis Staff (hereinafter referred to as CCS) is the supreme crisis management authority in accordance with Act No. 387/2002 Coll. All government departments and other central authorities of state administration are represented on CCS which co-ordinates activities of state administration, self-government and other components while handling a crisis situation, i.e. in relation to UJD SR and in dealing with a nuclear installation incident or accident or during transport. The Crisis Management System (whose part is CCS) consists, in addition to the Government, ministries and other central state administration authorities, of local state administration and self-governing bodies.

The UJD´s Emergency Response Centre (hereinafter referred to as “ERC“) is a technical support vehicle to monitor NI operation and assess technical condition and radiation situation in the event of a nuclear or radiation emergency, and to forecast emergency evolution and consequences by course of Act No. 541/2004 Coll. The Centre at the same time serves as a CCS technical support vehicle.

The Slovak Centre of Radiation Monitoring Network (hereinafter referred to as “SCRMN“ is a technical support body intended to provide an effective monitoring system involving the monitoring systems of the respective government departments. It was established at the Public Health Authority of SR under Act No. 355/2007.

On-site emergency plans and related documents are developed so as to provide for the protection and preparation of personnel in case of a major leak of radioactive substances into the working environment or surrounding area and it is necessary to take action to protect health of individuals at the nuclear installation or of the public in its surrounding area.

In compliance with legislation, the license holder must notify state administrative immediately after the classification of incident as Level 1 - emergency. After that, the license holder must subsequently inform the government authorities about the status of the incident. In case that the event develops to the level 2 – on-site emergency, the On-site System of Notification and Warning is activated and at level 3 of Off-site System of Notification and Warning is activated in specified sectors of emergency planning zone.

State administration authorities in the emergency planning zone have their own emergency plans.

International Cooperation

The Slovak Republic is a signatory of international Conventions on Early Notification in Case of a Nuclear Accident and on Mutual Assistance in Case of a Nuclear Accident, thereby ensuring international cooperation in minimizing consequences of a nuclear accident.

Further to Art. 9 of the Convention on early notification of a nuclear accident, the Slovak Republic succeeded or concluded bilateral agreements in the field of early notification of a nuclear accident, exchange of information and co-operation with all neighbouring countries. The agreements lay down the form, the method and the scope of information to be provided to contracting parties in the case of an accident relating to nuclear installations or nuclear activities, and establish the co-ordinators of contact points. The purpose of the said agreements is to make a contribution toward minimizing the risk and consequences of nuclear accidents and creating a framework for bilateral co-operation and exchange of information in areas of common interest in regard of peaceful uses of nuclear energy and protection against radiation.

Cooperation between the SR and the IAEA in the field of nuclear safety has been extraordinarily successful. Within of this cooperation expert missions are focusing on nuclear safety review. During the last decade dozens of expert mission were invite.

Results of specific <u>short term</u> actions made on EBO NPPs performed just after the Fukushima accident

Test title	Performance data/Planned performance	Test result
Test of reactor and SG auxiliary venting throughput during an overhaul.	Unit 3: 30 July 2011 Unit 4: 26 June 2011	Completed satisfactorily Completed satisfactorily
Test of opening connection from MCP motor room to steam generator compartment.	Unit 3: week 34 Unit 4: 30 June 2011	Completed satisfactorily Completed satisfactorily
Test of SFP make-up from bubble-condenser tower flumes	Unit 3: 4 August 2011 Unit 4: 27 June 2011	Completed satisfactorily Completed satisfactorily
Test of electricity supply from the 3rd source of V-2 NPP home consumption from Madunice HPP	week 34-35	
Test of make-up water recovery to V-2 NPP	All-Plant Exercise 19 October 2011	
Long-term type test 72 hours DG	Unit 4: 24 June 2011	Completed satisfactorily
Test of recovery of water supply by a mobile source to SG.	Unit 3: 18 August 2011	Completed satisfactorily
Test of capacity of petrol pumps from circulation cooling water tower pools to the ESW system.	25 May 2011	Completed satisfactorily
Test of unit cool-down by RHR system.	Unit 3: 31 July 2011	Completed satisfactorily
Test of auxiliary water pumping by fire pumps from flooded areas.	All-Plant Exercise 19 October 2011	-
Test of minimum pressurizer safety valve opening pressure.	Unit 3: 31 July 2011	Completed satisfactorily
Inspection of areas, where parts of auxiliary safety systems under the terrain level are situated, from the viewpoint of potential flooding during extremely long-time rains.	Unit 3: 21 April 2011 Unit 4: 21 April 2011	Completed satisfactorily, measures proposed
Inspection of barriers against water penetration between rooms inside V-2 NPP.	Unit 3: 21 April 2011 Unit 4: 21 April 2011	Completed satisfactorily, measures proposed
Inspection of rain water system capacity. Inspection of condition of barriers preventing water penetration from outside to power plant premises during extremely long-time rains.	Unit 3: 21 April 2011 Unit 4: 21 April 2011	Completed satisfactorily, measures proposed

Results of specific <u>short term</u> actions made on EMO NPPs performed just after the Fukushima accident

Test title	Performance data / Planned performance	Test result
Test of reactor and SG auxiliary venting throughput during an overhaul.	Unit 1: 10 May 2011 Unit 2: October 2011 during the outage	Completed satisfactorily
Test of opening connection from MCP motor room to steam generator compartment.	Unit 1: 29.4.2011 Unit 2: October 2011 during the outage	Completed satisfactorily
Test of SFP make-up from bubble-condenser tower flumes	Unit 1: 27.4.2011 Unit 2: October 2011 during the outage	Completed satisfactorily
Test of make-up water recovery to EMO1,2 NPP	April 2011	Completed satisfactorily
Test of recovery of water supply by a mobile source to SG.	Unit 1: 18 August 2011	Completed satisfactorily
Test of capacity of petrol pumps from circulation cooling water tower pools to the ESW system.	6 May 2011	Completed satisfactorily
Test of auxiliary water pumping by fire pumps from flooded areas.	April 2011	Completed satisfactorily
Inspection of areas, where parts of auxiliary safety systems under the terrain level are situated, from the viewpoint of potential flooding during extremely long-time rains.	Unit 1: 21 April 2011 Unit 2: 21 April 2011	Completed satisfactorily, measures proposed
Inspection of barriers against water penetration between rooms inside EMO1,2 NPP.	Unit 1: 21 April 2011 Unit 2: 21 April 2011	Completed satisfactorily, measures proposed
Inspection of rain water system capacity. Inspection of condition of barriers preventing water penetration from outside to power plant premises during extremely long-time rains.	Unit 1: 21 April 2011 Unit 2: 21 April 2011	Completed satisfactorily, measures proposed

Summary Table

of long term actions (in addition to short term actions)

Activity	Activities by the Operator*			Activities by the Regulator*		
	(Item 2.a) Activity - Taken? - Ongoing? - Planned?	(Item 2.b) Schedule Or Milestones for Planned Activities	(Item 2.c) Results Available - Yes? - No?	(Item 3.a) Activity - Taken? - Ongoing? - Planned?	(Item 3.b) Schedule Or Milestones for Planned Activities	(Item 3.c) Conclusion Available - Yes? - No?
Topic 1 – External Events						
• There are additional safety upgrading measures envisaged including in particular - quantification of margins of key SSCs for earthquakes beyond the design basis earthquake; - development of a seismic PSA; - updating the procedures for prevention of the blockage of inlets to the sewer system; - completion of the on-going implementation of preventive measures against water entering into the buildings and providing additional fire brigade pumps for removal of water from the flooded area;	Planned Planned Planned Planned			• The available legislation provides for sufficient power and flexibility for the regulatory body to address situations like occurred following the Fukushima accident. In particular, the Atomic Act among other. • After Fukushima, several meetings have been held between the operator and the regulatory body in order to provide for common understanding of the issues. • Additional measures by the regulator will be		

- a new meteorological study has been developed for the Mochovce site and will be completed soon also for Bohunice site; - updating of the corresponding parts of the SARs also regarding extreme weather conditions (i.e. extreme wind, temperatures and humidity, snow amount, freeze and icing, and their combinations); - operational measures like changes in plant operating procedures and preventive arrangements (including increased frequency for plant walk-down to diesel generator stations during period of low temperatures, snowing and icing, and preventive measures at ambient temperatures bellow design values to maintain the functionality of the required equipment).	Completed for EMO Ongoing for EBO Planned Ongoing	Completion of such works is preliminary expected in about 3 years.		taken after the peer review processes of the "stress tests" and inputs form the public participation if relevant. • The regulatory body will ask for further systematic and comprehensive assessment of plant resistance to the station blackout and loss of ultimate heat sink etc.		
Topic 2 – Design Issues						
• Reinforced power supply: - To increase resistance and reliability of AC emergency power supply for beyond design basis accidents by installation of new 6 kV emergency DG for severe accidents;	Planned			• After Fukushima, several meetings have been held between the operator and the regulatory body in order to provide for common understanding of the issues. • Additional measures by		

- To provide 0.4 kV DG for each unit for charging batteries and supplying selected unit consumers during SBO including modifications of the pumps of borated coolant system enabling their use during SBO;	Planned			the regulator will be taken after the peer review processes of the “stress tests” and inputs form the public participation if relevant.		
- To provide technical solution and cable pre-preparation in order to facilitate mechanical interconnection of batteries between systems;	Planned					
- To provide lowering the need for emergency illumination in order to extend life time of batteries (subdivision into sections with the possibility for switching off unnecessary consumers, use of energy saving bulbs);	Planned					
- To provide monitoring system of capacity of batteries (for NPP Bohunice V-2);	Planned					
- To provide mobile measuring instruments able to use stabile measuring sensors without power supply;	Planned					
- To provide vital power supply for containment drainage valves and hydroaccumulator isolation valves (for EMO);	Planned					

- To consider possibility to control selected valves without vital power supply by means of small portable motor 3-phase generator 0.4 kV;	Planned					
- To develop operating procedure for possible use of diesel generators installed in Levice switchyard for SBO event (for EMO);	Planned					
- To assure long-term serviceability of communication means for MCR operators and shift service staff.	Planned					
• For enhanced resistance of the plant in the case of loss of UHS the following modifications are planned:						
- To provide additional mobile high-pressure source of SG feedwater for each site, and to ensure logistics of supplies for the mobile source, with possible use for both EBO and EMO (the same nozzles);	Planned					
- To establish the logistic system for provision of emergency feedwater to suction of mobile emergency pumps from external pure (potable water) water sources after exhaustion of demineralized water	Planned					

inventory; - To modify connection of emergency mobile source of coolant to the emergency feedwater system suction and discharge with accessibility from the ground level (in EMO) in order to ensure availability of the source in cases of internal and external floods and fires; - To construct a fixed line for maintaining the coolant inventory in SFP from a mobile source (fire pumps); - To consider modifications providing for removal of steam from the SFP to the reactor hall and to the atmosphere is case of coolant boiling; - To document behaviour of the reactor coolant pump seals at long-term failure of cooling (more than 24 hours) in the UHS loss regime; - increase of site self sufficiency from 24 hours to 72 hours after implementing modifications to SAM	 Planned Planned Planned Planned Planned					

Topic 3 – Severe Accident Management						
• Plant specific severe accident management guidelines (SAMG) were already prepared for NPP Bohunice V-2 and EMO1,2 during the period from 2002 to 2004.		Completed				
• Further SAMG improvement and preparation of additional supporting documents for decision making by SAMG and main control room teams will be adopted based on results of validation at the project completion.	Planned			• After Fukushima, several meetings have been held between the operator and the regulatory body in order to provide for common understanding of the issues.		
• Modifications has been already implemented (e.g. installation of autocatalytic recombiners, measures for flooding of the reactor cavity), etc.		2013 for EBO resp. 2015 for EMO		• Additional measures by the regulator will be taken after the peer review processes of the "stress tests" and inputs form the public participation it relevant.		
Topic 4 – National Organizations						
				• The regulatory body gradually updates the relevant legislation in accordance with the progress under the WENRA framework and IAEA Safety Requirements.		

Topic 5 - Emergency Preparedness						
• At the end of December 2011 construction of the modernized warning and notification system for the public at the Nuclear Power Plants Bohunice V2 (IPR EBO 846) was successfully completed.		Completed 2011				
				• Resolution of the Government No. 320/2011 to the Minister of Interior of SR as the Chairman of the Central Task Force in cooperation with other ministries and other central authorities of state administration to prepare and realize simulated nuclear accident exercise at nuclear installation in Slovakia at a national level.	Planned by 31 Dec. 2012	N/A
				• Government resolution No. 819/2011 on the promotion of national defence for years 2012 – 2017 (which includes measures of state security in time of war, and state of emergency).	2012 – 2017	

Topic 6 – International Cooperation						
• Host an IRRS mission in 2012 including Fukushima modul. • Participate and implement "Stress Tests". • Participate in discussions related to changes to safety conventions.			Completed	• Extension of data exchange from monitoring stations with Hungary in connection with operation of Mochovce NPP. Taken May 2012 Ongoing	In progress (estimated 2012)	Completed

2 External Events

2.1 Seismic

2.1.1 Design basis

2.1.1.1 Earthquake against which the plants are designed

2.1.1.1.1 Characteristics of the design basis earthquake (DBE)

For preparation of basic design for NPP Bohunice V-2 the report of 1970 "Geological History, Tectonic Development and Seismicity in Jaslovské Bohunice" developed by GFÚ – SAV Bratislava was used. The report specified the maximum credible earthquake of Bohunice site with intensity of 6 – 6.5° MSC (Mercalli – Cancani - Siebert) at most (bal) or M = 4.2 of Richter's scale, according to data related to an earthquake of 1906. According to the report the peak horizontal acceleration was defined as PGA=0.025g. According to the standard CSN 730036 for constructions in seismic areas and places with intensity of 6° MSC or acceleration below 0.03g the earthquake effects need not be considered in the original plant design. **In subsequent steps, the original value was increased up to the current value 0.344 g**.

Similarly, for Mochovce site originally the seismicity level of 6° MSK 64 with horizontal free field acceleration PGA = 0.06 g with return period once per 10,000 years was specified. The accelerogram was derived from the earthquake in Vrancea in Romania from 1977. **In subsequent steps, the original value was increased up to the current value 0.143 g**.

2.1.1.1.2 Methodology used to evaluate the design basis earthquake

Initial seismological studies for the EBO site were prepared in 1969 – 1970 in compliance with CSN 730036 – Seismic Loading of Civil Constructions. Seismicity of the site was set to 7º of the MCS (Mercalli – Cancani – Siebert) scale using a map of seismic areas in the Czechoslovak Socialist Republic territory (see Figure 5). In compliance with the aforementioned standard (Article 31), a special study "Geological History, Tectonic Development and Seismicity of Jaslovské Bohunice" was prepared (06/1970) detailing EBO site seismicity. The document described seismicity of the site with important earthquake areas, seismically active geological fractures, seismic activity forecast with definition of maximum credible earthquake and in conclusion with expert opinion on seismicity with determined value of the maximum probabilistic earthquake as given above According to the study, the strongest probable earthquake in Jaslovské Bohunice may be the earthquake with 6 – 6.5° MCS, corresponding to 4.2 of the Richter's scale. The terrain in this territory is flat with maximal slope of 1°, which indicates favourable conditions excluding secondary earthquake effects, in particular a risk of gravitational dumping. It was stated that within the time period of 200 years, the strongest probable earthquake in Jaslovské Bohunice area will reach M = 4.2 of the Richter's scale (i. e. 6.5° MCS). Within the time period of 100 years, the assumed the strongest probable earthquake is in the range M = 3.5 and for the time period of 50 years in M = 3.0. It was subsequently stated that the earthquake in this area is a rare phenomenon, and, in compliance with the analysis, there were no seismic issues preventing use of this area as a construction site for a nuclear power plant. According to the standards valid at that time, it was not needed to prepare special seismic analyses.

For Mochovce site, originally the report on seismic risk of EMO site of 1978 was used, confirming by a simplified probabilistic assessment, that the earthquake with intensity of 6° MSK 64 will not be exceeded with return period once per 10,000 years; acceleration on free field PGA = 0.06 g. The value was increased to 0.1 g recommended as a minimum value (even currently) by the IAEA Safety Standards. Such value was used for completion of EMO 1,2 units.

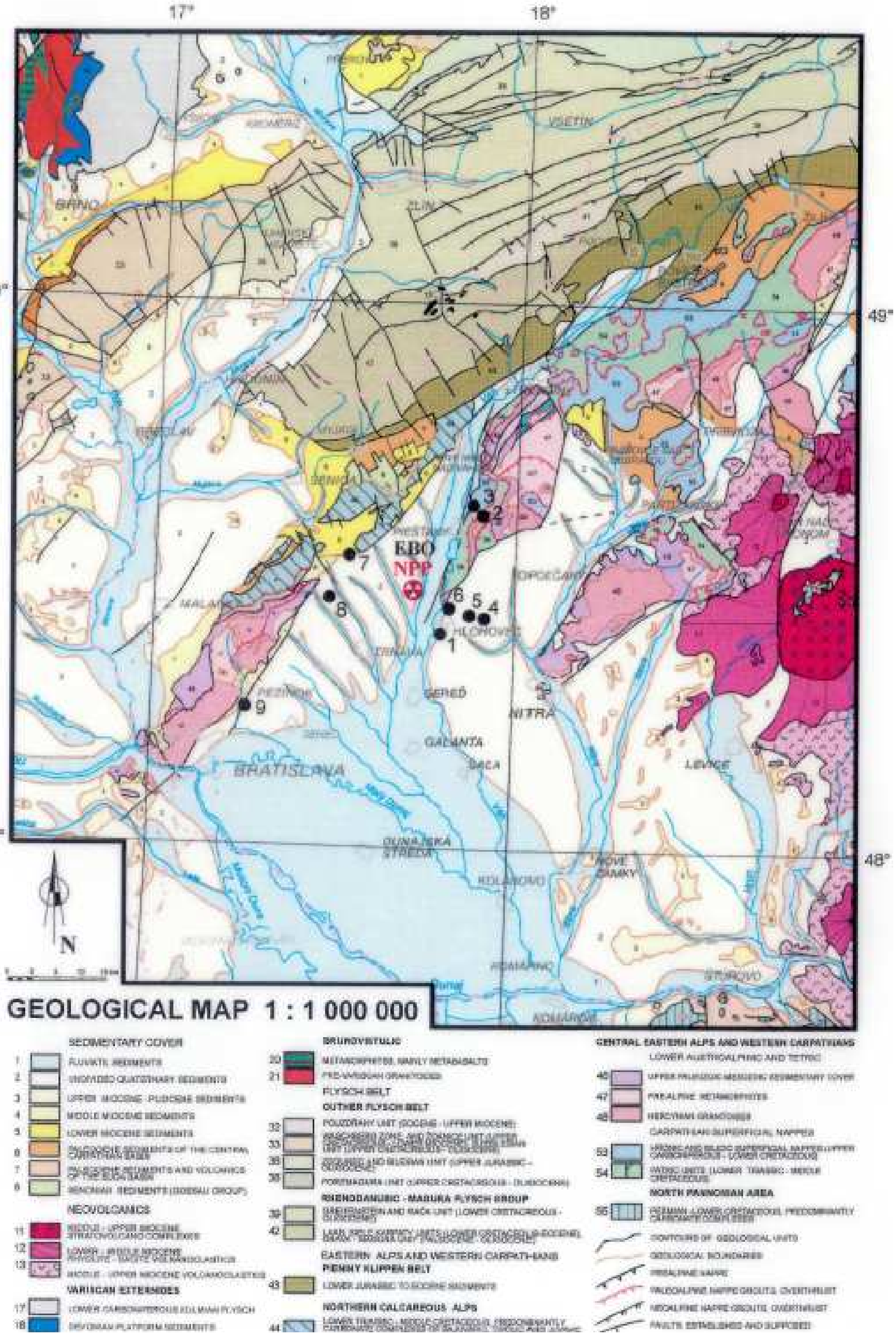

Figure 5: Geological map around NPPs in Slovakia

Taking into account the IAEA recommendations of 1998 and 2003, the UJD SR decided to increase the design-basis earthquake for Mochovce site with certain margin to PGA = 0.15g. This value is used for upgrading of EMO1,2. For EMO3,4, based on the probabilistic seismic assessment the UJD SR specified the value PGA=0.15 g as a design basis earthquake for the plant construction.

Conclusion on the adequacy of the design basis for the earthquake

Since 1980 till 2011, a number of different studies related to the seismic issues were elaborated for both sites in Slovakia ensuring that the current site assessment is performed in accordance with the current state-of-the-art knowledge.

NPP Bohunice V-2

Original plant design basis for the earthquake has been questioned since start up of the plant in 1986 and subsequently re-evaluated in several steps in accordance with development of methodologies, data and safety requirements. First step was the assessment of the seismic risk initiated by the Czechoslovak governmental commission in 1989. As a result of the work, the definition of the basic characteristics for the maximum design earthquake with the return period of 10,000 years and intensity of 8° MSK-64 was specifi ed as PGA = 0.25g in horizontal direction and PGA = 0.13g in vertical direction. Validity of this specification was conditioned by installation of permanent monitoring of seismic phenomena by a network of stations in Male Karpaty region.

In 1997, the new Probabilistic Seismic Hazard Analysis for EBO site was prepared. The final report covered several components in compliance with IAEA recommendations as follows:

- formation of seismological database and geological database in wider region, close region, close vicinity and for the site itself;
- preparation of seismic-tectonic model;
- specification of attenuation for chosen soil movement characteristics;
- execution of the probabilistic calculation itself.

The analysis resulted in determination of ground response spectra RLE (Review Level Earthquake) for the entire EBO site with the following main characteristics:

- Probability of occurrence once per 10,000 years;
- Intensity 8º of MSK 64 scale;
- Maximal horizontal acceleration PGA_{RLE-H} = 0.344 g
- Maximal vertical acceleration PGA_{RLE-V} = 0.214 g
- Duration of decisive movements 10 s.

These new data were used for recent seismic upgrading of existing systems, for structures and components, and for installation of new structures and components.

The Figure 6 below illustrates development in time the EBO site specific hazard. Since the original design, in terms of the peak horizontal acceleration, the robustness of the plant has been increased about 14-times.

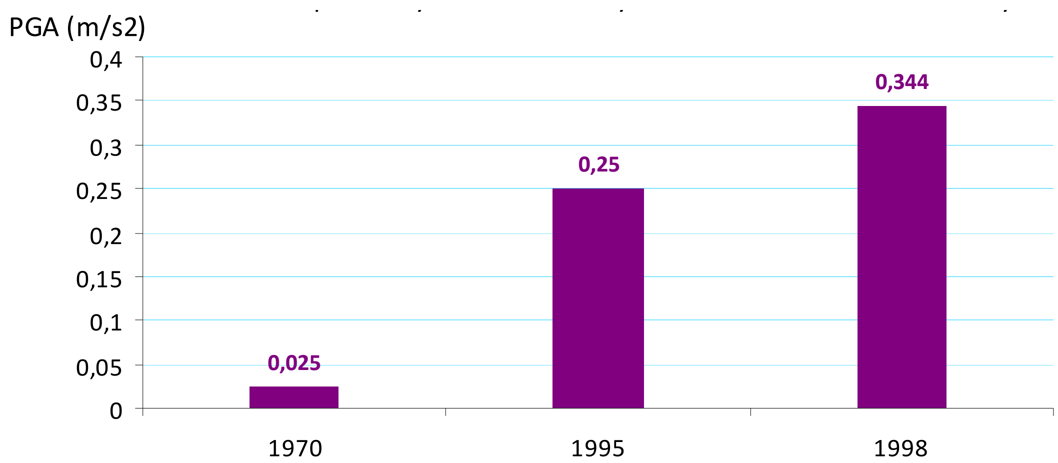

Figure 6: Gradual increase of EBO site seismic hazard

EMO

Following the decision on completion of EMO1,2, new assessment of the site seismic risk was made using deterministic approach, taking into account recommendations of the IAEA mission held in 1993.Based on this assessment, original design values (i. e. 6.5 - 7 MSK 64, acceleration of free field PGA = 0.06 g) were confirmed. However, recommendation of the IAEA Safety Guide No. 50-SG-S1 on minimum seismic resistance was accepted, with horizontal PGA= 0.1 g and the response spectrum from NUREG-0098 for bedrock. These input data were taken as a basis for the Technical Guide for Seismic Re-assessment Programme of the Mochovce NPP Units 1-4, prepared by IAEA in 1995. In 1996, the document “Requirements for Re-assessment of Seismic Resistance of EMO Units 1&2 Structures and Equipment” was prepared based on IAEA technical guide. This document, after positive confirmation by the UJD SR, became the fundamental document for EMO1,2 completion in the seismicity area.

After EMO1,2 commissioning, an IAEA mission took place in 1998, based on UJD SR invitation to verify seismic input data for EMO site. Based on recommendations of this mission, a detailed geological survey was performed in 1999-2003 aimed at identification of potential geological fractures in EMO region. The document “Probabilistic Analysis of Seismic Endangering of Mochovce NPP Site” was prepared in compliance with the IAEA Safety Guide NS-G-3.3 The document defined a new value for seismic level of the site, PGA = 0.143g according to the USNRC RG 1.165 (1997), with subsequent deaggregation of these values to the frequency of 10 Hz. The procedure of assessment and calculation methodology were verified and approved by the IAEA mission (SIDAM) in 2003. The probabilistic assessment resulted in determination of the seismicity levels for return periods of 475 years (SL1) and 10,000 years (SL2).

IAEA mission (SIDAM) in 2003 also recommended more detailed geological survey of Dobrica fracture that was identified as a potential active fracture. To document the aforementioned fracture stability or to prove its small depth, works documenting the fracture stability were made in 2006. In 2006, repeated measurements of shifts on the geodetic position net of the site were made in compliance with the IAEA mission recommendations, and in 2007 a sensitivity study of inclusion of fractures in the close Mochovce NPP region was prepared. Previous decisions regarding the seismicity level were not modified.

Taking into account the IAEA recommendations of 1998, 2003, the UJD SR decided to increase the design-basis earthquake for Mochovce site with certain margin to PGA = 0.15g (see

Figure 7). This value is used for completion of MO 3,4 and also for currently ongoing upgrading of EMO1,2.

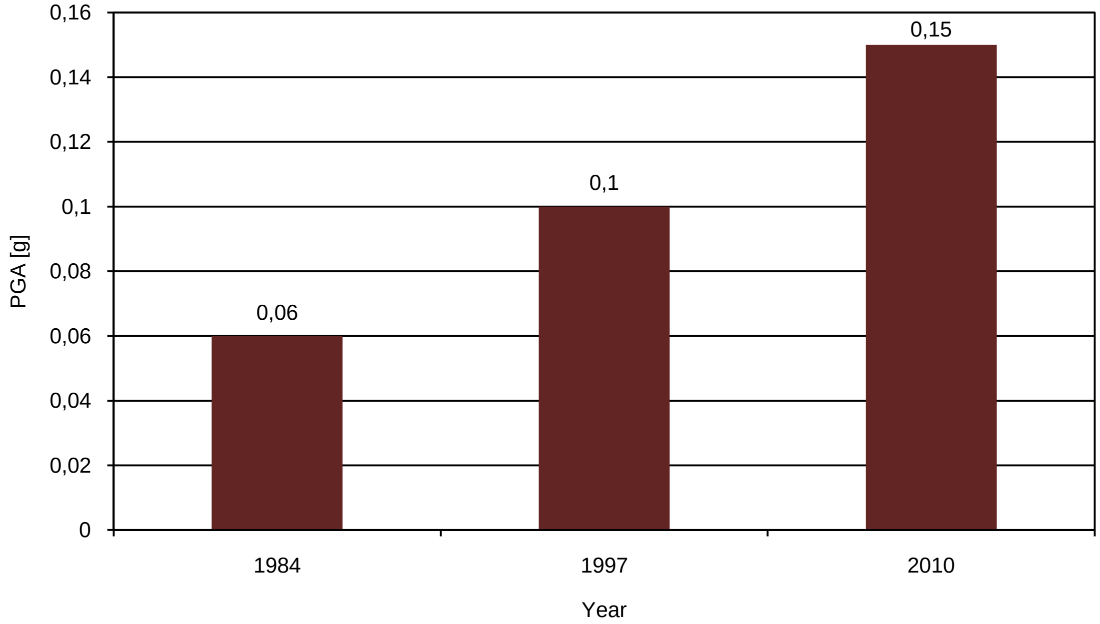

Figure 7: Gradual increase of EMO site seismic hazard

For both sites (Bohunice and Mochovce), the seismic monitoring system has been implemented and is currently in use for early identification of any seismic activity potentially affecting the NPPs (see Figure 8). Features of monitoring of seismic activities and micro-activities of Bohunice and Mochovce NPPs include continuous recording and analysis of seismic events performed in 22 seismic stations. The seismic network of Bohunice NPP vicinity consists of 11 seismic stations in the following locations: EBO, Bukova, Dobra Voda, Hradiste, Lancar, Laksar, Katarinka, Pusta Ves, Plavecke Podhradie, Smolenice and Spacince. The seismic network of Mochovce NPP vicinity consists of 11 seismic stations in the following locations: EMO, Hrusov, Bory, Kolacno, Michalkova, Polichno, Mlynany, Hostie, Dlzin, Devicany, Valentova. Arrangement of Mochovce seismic stations was proposed and built based on detailed seismic and geological survey prepared by the Geophysical Institute of the Slovak Academy of Science and reviewed by IAEA missions in 1998 and 2004. The stations can be remotely controlled. Monitoring results are summarized in quarterly reports. In case of stronger seismic events of interest for the plant operation, the analysis results are prepared within two days from their recording. The seismic stations enable detection and localisation of local earthquakes with magnitude exceeding Ml > 1. Seismic monitoring system is used for:

- Continuous monitoring of RB foundation plate vibrations,
- Automatic signal formation for the MCR, if specified acceleration value is exceeded(for EMO12 0.035g, for EBO 0.115g),
- Registration of vibration history when reaching pre-set acceleration value.

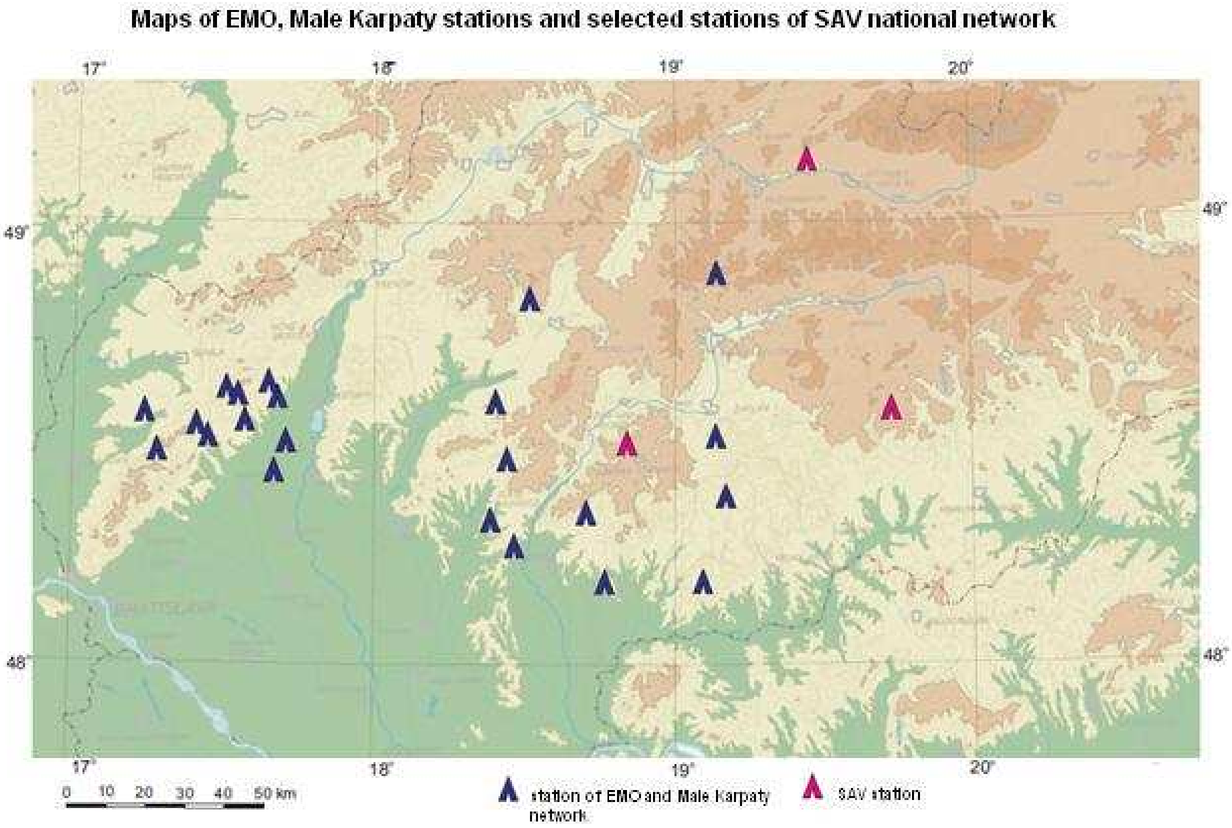

Figure 8: Arrangement of seismic monitoring stations in EBO and EMO areas

2.1.1.2 Provisions to protect the plants against the design basis earthquake

2.1.1.2.1 Identification of most endangered SSC required for safe shutdown state

All structures, systems and components required for safe shutdown and residual heat removal after a seismic event and their classification into individual seismic categories are listed in the SSEL list (list of equipment for safe shutdown and cool down following a seismic event). Individual systems, structures and components and their various configurations available for maintaining the safety functions were also briefly described in Chapter 0, including information regarding their seismic resistance. Only systems seismically classified and having adequate seismic resistance were considered as available for performing safety functions following an earthquake, all other systems were assumed to be disabled.

For both operating plants the criteria for classification of individual components to seismic categories were used in accordance with the document "Technical Guidelines for the Re-Evaluation Programme of Mochovce NPP" (IAEA, 1996) and the "Technical Guidelines for the Re-Evaluation Programme of Bohunice NPP (Units V-1 and V-2)". The categories are as follows:

- Seismic category 1 includes civil structures, systems and components required for:
  - safe reactor shutdown, its maintaining in shut-down condition and residual heat removal and cooling down at least for 72 hours
  - integrity of the primary and secondary circuit up to the isolation valves
  - prevention of radioactive releases into the environment
- Seismic category 2 includes all equipment not classified in seismic category 1.Seismic category 2 is divided to the following subcategories:

- 2a containing civil structures, systems and components, which could, due to so called seismic interactions, directly or indirectly evoke loss of functionality, strength, leak-tightness and stability of position of structures, systems and components of equipment belonging to seismic category 1.Stability of position of structures and components is usually required to be preserved in this category during and after an earthquake.
- 2 for EBO and 2b for EMO1,2 containing all other civil structures, systems and components of technological equipment.

Within the plant safety upgrading to newly defined site seismicity level (PGA=0.1, 0.15 or 0.344 g) all equipment included in the SSEL were re-evaluated using the Seismic Margin Assessment (SMA) method and upgraded to the required level, in accordance with the special methodology "Acceptance criteria and methodology for assessment of limiting (minimum) seismic resistance and for proposal of seismic modifications".

Robustness of each component was determined by its HCLPF (which is also expression of the safety margin of a given component) using CDFM and GIP VVER method (EPRI NP-6041, IAEA-SSS No-28, IAEA-TECDOC-1333).

The main CDFM principles for calculation of the limiting seismic resistance (SMA) are as follows:

- Combination of effects of NPP operation loads and the earthquake
- Loading of material up to ultimate bearing capacity with minimal guaranteed values according to design standards
- Strength conditions corresponding to ultimate bearing capacity for concrete and steel structures, service level D for pressure components, pipes and vessels in accordance with ASME BPVC Section III
- Ductility – used for ductile mode of damage; for these cases, the factor usually ranges from 1.25 to 2.

The GIP VVER methodology also used for re-evaluation describes detection of seismic interactions and provides forms for recording of findings of seismic walk-downs together with correction methods. Accelerograms used for the upgrading were generated in accordance with NUREG/CR-0098. Special method was developed on assessment of stability and strength of anchors including the procedure for fulfilment of requirements and their verification.

No detailed collapse related analyses were performed for civil structures without seismic classification. Only requirements given in CSN 730036 were applied to these objects. However, in the assessment of the robustness of various equipment configurations all non-classified systems, structures and components were assumed to fail in case of the design basis earthquake or beyond.

The following procedures are applicable for residual heat removal after an earthquake:

- Technological procedure for Anti-seismic protection system SYSCOM
- Technological procedure for Residual heat removal after earthquake.

The procedures describe activities to be performed for the residual heat removal after a seismic event, including description of equipment and system interactions, operational limits and technological restrictions, attendance method and activities, system start-up and operation. The following conditions were specified for the "Scenario for safe unit conditions after a seismic event":

- The main expected effects connected with vibrations induced in SSCs via the civil structures;
- Systems necessary for safe shutdown, residual heat removal and prevention of release of radioactive substances to the environment after a seismic event (listed in SSEL).This list includes also tanks with large water inventory that could worsen conditions due to their rupture or interaction.

- Electric components in switchboards are protected against water leaking from upper levels in the lengthwise electrical building by a protective cover.
- Seismic resistance of the systems is provided to the level SL2. Systems not designed as seismically resistant can be damaged.
- Seismic event is assumed to be connected with loss of power supply from external and internal sources, with a possibility of occurrence of local fires.
- Electric power supply of equipment listed in SSEL will be provided from EPS system categories I and II.

2.1.1.2.2 Main operating contingencies in case of damage that could be caused by an earthquake and could threaten achieving safe shutdown state

All potential affects which could threaten achieving safe shutdown state were taken into account, including:

- Potential failures of heavy structures; in order to prevent impermissible impact of failed operational equipment on seismic class 1 structures the situations with this possible interactions were evaluated. This evaluation was based on walk-down in rooms with installed safety equipment. Walk-downs focused on evaluation of operational equipment in given rooms and whether their failure caused by an earthquake could cause problems for any seismic category 1 equipment.
- Turbine damage could result in release of flying objects with high energy possibly impacting the lengthwise electrical building and then the reactor building. It was proven that earthquake with intensity 8º of MSK 64 scale will not result in damaging of rotating parts of turbo generators. Thanks to seismic design of the main turbine hall structures, the turbine and generator bearings and shafts are assumed to manage the seismic load. The over-speed turbine protection was justified to work safely even in case of its failure (fail-safe design) to prevent turbine damage caused by high speed in case of earthquake.
- High-energy piping rupture - in order to prevent pressure surges and flying fragments resulting from damaging large vessels, operational tanks with high-energy content in areas containing equipment of seismic class 1 were analysed and then reinforced to seismic category 2a to maintain their overall stability after an earthquake.
- *Fall of heavy handling equipment:* simultaneous operation of the crane with heavy load and earthquake is not assumed due to very low probability of such situation (only several operational hours of the crane / year). Seismic modifications proved that crane bridges installed in safety important buildings do not fall after an earthquake. Handling equipment in the reactor building installed above the containment top level, e. g. bridge cranes in the reactor hall or refuelling machine were analysed with regard to maintained stability during and after an earthquake.
- For seismic events, loss of external power supply was assumed, as evaluated in chapter 3 of this report.
- For the earthquake of design basis level, the site can be affected by damage of access roads namely those close to assumed earthquake epicentre; access of staff and necessary technical means requires consideration of damage of power plant access points, as they weren't considered as seismically reinforced. These damages were considered in chapter 4 devoted to accident management.
- Availability of routes for potential transport of cooling water can also be affected.
- Occurrence of local fires induced by earthquakes should be and was considered.

2.1.1.2.3 Protection against indirect effects of the earthquake

The following measures were taken in order to prevent or mitigate the indirect effects of the earthquake:

- Operational equipment considered potentially risky is classified in seismic category 2a and its seismic resistance is proved considering the failure mechanisms, such as mechanical damaging, extensive flooding, incorrect function, etc., that must be eliminated.
- Civil structures located close to equipment important for safety were classified in seismic category 2a and then seismically reinforced to prevent their collapse due to seismicity. These are mainly:
  - Turbine hall directly connected with the lengthwise electrical building of RB; Stability of loaded main structures of the turbine hall is necessary not only to provide for stability of the reactor power block, but also to decrease possible extensive impact on equipment with higher risk potential installed inside the turbine hall,
  - Cooling towers with impact on ESCW CPS,
  - Operational building SO803,
  - Vent stack, since it is located nearby the reactor building.
- In order to prevent pressure surges and missiles resulting from damaged large vessels, operational tanks with high-energy content in areas containing equipment of seismic class 1 were analysed and then reinforced to seismic category 2a to maintain their overall stability after an earthquake. They include the following components:
  - HP- coolant purification system filter considering their possible impact on the containment integrity,
  - Feedwater tanks located in the lengthwise side electrical building.
- In order to prevent falling of heavy equipment, bridge cranes in the turbine hall and lengthwise electrical building (level +14.7m) have defined parking positions away from equipment (TG, steam and feedwater pipes and components) during unit operation at power.
- Access of fire brigades to individual important civil structures in case of fire is provided minimally from two directions and is defined in their intervention cards.
- Based on situation, cooling water pools can be supplied with cooling water from EBO hydrant network. This procedure was verified by non-standard tests.
- In case of destruction of the above source, water can be supplied from nearby water sources by shuttle transport, hoses or in a helicopter suspension sack. If the siding railis not damaged, water can be transported in large volume railway cisterns.
- For Bohunice, Upper Dudvah can be considered as a potential source for shuttle traffic with access points in Pecenady, Zlkovce and Trakovice. Other possible sources include the creek Horna Blava and the pond in Jaslovské Bohunice, water reservoir Enviral in Leopoldov, the Vah channel in Drahovce and a water mill in Radosovce.
- The most suitable source for water pumping and subsequent supply to EBO is the dam Dolne Dubove. Its part next to the hatch is suitable for water extraction by a helicopter with suspension sack. This procedure was actually trained during an emergency drill (see the Figure 9).

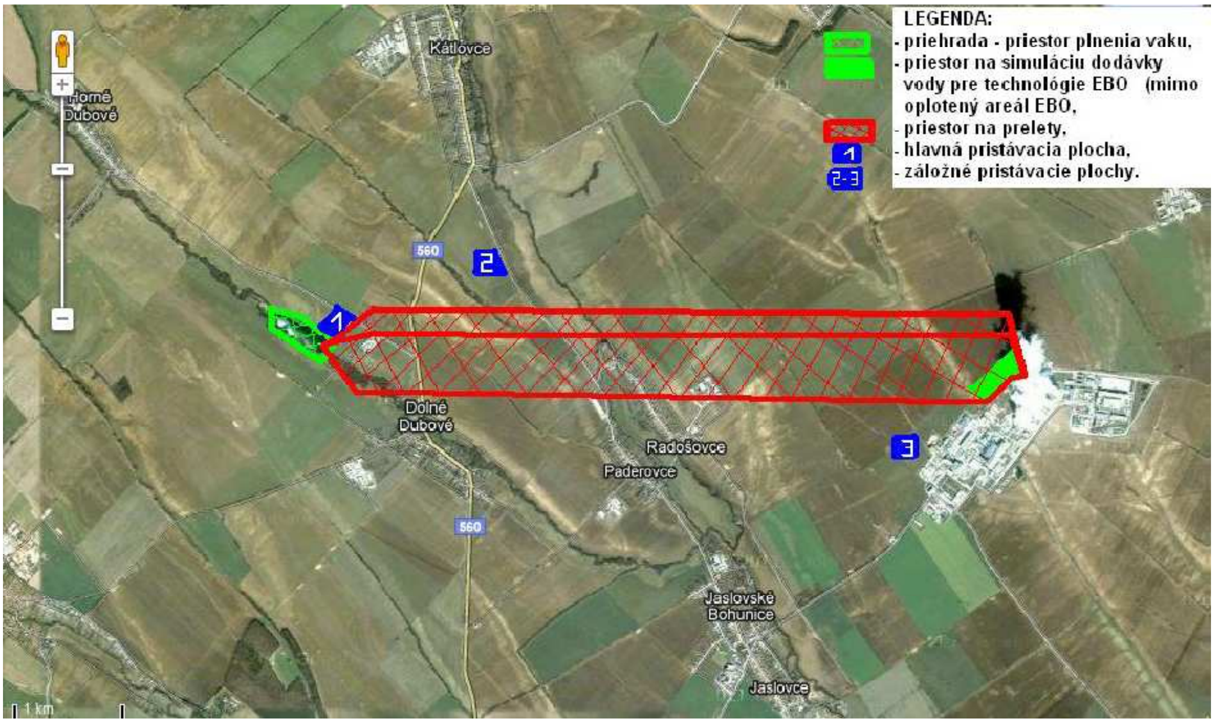

Figure 9: Working area for activities with the helicopter

Legend:

Priehrada … - dam	– space for sack filling
Priestora na simuláciu …	– area for water supply simulation for EBO technologies (out of EBO fenced area)
Priestor na prelety	– space for flyover
Hlavná pristávacia plocha	– main landing area
Záložné …	– back-up landing areas

For Mochovce, provision of cooling water supply can be by fire fighting trucks from the water reservoir in Velke Kozmalovce. Access roads are from the state road Mochovce – Male Kozmalovce and then to the pumping station extraction point. There is no road bridge on the route that could be considered as an obstruction in case of a seismic event. As another water source a small hydro plant on the river Hron close to the village Kalnica (Kalna nad Hronom) can be used. There is no bridge on this route.

For Mochovce, staff access is assumed from the directions of Levice, Nitra, Zlate Moravce. The cities of Nitra and Zlate Moravce are available via the state roads and are assumed to remain available after defined seismic event. From the direction of Levice it is necessary to consider three road bridges on the river Hron within 10 km distance; thus, the river Hron is not going to limit arrival of specialized staff.

The following is considered for managing the local fires:

- Seismic and fire resistant fire-separating walls between individual fire sections,
- Seismic resistant HVAC fire dampers protected by fire insulation of HVAC ducts,
- Seismically resistant stable fire fighting system with seismically resistant EPS for fire identification and subsequent SFFE activation,
- Equipment containing flammables (namely oil) seismically classified,
- Extinguishing the fires by the plant fire brigade.

Equipment of EPS and VPS systems will be seismically reinforced regardless of whether they supply consumers included in the SSEL list or not, thus significantly decreasing the fire risk.

2.1.1.3 Compliance of the plants with its current licensing basis

2.1.1.3.1 Licensee's processes to ensure that plants SSC that are needed for achieving safe shutdown after earthquake, or that might cause indirect effects discussed under the previous section remain in operable conditions

Equipment in classified categories has individual quality assurance programmes subject to supervision by UJD SR. These programmes define inspection requirements for individual equipment since their commissioning. Inspections (revisions) are recorded in form of protocols. Besides these inspections, defined technological parameters are periodically evaluated in line with IAEA recommendations as part of controlled aging program for selected components and evaluation programme of civil structures. During the stress tests the plant walk-down was performed to verify the status of the equipment. It has been confirmed that all SSC is in compliance with its current licensing basis.

2.1.1.3.2 Licensee's processes to ensure that mobile equipment and supplies that are planned to be available after an earthquake are in continuous preparedness to be used

In order to maintain operability of mobile equipment designated for water delivery to the emergency feedwater make-up system, relevant pumps are prepared to deliver water from external sources in line with the time schedule for functional tests of RCS and SC equipment. In preparation of the stress tests and in response to WANO recommendations, selected mobile equipment and its capability to perform the required functions were tested.

2.1.1.3.3 Potential deviations from licensing basis and actions to address those deviations

In several safety upgrading steps, capability of the NPP Bohunice V-2 units to maintain fundamental safety functions have been strongly increased from the original design basis PGA value 0.025 g (built as non-seismic design) through upgrading to PGA 0.25 g in 1995 up to the current value PGA=0.344 g, with corresponding upgrading completed in 2008.

For NPP Bohunice V-2 no deviation from licensing basis regarding seismic resistance were identified. Seismic resistance of all relevant SSC was continuously increased based on regular reassessment of the site seismic risk.

Mochovce site was re-evaluated on the basis of a new methodology in period 1998 – 2003, and the new design basis earthquake value was set to PGA=0.143g with the return period of 10,000 years. Re-evaluation method was reviewed by an IAEA mission in 2003. In order to reach increased seismic safety margin, the power plant is currently being reinforced to PGA=0.15g. The same value was used for on-going construction of MO 3,4 units.

2.1.2 Evaluation of safety margins

2.1.2.1 Range of earthquake leading to severe fuel damage

For mechanical and electrical equipment, the assessment and the upgrading was based on conservative approach considering elastic behaviour of the structures. Assessment of civil structures included, however, moderate structural inelastic behaviour of the structures. Taking into account properties of materials used for individual safety system components, first occurrence of plastic deformation should take place and only after exceeding the structural limit values the component damage will take place. However, such assessment is beyond the current regulatory requirements and international standards, and the margin was not quantified yet. The evaluation of the seismic margins can only be obtained through refined elasto-plastic structural analyses. Work on the analyses has already started and the results are expected to be available early in 2012. Based on preliminary results, seismic safety margins of about 20-30 % are generally expected.

2.1.2.2 Range of earthquake leading to loss of containment integrity

The same assessment as made for the range to severe fuel damage is valid also for the containment. Consistently, the loss of containment integrity in NPP Bohunice V-2 is assumed not to occur below PGA=0.35 g, and in EMO not below 0.2 g.

2.1.2.3 Earthquake exceeding the design basis earthquake for the plants and consequent flooding exceeding design basis flood

Taking into account the site location, geomorphological and hydrological characteristics and in accordance with the analyses performed it was shown that even dam failures on the nearest rivers induced by an earthquake do not lead to flooding of the site. Structures for raw water supply installed on the rivers can be affected resulting in interruption of the raw water supply. The relevant issues are addressed as a loss of the ultimate heat sink event in chapter 3.

2.1.2.4 Measures which can be envisaged to increase robustness of the plants against earthquakes

Robustness of the plant against earthquakes has been significantly increased recently and it is considered adequate in accordance with the current requirements. Nevertheless, the following measures for quantification of margins and further improvements are envisaged:

- Quantification of margins of key SSCs for earthquakes beyond the design basis earthquake
- Development of seismic PSA
- Updating plans for logistic arrangement of transport to the NPP following an extreme earthquake.

2.2 Flooding

2.2.1 Design basis

2.2.1.1 Flooding against which the plants are designed

2.2.1.1.1 Characteristics of the design basis flood

Due to the inland location of both nuclear sites in Slovakia and a large distance from any major source of flooding, the design basis flood was not specified in the design documentation. However, potential sources of flooding, and in particular a strong rain, were postulated. The only credible cause of a large water intake, i. e. extreme precipitation, was specified and addressed in the plant structures and objects. The design basis rainfall set for NPP Bohunice V-2 was 65 l/s/ha, for all Mochovce units it was 140l/s/ha, in both cases with the duration of 15 minutes and a return period of 100 years. The largest values of precipitation typically take place in summer months, during strong storms.

However, within the stress tests, all other potential causes of flooding were evaluated, too. These included a potential for floods evoked by surface water sources, dam failures, ground water and extreme weather conditions, namely heavy rain, melting snow and combination of heavy rain and melting snow. A seismic event with subsequent internal floods was also considered. Evaluation of the floods which could impact the provision of the safety functions is provided below.

2.2.1.1.2 Methodology used to evaluate the design basis flood

Close surface water sources

Both sites are located far from significant surface water sources (rivers, large water areas).

The river Vah with the Slnava water reservoir is about 8 km far from the Bohunice site. Between the site and the river Vah, the lowland river Dudvah flows as the Vah right-bank affluent. The right-bank Dudvah effluents drain the area of the site. Between the site and the Jaslovské Bohunice village there is another small river Blava. The altitude difference of about 11 m in the east in a distance of about 3 km divides the site from the flat and in this part also sufficiently wide valley of the river Vah.

Mochovce site is located 5 km from the river Hron. The altitude of the Mochovce site is 233.10 – 242.10 m, while the top of the dam of the water storage reservoir Velke Kozmalovce on River Hron is at altitude 176.0m, and maximum water level is at the altitude of 175.0 m.

Taking into account the distance from the rivers, the landscape and the elevation of the sites it can be concluded that the plant structures and the equipment inside the site cannot be directly endangered by floods from surrounding water flows and waterworks.

Failure of dams

The floods on the above mentioned rivers can affect operation of pumping stations located close to water reservoirs on the rivers and to interrupt the operation of the service water make-up systems.

Failure of dams on the river Vah could potentially affect the operation of NPP Bohunice V-2. In such case make-up water source in Drahovce (due to the failure of the pumps power supply) will be endangered and Pecenady pumping station will be partially flooded when water level reaches 0.5 m (in the case of Oravska dam failure) or 1.2 m (in the case of Liptovska Mara dam failure). In the case of the complete loss of water supply from Vah and Pecenady pumping station failure, the safety functions would be provided through usage of water inventory in cooling tower pools and in cooling water channels.

Rupture of existing dams in the River Hron basin does not pose a significant threat to the EMO1,2 and EMO3,4 site considering their relatively small volumes and localization namely in the upper basin part. NPP structures are situated on a hillside. There are no dams in the vicinity that in the case of damaging (earthquake, intentional damage) could endanger the EMO1,2 and EMO3,4 structures. If the Velke Kozmalovce water reservoir dam fails, the service water source will be endangered due to the flooding of the service water pumping station providing the service water to the Mochovce site. At the complete loss of the service water supply, water inventory in cooling tower pools and in cooling water channels will be used. At Mochovce site additional raw water reservoir is available and can be used.

The issues of the loss of service water are addressed within the scope of analysis related to the loss of heat sink. These issues are discussed separately in the chapter 5 of this report. However, the flooding hazard directly for the plant structures and equipment due to dam failures can be screened out.

Ground water

At the Bohunice site, the underground water level is situated in the depth of 16÷20 m. Underground water (activities and hydraulic regime) monitoring is made by means of the large network (143) of existing and newly constructed monitoring wells. The main objective of this monitoring system is mainly to ensure the protection of underground water sources against spreading of radioactive substances.

At the Mochovce site deep drilling works did not find any groundwater in the rock foundations. The analysis of geomorphologic, geologic, and hydrogeological conditions showed, that the groundwater cannot reach the NPP buildings foundations. Thus, the NPP does not have any permanent draining system for the control of the underground water level. Existing wells situated inside and outside the NPP site serve only for the dosimetric control of underground water.

It is therefore not necessary to neither consider effects of underground water on the stability of the civil structures nor consider this water as a potential source of flooding.

Extreme precipitation

Flooding due to a storm rain is normally prevented by the proper design of the rainwater draining (sewer) system.

Conservative estimate for NPP Bohunice V-2 site area, the basis for the capacity of the draining system, is 18.2 ha. The 65 l/s/ha rain (5.85 mm in 15 minutes) corresponds to the total flow rate 1.18 m^3/s, which is about 50 % of the capacity of the draining system (2.365 m^3/s). The rainwater pipe system from the NPP site is led to settling reservoirs and from there to the Manivier stream. The settling reservoirs serve for catching of suspending substances and potential oil products from the site. In the case of extreme precipitations, the surface outflow from the highest situated area, which is the central pumping station, will be directed towards the lowest situated areas, which is the part of the site around settling reservoirs. It is seen that the capacity of the draining system has a large margin in comparison with the original design basis.

At the Mochovce site, the rainwater system collects and conveys water from different plant areas to the lowest point of the Mochovce site, located outside the plant boundary. The rainwater pipe system drains all rainwater to the single lowest situated place, where the rainwater pipe system settling reservoir is situated in the waste water treatment plant. During the normal operation, the reservoir serves for catching of rainwater from flushing of areas from the Mochovce NPP site and serves as a safety element for catching of eventual leaks of oil products from the plant area. The topography of the site prevents accumulating of water at any level where the buildings with critical structures, systems and components are situated. The drainage system has independent piping for each of the platforms and the rainwater from each level is directly conveyed into the common reservoir which is shared by EMO1,2 and EMO3,4.

The drainage system was designed taking into account a 15 min storm rain with a periodicity of 1 year and rain intensity of 140 l/s/ha. This rain intensity corresponds to a flow rate of 26.18 l/s in the smaller collector. The drained area of the smaller collector is 0.38 ha, of which 0.2 ha is hard surface (outflow coefficient 0.8) and 0.18 ha unpaved surface (outflow coefficient 0.15). The minimum size of the drainage system piping is DN300 and its capacity, with a slope of 2%, is 147.07 l/s. The rainfall on the same drained area which could origin such flow rate corresponds to almost 70 mm of precipitation with duration of 15 min, which is almost double of the one with 100 year return period.

The margin is 38 mm with reference to the 100 year return period precipitation with duration of 15 min.

The extreme precipitation values were assessed in the report prepared recently (in 2011) by the Slovak Hydro-meteorological Institute for the Mochovce site, in connection with EMO3,4 construction. For the assessment of maximum rainfall/snowfall values, 30-years of annual measurements from Mochovce meteorological station were used (1981-2010), as well as values of up to the65-year time series of annual values of highest rainfall intensities at Mochovce and historical time series of rainfall intensities in Slovakia. The assessment was done by extrapolations using DDF (Depth Duration Frequency) curves. The main results of the study are summarized in the following table of recommended extreme values of meteorological parameters to be used for safety assessments:

Meteorological parameter	Return period		
	unit	100 years	10 000 years
Inventory of water in the snow layer	mm	88.4	165.8
Extreme snow and precipitation	mm	120.6	224.4
Storm raifall intensity with duration of 300 min.	mm/min	0.226	0.389
Storm raifall intensity with duration of 30 min.	mm/min	1.379	2.330
Storm raifall intensity with duration of 15 min.	mm/min	2.133	4.067
Maximum daily height of water layer from melting of snow	mm	50	100

Common part of the sewer system for both EMO1,2 and EMO3,4 collect rain water from 33.12 ha and its capacity is 5.9 m^3/s. The capacity is sufficient for draining of the whole site, even if all the rain water would be collected by the sewer system (not the case).

From the table it can be seen, that the value of 140 l/s/ha used in the design basis of EMO is significantly lower (~12.6 mm) than predicted in the new study. Similar meteorological study for Bohunice site as already developed for Mochovce is also under preparation in order to update the original design values, with the completion date in January 2012. The study will also include methodology for the assessment of the maximum water level on the site for extreme precipitation. It is expected that more substantial difference in comparison with NPP Bohunice V-2 design value of 65 l/s/ha can be estimated and capacity of the drainage system can be questioned. Of course it does not mean that short intensive rain beyond the design value will result in site flooding. In particular, not full amount of raining water should be immediately drained, it can be done with certain delay. It is expected that in the case of correct functioning of the drainage system there is no risk of any significant site flooding. However, this expectation should be confirmed after finalization of the new meteorological study by more detailed assessment.

Nevertheless, in order to be on the conservative side, despite of the fact that the proper functioning of the sewer system excludes the possibility of flooding by the strong rainfall, the behavior of the plants in case of complete loss (clogging) of the drainage system was also analyzed. It was conservatively considered that the extreme rainfalls can cause inoperability of sewer system inlets by deposits released from non-hardened areas and that the water gradually flows along the structures to the lowest places. In such case, certain water level above the ground can be established around the civil structures of the plant.

Estimation of the water level under conditions described above is quite complicated task. Using the table above, considering both extreme rain and snow melting and taking into account the shape of the terrain it was estimated, that temporary flooding height with return period 10,000 years will not exceed 10 cm.

Internal floods caused by an earthquake

In addition to external sources of flooding, vulnerability of all buildings containing electrical equipment potentially affected by flooding (reactor building and auxiliary building, turbine hall, lengthwise and transversal electrical building, diesel generator stations, essential service water station, emergency feedwater system building), internal floods (caused by ruptures of pipes/tanks) were assessed considering the rupture of the most vulnerable water pipelines following an earthquake.

The following sources of internal flooding were considered for the both NPP Bohunice V-2 and EMO1,2:

- Large break of the feedwater pipeline in the lengthwise electrical building,

- Large break of circulating cooling water system in the turbine hall,
- Large break of feedwater pipeline and condensate pipeline in the turbine hall.

From flooding point of view, the worst case is the large break of the circulating cooling water pipeline, potentially releasing up to 85 100 m^3 of water (the value is given for EMO3,4, for NPP Bohunice V-2 the equivalent value is 52 000 m^3). Damage of this seismically not classified pipeline in the turbine hall can be considered as the most serious consequence of the earthquake. However, the analysis has shown that even in the case of release of the complete volume of water the cable channels, located in the turbine hall basement with manholes situated at -3.0 m that could cause spreading of the flood to the adjacent electrical building, will not be endangered.

In addition, in the case of EMO1,2, the flood caused by the make-up water storage tank damage (2 x 6000 m^3) was considered. The make-up water storage tank is located outside the EMO1,2 site, about 300 m in north-eastern direction towards the wastewater treatment plant. Wastewater is transported from the storage tank to the chemical water treatment (CWT) plant via two pipelines of 1,200 mm diameter and length approx. 550 m. The chemical water treatment plant is located directly in the NPP site, and the elevation difference between the chemical water treatment and the make-up water storage tank is about 17 m. The NPP site is separated from the make-up water storage tank with 2.6m high concrete wall. The terrain slopes towards a ditch with depth from 3 to 5m in front of this wall in direction to the make-up water storage tank. Water level in the tanks 2 x 6,000 m^3 is checked remotely via sensors from pumping station on the River Hron. In the case of a potential damage of the tanks and under the assumption of release of the whole make-up water volume, i. e. 12,000 m^3, the NPP site flooding is not possible.

2.2.1.1.3 Conclusion on the adequacy of protection against external flooding

As explained above, no protection against external sources of the site flooding is needed, except adequately designed capacity and ensured operability of the sewer system in order to cope with the extreme precipitation. The systems have been designed for the original design basis precipitation (storm rain) with large margins. Updated meteorological studies however indicate that initial design basis for maximum precipitation might be reconsidered. This reconsideration has been already taken into account in implementing upgraded design measures against entering of water into the safety important buildings.

2.2.1.2 Provisions to protect the plants against the design basis flood

2.2.1.2.1 Identification of systems, structures and components (SSC) that are required for achieving and maintaining safe shutdown state and are most endangered when flood is increasing

Vulnerability to flooding differs for different types of structures, systems and components, namely for civil structures, mechanical components, electrical and I&C components.

Since the impact of the ground water has been screened out, the event of flooding in general is not endangering the civil structures: no consequences of flooding on civil structures are expected, but only consequences to technological equipment installed therein. The analysis is significant only for the civil structures housing safety significant structures, systems and components and whose ground floor is at the lowest absolute elevation, which is then evaluated as the most vulnerable one in the stress tests analyses. The vulnerability is evaluated by progressively increasing water level, starting from the lowest site elevation.

In the internal flooding analysis it is assumed that:

- if flooding reaches the elevation of the room in which an active component is installed, such component is lost unless hydraulic guards are available;

- if flooding reaches the elevation of the floor of the room in which electrical equipment ensuring power to an active component is installed, such component is lost unless hydraulic guards are available;
- safety-related I&C cabinets and MCR/ECR panels are installed at sufficiently high level; for this reason, it is assumed that no loss of active components due to the loss of safety-related I&C control can be induced by flooding.

If needed, as a second step, it is evaluated whether refined considerations (e. g. analysis of the precise elevation of a component within the room) are needed. Cables and passive components (e. g. piping) have a significant resistance against flooding and hence have not been further taken into account in the analyses.

The buildings of the plants requiring detailed assessment of vulnerability to flooding are:

- Reactor building and auxiliary building, where the electric drives of the emergency injection pumps and auxiliary feedwater pumps are located,
- Turbine hall, longitudinal and transversal electrical buildings, where electric switchboards and power supply automats could be affected,
- DG station, with 6 kV outlets, after exceeding certain level, water penetrating mainly through untight gates on the northern side of the object will run to the areas under DG, where it can flood 6kV outlets in case of further increased level,
- Pumping station with ESCW pumps and firewater pumps,
- Emergency feedwater system building; elevated level water could rise up to the EFWP drive levels,
- Emergency response center,
- Power cable ducts.

2.2.1.2.2 Main design and construction provisions to prevent flood impact to the plants

Due to the fact that the only possibility for the site flooding in Slovakia is extreme precipitation, the main way of prevention is adequately designed and maintained sewer system. If in spite of this measure a failure of the system is postulated, proper sealing of the buildings and elevated access doors to the building is the adequate design provision. The current situation in this matter is described below.

In EMO1,2 and EMO3,4 design, the elevated access (20 cm above the ground) have been considered for safety-related buildings housing safety equipment i. e.:

- diesel generator station,
- reactor building,
- longitudinal and transversal electrical building,
- essential service water (ESCW) pumping station.

In fact, as far as reactor building, longitudinal/transversal electrical buildings and diesel generator station are concerned, such buildings have either hermetic doors and minimum access thresholds of 20 cm to the rooms housing safety-related equipment(reactor building) or have a 20-cm access threshold (diesel generator station and longitudinal/transversal electrical buildings). Sensitive components in the essential service water station are the electric motors of the ESCW pumps, which are placed 60 cm above the ground level. Taking into account that electric cable functionality is not affected by flooding, the damage to the pumps occurs when the water reaches the 60-cm height above the ground level.

In NPP Bohunice V-2 units which were designed earlier, less attention was originally paid to the protection against flooding due to extreme precipitation. The relatively vulnerable buildings of the plant are:

- Reactor building, where emergency core cooling system pumps and spray pumps are located (at -6.5 m elevation),
- DG station, with 6 kV outlets,
- Longitudinal and transversal electrical building,
- Chemical water treatment plant with EFWP,
- Emergency response centre.

A very conservative calculation model was prepared for quantification of time margins and assumption of flooding duration for the calculation of endangering of the emergency pumps installed in the reactor building basement. Based on this model, the pumps could be under risk only after more than 72 hours of flooding resulting in constant water level at 10 cm (i. e. conservatively not taking into account any active countermeasures and the natural draining profile of the site) – see the Figure 10.

There are two drainage pumps (each 25 m^3/hr) installed in the reactor building for pumping water out of the rooms in the case of internal flooding. However, capacity of the pumps, even considering all mobile pumps available for the fire brigade on the site (altogether 216 m^3/hr) is not sufficient for adequate removal of water under such severe assumptions. Therefore, measures aimed at the prevention of water inflow into the building were necessary.

Detailed analysis showed that the site flooding with the water level more than 30 cm combined with the loss of all sources of external power supply could result in station blackout scenario but not sooner than in 24 hours, due to flooding of busbars in the electrical building and unavailability of DGs. Provision of safety functions (heat removal both from the core as well as from the spent fuel pool, in particular) for SBO scenario is thoroughly analysed in the chapter 3.

However, in the case of combination of flooding and loss of all sources of external power supply and no countermeasure taken, the availability of DGs is vital. The vulnerability of DG station to flooding can be assumed above about 20 cm of constant level of water around the DG building (this very conservative assumption has to be confirmed by planned detailed topological study of natural drainage characteristics of the site).

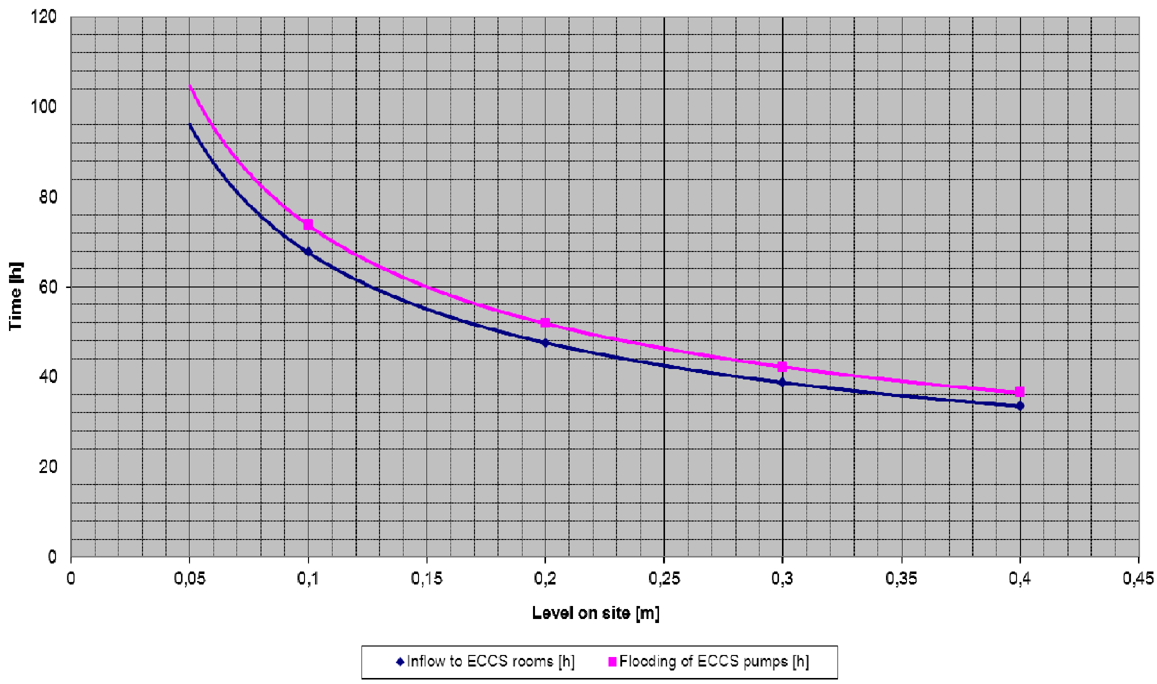

Figure 10: Prediction of time margins to endangering of emergency pumps by flooding

It is assumed that the underground situated DGs power outlet could be disabled within 1-2 hours of constant flooding. This would result in the station blackout scenario. Provision of safety functions (heat removal both from the core as well as from the spent fuel pool, in particular) in SBO can be found in the chapter 3.

Based on the analysis, certain improvements were promptly implemented during the period of stress tests. In particular, sand bags were prepared as a temporary passive protection which can be placed in front of the gates into the reactor building and DG station. Final solution with permanent passive protection is in the pre-design stage (need to consider transportation needs during maintenance period). The walk-down and measurements of position of doors and gates performed in October 2011 led to the following conclusions which need to be proved by above mentioned planned analyses:

– Entrance to the reactor building is increased by ~10 cm above the ground level, i. e. flooding with return period of more than 10,000 years would be necessary to allow inflow of water into the reactor building.

– External flooding water level near the DG station should be ~20 cm in order to allow water inflow to the room with 6 kV power outlet, which is significantly higher than the possible flooding level due to the drainage characteristics of the site.

Sufficient protection of components of the safety systems against internal flooding caused by ruptures of the pipelines and tanks is ensured:

– By designed redundancy of safety systems and their components;

– By their own protection cover resistant to humidity and increased temperature or by technological design of the component itself;

– By its position in a sufficient height to have the maximum water level resulting from the conservative calculation below the level of these components;

– By possibility to drain water leaking to the room floor;

– By periodical inspections made by operators, who can close valves in some pipes (not critical for safety) by manual manipulation from corridors, thus stopping the fluid leaks.

Based on the analysis it was concluded that configurations with three redundant safety systems in the plants are resistant against internal floods. Various measures implemented before the stress tests in order to limit consequences of internal flooding (e. g. improved sealing between compartments, provisions of water draining, modified layout to set-up proper inclination for water pathways) were taken into account in the analysis.

2.2.1.2.3 Main operating provisions to prevent flood impact to the plants

Operating provisions include

– Procedures for maintaining operability of rainwater, industrial and sanitary sewer system,

– Procedures for the fire brigade for pumping water out of the flooded areas.

2.2.1.2.4 Situation outside the plants, including preventing or delaying access of personnel and equipment to the site

During floods evoked by surrounding water streams and waterworks, road in the river Vah basin will be affected and it will be necessary to adopt and manage measures based on decisions of state administration and local self-administration authorities. It is assumed that Piestany town will be evacuated and the relevant connecting roads near Zlkovce, Leopoldov, Hlohovec, Cervenik, Madunice and Drahovce will be unusable. However, accessibility of the Bohunice site through the roads J. Bohunice – Trnava, Malzenice – Trnava and Velke Kostolany – Vrbove will be without any limitation.

In order to maintain raw water supplies, it will be necessary to transport personnel for operation or inspection and potential repair of equipment in the Drahovce intake structure and in pumping station Pecenady. Sources and commodities needed for assurance of life needs of staff and operation of SSCs will be provided by roads through areas not affected by flooding. Potable water distribution will remain functional.

Access roads to the Mochovce site are not vulnerable to major flooding and there should be no problems with access to the site.

In more complex situations the sources, commodities and assistance needed for assurance of life needs of staff and operation of structures, systems and components, including potable water, will be provided in a manner described for both sites in chapter 2 in case of earthquake.

2.2.1.3 Plants compliance with its current licensing basis

2.2.1.3.1 Licensee's processes to ensure that plants systems, structures, and components that are needed for achieving and maintaining the safe shutdown state, as well as systems and structures designed for flood protection remain in operable condition

External flooding was not postulated within the original design basis of NPP Bohunice V-2 and EMO1,2. External flooding has been included in the plant design basis and therefore properly taken into account in the design of EMO3,4. As it was explained above, plant civil structures where safety important systems and components are located is adequately protected including newly conservatively estimated level of potential external flooding. Administrative procedures and processes to ensure the availability of systems and components needed to cope with flooding scenarios are available and will be further improved.

2.2.1.3.2 Licensee's processes to ensure that mobile equipment and supplies that are planned for use in connection with flooding are in continuous preparedness to be used

There are several mobile pumps available in both sites for the fire brigades and purchasing of additional pumps is planned. For example, in Bohunice existing equipment include:

- 1 floating pump FROGGY with capacity 800l/min; own petrol engine
- 1floating pump SAW 200 with capacity 800l/min; own petrol engine
- 4submersible electric pumps MAST T12 (capacity 1,200l/min each), 380V
- 1 submersible pump SIGMA KDFU 80, capacity 800l/min, 380V.

Operability of the pumps was tested during special tests following the Fukushima accident.

Regular maintenance/inspection programmes of mobile equipment intended to be used in a flooding scenarios are in place for NPP Bohunice V-2 and EMO1,2 and will be developed in EMO3,4 before commissioning. Pump maintenance follows relevant technical documentation.

2.2.1.3.3 Potential deviations from licensing basis and actions to address those deviations

Plants are in compliance with the original licensing basis and actions have been taken to strengthen their level of protection in order to cope with newly defined external threats of flooding. Based on the new meteorological data already available for Mochovce site and under development for Bohunice site it seems appropriate to reconsider the original design basis accordingly.

2.2.2 Evaluation of safety margins

2.2.2.1 Estimation of safety margin against flooding

Only extreme precipitation can be considered in Slovakia as a potential source of flooding.

In the safety report for EMO1,2 it is stated that in the case of strong rain with a return period 10,000 years and a duration of 300 minutes, assuming complete blockage of sewer system and no staff action to recover it, the water level flowing around the civil structures could reach maximum height 74 mm. This value has been taken asvery conservative also for EMO3,4. The value is nearly 3-times higher than the very conservative estimate of the flooding level, since water could affect safety systems only if water level would exceed 20 cm.

In Bohunice, the protection is less robust than in Mochovce, but taking into account the temporary measures taken (permanent passive protection being prepared), the margins are also sufficient, capable to protect important plant structures, systems and components against extreme rain with a return period of 10,000 years.

It should be underlined again that previous description corresponds to combination of extreme precipitation, failed rainwater pipe system and no corrective measures taken by the staff, namely sealing gaps in doors and gates. In addition, flooding due to the extreme precipitation will be limited in time.

2.2.2.2 Measures which can be envisaged to increase robustness of the plants against flooding

In spite of the extremely low probability of site flooding and measures already available, additional provisions are considered to further increase safety level of the plants as follows:

- To finalize a new meteorological study for Bohunice site including recommended extreme values of meteorological parameters to be used for safety assessments and methodology for determination of maximum possible site flooding due to extreme precipitation
- To update the Preoperational Safety Analysis Reports for both NPP Bohunice V-2 and EMO1,2 for internal and external hazards taking into account updated meteorological data, plant improvements and state of the art methodology
- To update procedures for maintaining operability of rainwater, industrial and sanitary sewer system
- To update procedures for recovery of serviceability of affected plant systems and components following an internal flooding, including activities of operating staff and firemen
- To purchase manually portable submersible pumps with possibility of fire hoses connection
- To purchase portable gasoline/diesel pump
- To install permanent provisions against penetration of water into safety important buildings in the case of flooding in Bohunice site.

2.3 Extreme weather conditions

2.3.1 Design basis

2.3.1.1 Reassessment of weather conditions used as design basis

2.3.1.1.1 *Verification of weather conditions that were used as design basis for various plants systems, structures and components: maximum temperature, minimum temperature, various types of storms, heavy rainfall, high winds, etc.*

This section of the report deals with weather conditions used for design basis: extreme wind, extreme temperatures and humidity, extreme snow amount, extreme freeze and icing, and their combinations. The extreme rainfall, storm, and floods were discussed in the previous Chapter 2.2 of the report.

Information on the weather conditions at the site of the Bohunice and Mochovce nuclear power plants is summarised in the design documentation, safety reports and their supportive documentation. An overview of the weather conditions is given in the stress test reports from particular plants. The provided information is processed in the context of the IAEA documents, which set out the requirements, conditions and procedures for compliance with the safety criteria. The summarisation uses:

- Meteorological data from off-site sources, i. e. data from the meteorological stations collected for a long period of time under conditions determined by the World Meteorological Organisation (WMO);
- Data from on-site meteorological program implemented for the measurement of site specific data and dispersion of radioactive substances in the air and water.

The on-site meteorological data for Bohunice site are available from 1961, and for Mochovce site from 1981. The off-site meteorological data are recorded and stored in the databases of Slovak Hydro-meteorological Institute (hereinafter “SHMI”) and other relevant documents.

Following the on-site and off-site measurements of meteorological stations an absolute maximum temperature of climate normal for Bohunice (38℃) has been taken. The absolute maximum air temperature was reached 38℃ on18 July 2007. The absolute minimum air temperature reached -26.1℃ on13 January 1987, which is not far away from an absolute temperature minimum of climate normal for Bohunice (-30℃).

Data from meteorological observations for the period from the beginning of the 80thyearsup to the present are in the global but also in regional climate characterized by the increased dynamism to its warming. Such changes are accompanied by a smaller or greater incidence of extreme changes of climate characteristics of the meteorological phenomena.

According to the results of the Intergovernmental Panel on climate change it may be in the time span of several decades to expect clear manifestations of climate change in the Central European region. In view of the expected lifetime of the nuclear power plants in Slovakia, the utility adopted necessary measures to continue in the meteorological measurements and evaluation of data received on nuclear power plant sites. These data will be used in the near future for assessing and predicting the consequences of climate change to the operation of nuclear power plants and for the eventual future review of meteorological and hydrological characteristics of the sites.

In 2011 SHMI produced a study for Mochovce nuclear power plants, which deals with the general climatological evaluation of the Mochovce site, as well as evaluation of the meteorological variables (the extreme rainfall, extreme snow amount, extreme wind, extreme air temperature and humidity, extreme frost and icing, and the minimum and maximum flow rates in the neighbouring major rivers). The study was processed within the meaning of the procedures for the evaluation of the extremes and climatological procedures according to the IAEA recommendations. Results of the study were also used for the reassessment of weather conditions applied for design basis.

Similar study for the Bohunice site, as already developed for the Mochovce site, is under preparation, in order to update the original design values for weather conditions, with the completion date in January 2012.

After the last verification and completion, the weather conditions used for current design basis of Bohunice and Mochovce nuclear power plants are actualised. Specifications are provided in the design documentation, safety reports and referenced documents.

2.3.1.1.2 Postulation of proper specifications for extreme weather conditions if not included in the original design basis

Hurricanes and tornados were originally excluded for the Bohunice and Mochovce sites and thus not included in the design. However, on the basis of current meteorological studies, tornados should be considered. The updated analysis of the threats show that only credible rotating winds for the Bohunice and Mochovce sites are those associated with the tornados categories F0 and F1 of Fujita scale. Now, the tornados are added to the actualised plant design and evaluated.

2.3.1.1.3 Assessment of the expected frequency of the originally postulated or the redefined design basis conditions

Assessment and specifications of extreme weather conditions relevant for the Bohunice and Mochovce sites are contained in the design documentation, safety reports, studies and their referenced supportive documentation. An overview of results from the assessments is provided in the utility reports.

Due to the vicinity of Bohunice and Mochovce sites (80 km distance) and the similar climatic conditions of the sites, the expected intensities and frequencies are foreseen to be the same for extreme meteorological conditions (temperature and humidity, snow amount, icing, wind, etc.) and their combinations.

Characteristics of some meteorological variables are listed in the table below. A summary of the site relevant meteorological variables and their characteristics including frequencies can be found in the plant safety reports and their referenced documentation. Complete information is given in the source document "Summary Report of Slovak Hydro-meteorological Institute for Mochovce Site, 2011".

Characteristics of meteorological variables – temperatures

Meteorological variable	Likelihood of adhering to the		
	Unit	100 years	10 000 years
Absolute maximum of yearly air temperature	°C	+38.7	+43.2
Absolute minimum of yearly air temperature	°C	-31.5	-47.4
Maximum temperature lasting 6 hours	°C	+37.5	+41.6
Minimum temperature lasting 6 hours	°C	-23.0	-33.7
Maximum temperature lasting 7 days	°C	+29.0	+33.5
Minimum temperature lasting 7 days	°C	-17.2	-27.3

Meteorological variable	Return period		
	Unit	100 years	10 000 years
Maximum snow amount	cm	81	123

A summary on the assessment of scope, intensities and frequencies of the originally postulated or the redefined design basis weather conditions are provided in the stress test reports. The assessment also includes a comparison of current design basis for extreme weather conditions with IAEA recommendations, European Utility Requirements (hereinafter “EUR”), and relevant STN EN standards.

In general, specifications of extreme weather conditions for Mochovce site are in compliance with IAEA recommendations, European Utility Requirements and relevant STN EN standards. However, as mentioned before, the Bohunice nuclear power plant has to finalize the update of assessment of site weather characteristics, which is near completion, to take into account recent knowledge of meteorological conditions.

2.3.1.1.4 Consideration of potential combination of weather condition

In the design basis, the loads of following combinations of extreme weather conditions are considered to be most severe for safety of both nuclear power plants Bohunice and Mochovce:

- Wind/snow and icing, and
- High atmospheric temperatures and long-term deficit of precipitations.

To assess the combination of wind/snow and icing loads the values based on STN EN1991 standard for electrical equipment are used in design and plant safety evaluations. For return period of 100 years the wind speed is considered 27.2 m/s and icing thickness is 29 cm; for return period of 10 000 years the considered wind speed is 38.7 m/s and icing thickness is 38 cm.

Characteristic feature of the extreme drought from the point view of its consequences on nuclear power plant is that the extreme drought is not a dynamic change but a long progressive process, where there is enough time for the implementation of specific foreseen safety measures. So, the considered extreme drought should not endanger safety of the plants. The situation with loss of water intake is solved in plant operational procedures.

2.3.1.1.5 Conclusion on the adequacy of protection against extreme weather conditions

The protection of the nuclear power plants against extreme weather conditions is described in the plant documentation and utility reports. The defence in depth concept is applied for the design of Bohunice and Mochovce nuclear power plants. It consists of multiple physical barriers and set levels of protection. In general, safety systems are designed as redundant, independent, diverse, and physically separated. In addition to the design features, the plants have qualified staff, operational procedures and arrangements to avoid, manage and mitigate the events, if occurred.

The utility evaluated weather conditions used as design basis. All weather conditions and their combinations important for the Bohunice and Mochovce sites are considered. The evaluation follows procedures and guidance provided in the relevant IAEA documents. It uses on-site as well as off-site data from standard meteorological measurements and observations, data processing, extrapolations, prognosis, expert judgements, and conclusions.

Postulated external events and their characteristics caused by extreme meteorological conditions are considered complete and specified in line with international practice. Originally postulated events were extended by tornadoes. Evaluated meteorological phenomena and their combinations include extreme temperatures and humidity, drought, snow and icing, direct and rotating wind. Specifications of the events are estimated for up to the 10,000 year return period.

The evaluations and also the experience gained with the operation of Bohunice NPP at the maximum/ minimum values of temperature nearly at a level oftheir100 year extreme values have demonstrated resilience and stability of Bohunice plant service during the real meteorological extremes, what is to be expected for Mochovce nuclear power plants because of the proximity of the plant design.

The protection of plants against extreme weather conditions is considered to be adequate. Provided evidences show that considered extreme weather conditions should not endanger the safety of the Mochovce nuclear power plants and Bohunice nuclear power plant.

Results of analyses and evaluation of safety margins as well as measures, which can be envisaged to increase robustness of the plants and/ or safety demonstration against the extreme weather conditions are summarised in the following chapter of this report.

2.3.2 Evaluation of safety margins

2.3.2.1 Estimation of safety margin against extreme weather conditions

2.3.2.1.1 Analysis of potential impact of different extreme weather conditions to the reliable operation of the safety systems, which are essential for heat transfer from the reactor and the spent fuel to ultimate heat sink

Analyses of potential impact of different extreme weather conditions to the plant safety and reliable operation of the safety systems are documented in supportive documents referenced in design documentation, safety reports, and documentation elaborated in the frame of safety evaluation and safety upgrading programmes of the plants. The scope of the analyses, depth of the analyses and their quality in regard to the current requirements on safety analyses varies from plant to plant. More complex analyses and evidences of the plant response to extreme weather conditions are elaborated for the EMO3,4 nuclear power plant which is under construction. Ability of logistical arrangements, transport of resources and connections necessary for ensuring the needs of staff were also evaluated. Results of analyses and evaluations are summarised in the particular utility report.

The evaluation of the impact of extreme meteorological conditions of beyond design basis accidents to the safety important systems, structures and components of NPP Bohuncie V-2 and EMO1,2 nuclear power plants strikes on the lack of information in the current plant documentation. Therefore, the missing information for the stress test analyses has been conservatively adopted from newly drawn up documentation for EMO3,4 nuclear power plant. This is considered to be acceptable because of similar design, plant site characteristics and similar operational procedures.

Where information on resistance of safety systems, structures and components to the beyond design basis weather conditions is missing in plant documentation then engineering judgement is applied to estimate the plant response.

The results of analyses and evaluations highlights that the changes to the original design effected favourably the increase of Bohunice and Mochovce plant resistance against the extreme weather conditions, and the possibility to compensate adverse effects of extreme weather on plant technological equipment (for example, the seismic upgrading increases the resistance of the buildings against the extreme wind and snow load). Sufficient time reserves for taking measures in the extreme weather situations are shown.

However, some analyses, evaluations, used conditions, considered consequent failures of equipment or actions of plant personnel require further precision and complementary evidences to be sure that conclusions based on thereof in regard to safety of the plants are fully correct. The review concludes that it is needed:

- To update the safety report for Bohunice nuclear power plant and its referenced supportive documents dealing with external threats to be in line with international requirements and recent knowledge of meteorological conditions;
- To perform the detailed assessment of impact of extreme meteorological conditions (temperature and combination of wind/ icing)to the vulnerability of high voltage line at Bohunice and Mochovce sites;
- To assess all roof constructions of Bohunice nuclear power plant against the EUR code, and implement measures drawn up from the assessment conclusions.

2.3.2.1.2 Estimation of difference between the design basis conditions and the cliff edge type limits, i. e. limits that would seriously challenge the reliability of heat transfer

The estimation of safety margins against extreme weather conditions has been done for safe shutdown routes:

- Margin against direct wind, snow and icing loads for buildings and constructions, which contain components of safe shutdown roads,
- Margin against temperatures for technological equipment included in the safe shutdown routes, i. e. safety important equipment its functionality has to be maintained during external event or components, which loss of functionality, although acceptable, could endanger the components, which functionality has to be maintained (components of safe shutdown routes placed outdoor or specific air conditioning systems).

Detailed information on the quantitative or qualitative estimation of safety margins for extreme weather conditions and their combinations is provided in the nuclear power plant documentation and particular utility report. An overview of generalised major results is given in the following text.

An equivalent direct wind speed for tornado (category F1 of Fujita scale reaches 50 m/s)is less than wind speed determined for extreme wind loads (see table below). So, buildings of safe shutdown routes have been successfully evaluated for the wind loads equal to1.2 multiple load of tornado F1 category.

Characteristics of meteorological variables – wind

Meteorological variable	Likelihood of adhering to the		
	Unit	100 years	10 000 years
Extreme wind speed for 10 minutes at 10 m above the measured surface	m/s	27.2	38.7
Maximum impact of the wind at 10 m above the measured surface	m/s	40.0	53.9

The safety margin of nuclear power plants against the snow load has been estimated as relation between the snow loads considered for the plant evaluation in the frame of design basis revision (1.40 kN/m^2) and design value (1.17 kN/m^2) based on STN EN 1991 standard. So, the evaluation (Mochovce NPP) shows the resistance of building of seismic categories 1 and 2 against the snow loads is about 1.2-times higher than design loads.

Safety margins for extreme weather temperatures

	Threat,°C (TR=10,000 y)	Design basis,°C	Margin, °C
Maximum temperature lasting 6 hours	+41.6	+43.8	2.2
Minimum temperature lasting 6 hours	-33.7	-44.2	8.5
Maximum temperature lasting 7 days	+33.5	+38.0	4.5
Minimum temperature lasting 7 days	-27.3	-30.0	2.7

Safety margins between the threats and design values for extreme temperatures are listed in table above. The evaluation has been performed for threats estimated for return period 10,000 years. The design of relevant equipment of the safe shutdown routs has been done for the consideration of stable conditions of external temperature and not for short-term temperature transients.

2.3.2.2 Measures, which can be envisaged to increase robustness of the plants against extreme weather conditions

2.3.2.2.1 Consideration of measures, which could be envisaged to increase plants robustness against extreme weather conditions and would enhance plants safety

Major design and construction measures and administrative arrangements, which can be envisaged to increase robustness of the Bohunice and Mochovce plants against extreme weather conditions (i. e. extreme wind, temperatures and humidity, snow amount, freeze and icing, and their combinations) include:

- Finalize the report of Slovak Hydro-meteorological Institute for Bohunice site to consider recent knowledge on meteorological conditions;
- Update the safety report for NPP Bohunice V-2 and EMO1.2 nuclear power plant and its referenced supportive documents dealing with external threats to be in line with international requirements and recent knowledge of meteorological conditions;
- Perform the detailed assessment of impact of extreme meteorological conditions (temperature and combination of wind/ icing) to the vulnerability of high voltage lines at the Bohunice and Mochovce sites.

Specific proposals for changes in plant operating procedures and recommendations for preventive arrangements at the plants are provided in the utility reports. These include:

- An increase of the frequency for plant walk-down of diesel generator stations at time of low temperatures, snowing and icing;
- To design and implement preventive measures at ambient temperatures below design basis to maintain the functionality of equipment relevant to safety

Design and construction measures and administrative arrangements, which can be envisaged to increase robustness of the Bohunice and Mochovce plants against extreme rainfall and floods, are summarised in the Chapter 2.2 of this report.

3 Design Issues

3.1 Loss of electrical power

Power supply of electric consumers important for nuclear safety, safe plant shutdown, core cooling, residual power removal and maintenance of integrity of barriers for in-depth protection is the principal prerequisite for safe NPP operation. In all units there are several possibilities for AC power supply.

In case of NPP Bohunice V-2 these possibilities include:

1. One out of four plant generators, if the power is delivered to the 400 kV power grid or successful transition to home consumption has been performed
2. 2 independent lines from the 400 kV distribution grid– through power output lines to the station grid
3. 2 independent lines to stand-by unit transformers (from 110 kV Bosaca substation, from 220 kV Krizovany substation, if outlet to the 400 kV grid is disconnected);
4. One out of four plant generators, if successful transition to home consumption has been performed;
5. Three DGs for each unit – if none from the aforementioned sources is available. Connection of any one of three DGs per unit is sufficient to ensure fulfillment of safety functions.
6. In case all DGs fail to start or to connect to the emergency power supply switchboards, there is an additional possibility to recover the home consumption power supply from the Madunice hydro station by a separate 110 kV line.
7. In addition to these design solutions, the power supply of V-2 NPP can be ensured also by emergency connection of one of three 6 kV DGs with a power of 2.9 MVA from the neighboring V1 NPP.
8. Furthermore, within the ongoing SAM project an emergency diverse 6 kV SAM DG with a power of 1.2 MW is under installation. It will be able to supply consumers also in case of a loss of other power sources considered in the design.
9. The jumper to MO3,4 works also vice-versa to EMO1,2.

In Mochovce EMO1,2 units the possibilities for power supply are as follows:

1. One out of four plant generators, if the power is delivered to the 400 kV power grid or successful transition to home consumption has been performed;
2. 2 independent lines from the 400 kV distribution – through power output lines to the station grid when TGs are shut down (400 kV line from VelkyDur switchyard);
3. 2 independent lines to standby transformers (from Velky Dur substation 110 kV);
4. Diverse source from Gabcikovo Hydropower Plant;
5. Diesel generator station 16 x 2 MWe situated in the 400 kV Levice switchyard;
6. Three DGs for each unit – if none from the aforementioned sources is available
7. Within the ongoing SAM project a diverse 6 kV SAM DG with a power 1.2 MW which will be able to supply consumers to mitigate severe accident consequences is being installed.
8. Furthermore, there is an on-going procurement in 2011 of additional mobile DGs of 0.4 kV with 300 kW power per unit for recharging of accumulator batteries in case of a long-term SBO and failure of all home consumption power sources.

For EMO3,4 units the same possibilities as for EMO1,2 will be available. In addition, EMO3,4 design is improved in comparison to EMO1,2 design by the introduction of 400 kV breakers at the outlet of the unit main transformer. Furthermore, the EMO3,4 twin-unit design includes also measures using the four-unit configuration and assuming a manual interconnection of the DG of the respective redundancy between the twin-units. After the Units 3,4 start-up, options and stability of power supply of safety appliances not only in Units 1,2 but in the entire EMO site will be improved.

In addition, there is DC power provided by the batteries.

All options are described in more detail in the text below.

3.1.1 Loss of off-site power

If, after the plant disconnection from 400kV grid, TGs are not stopped and generators are not disconnected from the home consumption grid, the unit controllers regulate the unit to home consumption operation. In this regime, the generators ensure the unit home consumption supply. If regulation to home consumption fails, unit electric supply is recovered from the back-up power supply.

3.1.1.1 Design provisions taking into account this situation: normal back-up AC power sources provided capacity and preparedness to take them in operation, Dependence on the functions of other reactors on the same site. Robustness of the provisions in connection with seism and flooding

In case of failure or impossibility to transfer to the unit regime ensuring home consumption power supply by the unit, power supply of the unit home consumption (including emergency power supply category II sections) will be recovered from the back-up power supply. Back-up power supply is provided from 110 kV / 220kV substations.

3.1.1.2 Autonomy of the on-site power sources and provisions taken to prolong the service time of on-site AC power supply

Back-up power supply of both units is independent from the working supply and must be available in all unit regimes. Unit back-up supply has capacity dimensioned so as to provide for power supply of all unit consumers needed for operation in all regimes. Each NPP unit has own back-up power supply grid; these grids can be mutually interconnected, i. e. both units can use not only own back-up power supply, but also that of the neighbor unit. There are no time limitations for unit operation with power supplied from working or back-up supply.

3.1.2 Loss of off-site power and loss of the ordinary back-up AC power source

If unit back-up supply is not available and if the plant is disconnected from the 400kV grid and the unit fails to transfer to home consumption (or transfer to unit back-up supply fails), the unit home consumption can be supplied neither from working, nor from back-up power supply. In this case, the unit home consumption supply is recovered automatically in the minimal configuration needed for provision of the principal safety functions from the emergency power supply sources – three DGs per unit representing 3 x 100% redundancy. At this situation, the unit transfers automatically to regime 3.

3.1.2.1 Design provisions taking into account this situation: diverse permanently installed AC power sources and/or means to timely provide other diverse AC power sources, capacity and preparedness to take them in operation. Robustness of the provisions in connection with seismic events and flooding

Emergency power supply systems (diesel generators with their relevant sections) are designed as independent, while each of them is capable of supplying safety important consumers in any unit regime, i. e. 3x100 % redundancy is available.

The emergency power supply systems are fully autonomous, including automatic DG start-up, connection to 6kV emergency power supply section, loading and operation. Each DG has fuel inventory in its own tank with volume 110 m^3. DG consumption was measured during the stress tests with load 1.6MW. Obtained data show that DG could remain working for 220 – 240 hours considering the load and using the complete diesel fuel inventory from the tank.

If necessary, design solution of emergency sources enable extension of their operation by alternating (switching off and keeping only one or two systems running).

All three emergency power supply systems, including reserve sources, must be serviceable in regimes 1, 2, 3, and 4. Minimally two emergency power supply systems, including reserve sources, must be available in regimes 5, 6 and 7.

3.1.2.2 Battery capacity, duration and possibilities to recharge batteries

In the considered operational regime, the batteries are permanently charged from the emergency power source (DG); thus, their capacity is kept on nominal value.

3.1.3 Loss of off-site power and loss of the ordinary back-up AC power sources, and loss of permanently installed diverse back-up AC power sources

Complete loss of home consumption power supply (black-out) may occur at loss of power supply from the grid and a failure to regulate the unit to home consumption, with loss of back-up power supply and failure of start of all the DGs or their connection to 6 kV emergency power supply sections.

NPP Bohunice V-2 has an alternative power supply source for the situation with failed emergency power supplies, so called 3rd grid connection (external autonomous source). This source supplies two safety systems (one per unit, total power 5MW). The 3rd power grid connection consists of three parts: Madunice hydro plant, connecting line and substations in NPP. This source is capable to recover power supply of one emergency power supply section in each unit within 30 minutes. Emergency power supply sections can be also supplied by diesel generators from V1 NPP via the 3rd grid connection substations.

The Mochovce power plant has an alternative power supply for case of failed emergency power supply sources – a so called third grid connection (off-site autonomous source) either from Gabcikovo hydro plant or from DGs (16 x 2 MW) in Levice switchyard.

In case of station black-out, only the sub-set of the top priority consumers remains operating ensuring limited set of functions aimed primarily at monitoring of the unit conditions and safe equipment shutdown. These consumers are supplied from three vital power supply sources. Accumulators are power supply sources of these consumers.

A serious consequence of the SBO event could be a potential loss of integrity of the RCP seals due to failure of their cooling. In case of SBO, cooling of RCP seals will not be ensured due to loss of RCP seal water flow and loss of water flow through the coolers of the RCP, which, from the long-term point, may evoke the RCS coolant leakage through the drain line from the RCP seal. According to current data, RCP seal will not fail within 24 hours after loss of cooling; longer lasting cooling failures were not analysed.

3.1.3.1 Battery capacity, duration and possibilities to recharge batteries in this situation

Accumulators for NPP Bohunice V-2 and EMO1,2 are designed for 2 hours operation for 220 V level and in addition in EMO1,2 there are also24 V batteries designed to operate for 4 hours for without emergency power supply sources.

Design assumptions used for determination of this time were too conservative. Based on data collected during normal operation and analyses of the capacity of the batteries during real transients it was concluded they will remain operable for 8-10 hours at least. As part of the stress tests, capacity of batteries in NPP Bohunice V-2 was measured with the conclusion that it is sufficient for up to 11 hours of operation.

During blackout, batteries load can be decreased by means of the power saving programme in accordance with the procedure ECA-0.0, and thus the estimated value of serviceability of accumulators during blackout may be considered as a conservative estimation. Sequential use of other accumulator systems connected with the working system by a cable is another option. There is the residual battery capacity monitoring system installed in EMO1,2 and similar system is going to be installed in NPP Bohunice V-2.

3.1.3.2 Actions foreseen to arrange exceptional AC power supply from transportable or dedicated off-site source

After SBO unit home consumption is recovered from emergency sources or from working or back-up power supply. Power supply from the alternative grid (the 3rd grid connection (EBO) or Gabcikovo switch yard or DGs in Levice switchyard (EMO) will be used for unit stabilization only in case of failed recovery of the main sources. Connection of these power sources is described in relevant plant procedures.

In case of long-term SBO, if the unit power supply recovery failed from all of the abovementioned sources, the most important consumers will be able to be supplied from a mobile 0.4kV DG (emergency power supply consumers of vital power supply and selected important consumers for provision of the main safety functions) at each unit. The procurement process for these mobile DGs is on-going.

3.1.3.3 Competence of shift staff to make necessary electrical connections and time needed for those actions. Time needed by experts to make the necessary connections

The shift staff is competent and trained to perform relevant manipulations to recover power supply from assumed power supply sources. In case of need, other on-duty staff or day specialists as required by TSC can be involved. NPP staff training programs contain scenarios with unit power recovery in regular intervals. During non-standard tests in NPP Bohunice V-2 in 2011, power recovery of the emergency power supply sections from the 3rd grid connection was tested and it took place within 30 minutes from issuing the demand.

Recovery of working, back-up supply and emergency sources takes 1.5hours. Recovery of power supply from the alternative grids – the 3rd grid connection in NPP Bohunice V-2 and Gabcikovo switchyard or DG in Levice switchyard in EMO1,2requires1 5 hours and 2 hours respectively.

3.1.3.4 Time available to provide AC power and to restore core and spent fuel pool cooling before fuel damage: consideration of various examples of time delay from reactor shutdown and loss of normal reactor core cooling condition (e. g. start of water loss from the primary circuit)

The chapter does not consider water supply from external sources and time intervals given are margins enabled by internal feedwater and coolant stock in the plant only. In case of off-site support sources the time margin would be unlimited.

Regimes 1,2,3

Core reactivity control:

After station black-out the reactors are shutdown automatically and minimum subcriticality 2% is ensured conditions -one control rod stuck in upper position and RCS cool down to 240 ℃. Recriticality can occur only after RCS cool down to 150℃.

For the multiple failures (e. g. SBO and leaks from SC) during which positive reactivity could be inserted in case of SBO no pumps are available for injecting the boric acid concentration into the RCS. If the core sub-criticality decrease occurred, coolant containing boric acid could be supplied only from HA (HA discharge pressure for EBO, EMO3,4 is 3.5 MPa, for EMO1,2 it is 6MPa). To be prepared for HA injection to ensure core subcriticality, the RCS temperature should be decreased to allow RCS depressurisation and consequent HA injection in NPP Bohunice V-2 and EMO3,4. Because of higher HA injection pressure, this is not needed for EMO1,2. At EMO1,2 during 7 hours RCS pressure is passively stabilized at 6 MPa pressure with sufficiently sub-cooled core for long term status, without needs of additional inventory and cool down intervention requirements. In case of SBO on one unit only, boron injection pumps can be used and supplied from the other unit. These pumps can add boron to the RCS and also maintain coolant inventory in the RCS that is decreasing due to coolant shrinkage and possible small leakages from the RCS. Power supply of boron pumps will be also possible from DGs 0.4kV that are currently in the procurement process.

Time margin: If the unit is not cooled below ~240℃ during SBO, no fuel damage occurs due to loss of sub-criticality for unlimited period of time. Nevertheless to protect RCP seals it will be necessary to cool down RCS bellow 240℃ after 24hours. In tha t case it would be necessary to increase the core sub-criticality by injecting boron solution.

Heat removal from the primary circuit

The main SBO severe consequence is endangering of heat removal from the RCS, which will occur due to loss of SG feedwater that cannot be supplied without power supply. Due to interruption of SG feedwater supply, the residual heat removal from the core leads to gradual reduction of the secondary coolant. The unit staff has at least 5 hours available till the loss of heat removal from the RCS to SC, if using only water in steam generators (about 300 m^3). During this time it is necessary to activate the fire department to prepare and connect a mobile emergency high pressure feedwater system (currently available only in EMO1,2, in NPP Bohunice V-2 is being procured). To stabilize levels in two SGs after 5 hours from the event, 20 m^3/hour is sufficient. When considering the mobile source capacity ~33 m^3/hour, level in selected SGs could be also increased. Heat removal from the secondary side is thus ensured for 10 days. Blackout is a common cause event affecting both units, one mobile emergency feedwater system source is sufficient only for one unit. After 24 hours from the event one mobile emergency feedwater system source is sufficient to remove heat decay from both units.

Time margin: with available emergency mobile source, more than 10 days without the off-site assistance

If the mobile emergency feedwater source is not available, level in SG will drop. Once SG heat-exchange surface becomes ineffective for the core residual heat removal, temperature in the core outlet will start to increase together with RCS pressure. When the pressurizer relief valve or the pressurizer safety valve opening pressure is reached, loss of the RCS coolant continues with deterioration of core cooling. The reactor residual power is in this phase removed by the RCS coolant evaporation to the containment. The long-term loss of heat removal from the primary circuit will gradually change to loss of the core cooling. If power supply of the unit is not recovered on time and water supply to the SG or RCS is not recovered, the initiating event of blackout type leads to fuel damage.

To prevent this scenario, it is possible to use passive gravity SG feeding from FWT; however, stresses induced in the SG collectors should be considered. SG gravity feeding ensures RCS heat removal for about 20 hours. When feedwater tanks are emptied, it is possible to continue supplying SG low-pressure feedwater to the emergency feedwater discharge by mobile fire brigade pumps installed on a fire-fighting truck platform with pressure head of 1 MPa.

If establishment of feedwater flow by fire pumps was not successful, coolant contained in HA may be used to ensure core cooling. The RCS temperature will be controlled by releasing steam from RCS through PRZ PORV/SV. In the optimum case, the coolant volume in the HAs (160 m^3) can ensure the core cooling for 10 hours. It is however conservatively assumed that HA connected to the reactor upper plenum will not be fully used for the core cooling, since their volume will leak through the pressurizer relief valve/safety valve without participating in the core cooling. Thus it is assumed, that the HAs will ensure the core cooling for 5 hours only. Conditions for optimum utilization of coolant from the HAs must be formed even during the SG evaporation (RCS cooling to temperature corresponding to pressure in the HA). After emptying of HAs, the coolant volume in the RPV will ensure the core cooling for another approx. 2 hours.

Core fuel damage may occur after more than 32 hours after initiating event (see the Figure 11).

Time margin: 32 hours without off-site assistance

Based on performed stress test analysis, long-term reliable heat removal during blackout requires a modification of current provisions in order to enable high-pressure feedwater supply to the SG through the EFWS header also for the other unit in parallel (ensure another mobile EFW pump).

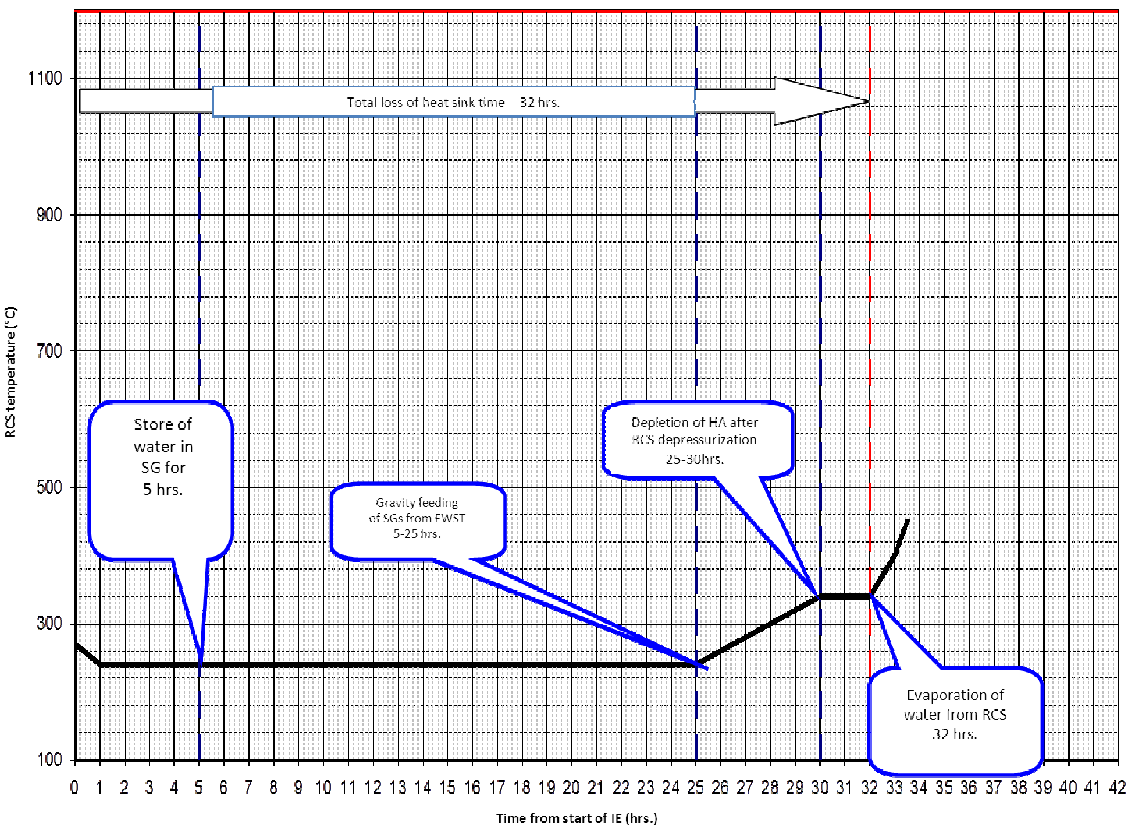

Figure 11: Temperature behaviour in core outlet during SBO

Legend:
x-axis – time elapsed from event occurrence (hours)
y-axis – temperature in RCS (°C)

Time margin to fuel damage depends on the scenario:

- With SG FW supply from the fire-fighting pumps – without limitation subject to RCS tightness
- Without SG FW supply from the fire-fighting pumps using gravity SG feeding – 32 hours

Containment integrity

During SBO, heat removal from the containment is not ensured due to loss of ESCW and containment cooling systems. No alternative system is available for containment cooling during SBO; thus, temperature in the containment starts to increase. Air in the containment will cause heating of concrete containment structure after certain time delay. After 8 hours from the loss of power supply, air in the containment will reach 100℃. After two days, expected centerline temperature in containment wall is approx. 60℃. Th e containment integrity is not endangered at this temperature. According to the European standard Eurocode 2-1-1, concrete strength decreases by max. 6% at 127℃. By the time of fuel damaging (32 hours from the initiating event), temperature in the containment does not exceed 110°C and pressure 140 kPa. The containment integrity is not affected at these values.

If the core cooling is lost during SBO (SG FW make-up sources are exhausted), PRZ RV opens to the containment that is supplied not only by RCS thermal losses, but also the complete residual core power, the containment heating trend will rise about 3 times and its pressure will continue to increase as well. Containment integrity could be challenged after fuel damage and subsequent hydrogen combustion. These processes are described in Chapter 3.

Time margin:

With available FW and emergency mobile pump – without time limitation

Without available FW emergency mobile source and without implementation of measures for preservation of containment integrity – 33 hours

RCS coolant inventory

During blackout, the RCS make-up is not available. Level in the pressurizer also decreases due to RCS coolant shrinkage and possible small leakages from the RCS. The cooling to 238℃ itself decreases RCS coolant volume by 17 m^3. If assumed leak from the RCS within 24 hours is 0.5 m^3/h, total decrease of RCS volume after 24 hours will be 30 m^3. The rest of coolant inventory in the primary circuit is sufficient from view point of the core cooling and heat removal from the core. In the time horizon for 24 hours after SBO, leaks from the RCS can be affected by possible leaks through RCP seals. If no leak occurs through RCP seals, coolant inventory in the RCS is sufficient to ensure heat removal for another 20 hours.

In the case of blackout, coolant can be added to the RCS only from HA (after RCS depressurization) or by boron pumps after implementation of the proposed modifications (connection to twin unit or use of dedicated 0.4kV DG).

Time margin: RCS coolant inventory is sufficient for fuel cooling for at least 24 hours. Further course depends on leak through RCP seals; however, no data is currently available for this case. If provisions for compensation of leaks are available, time is unlimited.

Monitoring of unit condition

Monitoring is possible only if vital power supply is available. According to values measured during the stress tests and considered capacity of VPS - batteries are sufficient for approx. 11 hours of operation. Similar estimate is 8-10 hours for EMO. When minimum capacity is reached, batteries must be switched off, because they would become irreversibly damaged after complete discharge, which would complicate plant stabilization after power supply recovery.

EBO does not have any batteries capacity monitoring system enabling correct interventions to reduce consumption, and to specify condition, when the vital power supply must be switched off. Such monitoring system is going to be installed within SAM project.

Time margin:

- If recharging of batteries from 0.4 kV DGs is available – standard unit monitoring would be available without time limitation.
- Without recharging the batteries or adopting measures for reducing the consumption– no standard unit monitoring would be available after 11 hours of blackout condition. Procedures for non standard monitoring of unit condition are under development (SAM project).

Regimes 4,5

Core reactivity control

In regimes 4 and 5, shutdown boric acid concentration is established in the RCS. Therefore, evaluation results of the core reactivity control at SBO in regime 3 can be considered as boundary assumption valid also for SBO in regimes 4 and 5.

Heat removal from the primary circuit

In regimes 4, 5 before the initiating event, heat removal from the primary circuit was in steam-water or water-water mode, or in phase of its transfer to the water-water regime. In case of SBO in regimes 4, 5 heat removal from the RCS cannot continue in the water-water mode, as it is not executable without power supply. Therefore, it is necessary to transfer the secondary heat removal to the steam-water. This requires drainage of the heat removal system and RCS heating to the temperature causing steam production in SG sufficient for all residual heat removal from the core.

The coolant inventory in SG in regimes 4, 5 is higher than the one in regimes 1, 2, 3. Residual core power in regimes 4,5 is lower due longer time elapsed from reactor shutdown, which extends time for SG depletion. Thus, the total time during which heat removal from RCS is ensured is greater than in regime 3.

Containment integrity

In regimes 4, 5, the coolant temperature in the RCS and the RCS structures is lower than in regime 1, 2, 3, and also the core residual power will be lower due to longer time elapsed since the reactor shutdown. Thus, the results of assessment of the heat removal from the RCS at SBO in regime 3 can be considered a boundary estimation applicable also to the SBO in regimes 4, 5.

Monitoring of unit condition

In regimes 4,5, no higher consumptions from accumulators system 1 - 4 are assumed, and therefore, conclusions of assessment of sustainability of the unit condition monitoring at SBO in regime 1,2,3 can be considered a boundary estimation applicable to SBO in regimes 4, 5.

Regime 6

Core reactivity control:

In regime 6, shutdown boric acid concentration is already established. For reactivity control the boric acid could be supplied to RCS by gravity from the bubbler condenser tower in the case of boron concentration decrease. Therefore, results of assessment of the reactivity control in the core and in the spent fuel pool at SBO in regimes 1, 2, 3 can be considered a conservative estimation applicable also to SBO in regime 6.

Heat removal from the primary circuit

In regime 6, the RCS is depressurized and it can be also open (the RCS pressure boundary is disabled). Heat removal from the RCS before the event was in the water-water regime. After the SBO, heat removal from the RCS cannot continue in the water-water regime, which is not executable without power supply. If only RCS air vents valves are open in regime 6, which can be closed, the assessment for regimes 4, 5 is applicable to assessment of heat removal from the RCS in case of SBO. If the reactor is open, the following options are available:

- Heat removal from the core in the core boiling regime, without any operator intervention, initial coolant level 200 mm below the RPV main flange - Time margin to fuel damage about 9 hours
- Heat removal from the core in the core boiling regime. With operator intervention, but without off-site support. Coolant is added to the RCS by gravity feeding from bubbler condenser trays. – Time margin to fuel damage about 4 days;
- Heat removal from the core partially by coolant boiling in RPV and partially by steam from SG. Coolant is added to the RPV by gravity feeding from water trays and to SG either from FWT or by fire pumps, without off-site sources with MCR operator´s intervention - Time margin to fuel damage about 12 days.

Containment integrity

The containment pressure boundary is disabled in the regime 6 and containment integrity cannot be endangered.

Monitoring of unit condition

In regime 6, power consumption from batteries is lower than in regime 1, 2, 3, so that these regimes envelope SBO also in regime 6.

Spent fuel pool

After station blackout, systems for residual heat removal from SFP to ESCW are inoperable. Residual heat from spent fuel pool can be removed by alternative methods only. These methods consist in decay heat accumulation in SFP coolant and in other RCS volumes or in regime of SFP boiling. When steam from SFP is evaporated to the reactor hall, coolant is added to the SFP either using passive means (bubbler containment trays) or using fire pumps.

Spent fuel pool reactivity control

Sub-criticality in the SFP is provided in two independent ways:

- Geometry and material of the storage grid
- Boric acid concentration

SFP design does not enable formation of critical conditions in the SFP even after boron concentration decrease to zero provided that no boiling takes place in the SFP. During SBO for SFP reactivity control, only passive methods are available – boric acid solution make–up to SFP by gravity from the bubbler condenser trays. During the stress tests, the flow rate was measured from trays and the flow rates were sufficient for reactivity control in the SFP.

For EMO1,2 lower grid of SFP it was justified, that even if assuming local decrease of subcriticality due to boiling, the grid with hexagonal absorption tubes itself is sufficient to prevent occurrence of critical assembly. Thus, there is no risk of reactivity control endangering at pure condensate make-up. Similar analysis should be performed also for NPP Bohunice V-2.

Heat removal from the spent fuel pool

In case of SBO, standard heat removal from the spent fuel pool through the ESCW is not available. Spent fuel residual power accumulates in the coolant and SFP structures and temperature in SFP starts to rise. Depending on residual power of fuel in the spent fuel pool, which can range from 1.25 MW to 5 MW, and coolant inventory in the spent fuel pool before the event, there are time margins available according to the table below (data for NPP Bohunice V-2, without operator´s intervention).

After blackout the only way for SFP cooling is passive make-up of the SFP from 7 bubbler condenser trays above SFP level, which ensures SFP cooling by heating-up coolant from the trays from 40 ℃ to 60 ℃ for 4 to 14 hours, depending on spent fuel residual power. After reaching the boiling point, cooling is provided by evaporation of coolant from SFP. To maintain required coolant inventory in the SFP, it is necessary to ensure its make-up from other sources (fire pumps). SFP make-up need per unit for residual heat removal from SFP by coolant boiling ranges from 2 m^3/hr (for power 1.25 MW) to 8 m^3/hr (power 5 MW). Steam produced in SFP is being removed to the atmosphere.

Time margins to damage of fuel in SFP depend on amount/residual heat of spent fuel and on initial coolant inventory. Some quantitative data without operator interventions (without alternative cooling) are seen from the next table. These margins can be extended by 4 – 14 hours by using water from the trays.

All fuel is off-loaded to SFP, level in SFP 21.27m

Fuel power	Level	Boiling in SFP	Coolant evaporation above the fuel	Complete coolant evaporation under the fuel and temperature 1,200°C
4,87MW	21,27m	2hrs48min	+20 hrs45min	+6 hrs52min

Only spent fuel from previous campaigns is placed in SFP, level in SFP 14.46m

Fuel power	Level	Boiling in SFP	Coolant evaporation above the fuel	Complete coolant evaporation under the fuel and temperature 1,200°C
1,25MW	14,46m	5 hrs14min	+37 hrs33min	+19 hrs15min

Only spent fuel from previous campaigns is placed in SFP, level in SFP 21.27m

Fuel power	Level	Boiling in SFP	Coolant evaporation above the fuel	Complete coolant evaporation under the fuel and temperature 1,200°C
1,25MW	21,27m	10 hrs55min	+127 hrs55min	+19 hrs15min

Similar estimate of the time margins was made for EMO1,2 and NPP Bohunice V-2 considering two kinds of SFP cooling:

- Make-up of SFP passively by gravity make-up from 7 containment trays installed above the SFP level +21m and increase of level from +14.45m to +21,17m (also considering the need to remove heat from the reactor core);
- SFP drainage through the overflow on +21.22m to LP ECCS tanks (if empty) or RCS drainage tank and SFP filling from containment trays

By realizing of these measures time to boiling will be increased by 5 to 10 hrs.

Further heat removal from SFP after exhaustion of the alternative cooling (5 – 10 hours after SBO) and SFP heating to the boiling point after another 2.6 hours for unloaded fuel from the reactor core (level on +21,17m) up to 10.7 hours for fuel assemblies in the basic rack only (level at +14.46m) can be ensured by coolant evaporation. To maintain required coolant inventory in SFP, it is necessary to ensure its make-up from other sources (bubbler condenser trays by gravity, fire pumps). SFP make-up need per unit at heat removal from SFP by coolant boiling ranges from 2 m^3/hr (power 1.25 MW) to 8 m^3/hr (power 5 MW).Steam generated in SFP is removed to the reactor hall.

Times without staff intervention are given in the following table:

Event SBO	Fuel assemblies in both racks +21.17 m/ 4.8 MWTime [hrs]	Fuel assemblies in basic racks only +14.46 m/1.26 MW Time [hrs]
Start of Event	0	0
Reaching of saturation limit – boiling in SFP	2,6	10,7
Exposure of stored fuel assemblies	23	42,5
Damaging of fuel assemblies 1,200℃	30,5	62

If filling of SFP by fire truck is applied the time margin is unlimited.

3.1.4 Conclusion on the adequacy of protection against loss of electrical power

The vulnerability against SBO is adequate, the design allows for approximately 30 hours margin (as a minimum) in provision of core cooling and spent fuel pool cooling safety functions.

3.1.5 Measures which can be envisaged to increase robustness of the plants in case of loss of electrical power

Evaluation of safety margins of V213 design at SBO proved the ability to ensure protection of safety barriers during considerably long time, thus providing sufficient time for accident management actions for recovery of the plant power supply. Despite the robustness of the current plant design, it can be improved by the following modifications and supported by tests and analyses:

- To increase resistance and reliability of EPS for beyond design basis events (installation of new 6kV emergency SAM DG);
- To provide for 0.4 kV DG for each unit for charging batteries and supplying selected unit consumers during SBO;
- Modifications of the power supply (also from 0.4 kV DGs) of the HP boron system pumps enabling their use during SBO;
- To provide for technical solution and cable pre-preparation in order to facilitate mechanical interconnection of accumulators between systems;
- To provide the mobile high-pressure source of SG feedwater available during SBO, with minimal flow rate 20-25 m^3/hr for one unit and with pressure head 6 MPa, and ensure logistics of supplies for the mobile source, with possible use for both NPP Bohunice V-2 and EMO3,4 (the same nozzle types);
- To optimize emergency illumination in order to extend life time of batteries (subdivision into sections with the possibility for switching off unnecessary parts, use of energy saving bulbs);

- To obtain data documenting behaviour of RCP seals at long-term failure of cooling (more than 24 hours);
- To provide for monitoring system of capacity of batteries (for NPP Bohunice V-2);
- To provide for mobile measuring instruments able to utilize standard measuring sensors (e. g. thermocouples);
- To provide for power supply of containment drainage valves and HAs isolation valves from the vital power supply system (EMO);
- To consider possibility to control selected valves without vital power supply by means of small portable motor 3-phase generator 0.4 kV (max. 7 kW);
- To install two physically separated fixed pipelines for make-up of the coolant inventory in SFP from a mobile source (fire pumps) and external water source dedicated for SA;
- To assure long-term serviceability of communication means for MCR operators and shift service staff;
- To develop operating procedure for possible use of diesel generators installed in Levice switchyard for SBO event (for EMO).

3.2 Loss of the decay heat removal capability/ultimate heat sink

The primary UHS is the surrounding atmosphere. Heat removal from the core, SFP and containment to ESCW and CW to the primary UHS in individual operating regimes is provided by various systems: In case of ESCW failure, the chain of systems participating in heat removal from the core, containment and SFP to the ultimate heat sink is interrupted at least in one regime. Thus, ESCW system is inevitable for provision of simultaneous long-term heat removal from the core, containment and SFP to UHS (atmosphere) at least in one unit regime. Complete, immediate and long-term loss of operability of all three ESCW system circuits can be considered as an envelope case of UHS loss that is conservatively covered by the previous SBO event analysis described in chapter 3.1. Considering low probability of immediate simultaneous mechanical failure of all ESCW systems, in following evaluation the scenario resulting in loss of UHS due to interruption of raw make-up water supply will be considered.

3.2.1 Design provisions to prevent the loss of the primary ultimate heat sink, such as alternative inlets for sea water or systems to protect main water inlet from blocking.

The ESCW system is the supporting system for core cooling safety systems. According to the UJD SR Decree No. 430/2011 Coll., it has been classified in the safety class 3. ESCW fulfills the safety function of heat removal from safety systems to the primary UHS (atmosphere). ESCW should provide not only for the ultimate heat removal system, but also to cool all consumers requiring uninterrupted cooling water supply.

ESCW system is designed as redundant 3x 100%; each system contains 2 pumps per unit (2x100%) and 2 forced draft cooling towers sections (2x100%). ESCW system is resistant against a single failure and a common-cause failure (fire, flooding, seismic events, interactions from high-energy pipes, flying objects, fall of a load, environmental conditions and extreme climatic conditions). ESCW circuit parts are mutually physically separated. Every ESCW system is supplied from different section of the emergency power supply in compliance with supplying of independent circuits of the core emergency cooling. ESCW system is common for both NPP units in the part of ESCW pools, main supply and return pipelines. Therefore, the neighboring unit can fully cover ESCW cooling requirements also in case of own unit system failure.

Twin-unit design of ESCW systems on the level of ESCW pumps and FDCT improves the system reliability, as the probability of unavailability of the complete system is lower than in case of single-unit design due to the power supply design solution of ESCW pumps and FDCT fans from both units and sufficient capacity 2/4 for one ESCW circuit, thus increasing the resistance against certain failure mechanisms of common cause.

ESCW system is dependent on equipment out of the NPP area supporting its operability. Considering ESCW operability, the most important among these systems is the raw make-up water supply system.

For NPP Bohunice V-2, raw make-up water can be supplied from water reservoir Slnava and the river Dudvah. Suctions from the water reservoir Slnava – Drahovce dam and Madunice hydro plant are supplied by the river Vah. The pumping station Pecenady is supplied with make-up water by gravity via four pipelines. From pumping station Pecenady to NPP Bohunice V-2 raw make-up water is pumped through two pipelines. Raw make-up water for NPP Bohunice V-2 can be supplied by independent piping system via V1 NPP.

In EMO3,4, the raw make-up water supply system is designed as operational system with double redundancy from the in-take point Male Kozmalovce on the river Hron.

Equipment ensuring water supply is protected against inlet clogging and freezing of sensitive system parts. However, in general the make-up water system is an operational system that was not upgraded for beyond-design basis external events including seismic events. Considering this fact, the protection against loss of UHS consists mainly in sufficient water inventory in ESCW and CW pools.

NPP Bohunice V-2 has total water inventory of 42,890 m^3 in the cooling water pools and 1,613 m^3 of usable water in each ESCW pool. In some regimes, another 37,510 m^3 of raw water is available in the inlet of raw water pipelines that can be supplied to NPP from operating pumping station Pecenady. In Mochovce, the total water inventory in NPP area is 44,000 m^3 in CW and 4,830 m^3 in all ESCW systems.

3.2.2 Loss of the primary ultimate heat sink (e. g. loss of access to cooling water from the river, lake or sea, or loss of the main cooling tower)

Loss of the main UHS can be initiated (with essential time delay) only in the case of loss of all ESCW systems in both units. Complete failure of all ESCW systems in both units can occur due to SBO, common cause failures (e. g. I&C failure) or it can result from the BDBA e. g. beyond design basis flooding or earthquake.

Complete loss of operability of all three ESCW trains can be considered as an envelope case of UHS loss that is conservatively covered by the previous SBO event analysis described in Chapter 3.1. For evaluation of other scenarios leading to loss of ultimate heat sink, the event with interruption of raw make-up water supply to NPP site was considered.

3.2.2.1 Long-term raw water supply to NPP area

The coolant inventory in the ESCW system decreases due to leakages, evaporation and water carry-over (0.5% flow rate on FDCT). The required coolant repository in ESCW is maintained by raw filtered water make-up from pumping stations. Available provisions are discussed below separately for each plant.

NPP Bohunice V-2

Besides the main source of raw water, ESCW basins can be fed from SCW system and from V-1 power plant. All these lines are not seismically qualified, and thus their failure after the design-basis seismic event is assumed. In such case, ESCW systems can be supplied by mobile means from off-site sources.

After loss of make-up raw water the reactor is shutdown in one hour. Total usable ESCW water inventory is 1,613 m^3. It was proven that the water inventory in the ESCW systems is sufficient for coverage of ESCW losses for 72 hours. After this time it is necessary to ensure make-up of ESCW pools. Required ESCW make-up flow decreases from value of 87 m^3/hr (3 days after the reactor shutdown) to 30 m^3/hr (one month from the reactor shutdown).

ESCW basins can be fed from water inventory in CW pools containing 42,890 m^3 of water (considering minimal operating level in CW pools). This volume will be sufficient for ESCW make-up for approx. one month of operation from the initiating event. If loss of raw make-up water supply event occurs during power operation, approx. 10,000 m^3 of this water is consumed for reactor shutdown and cool down to regime 3. In such case only 32,890 m^3 of water would remain in CW pools for make-up of ESCW basins, which would be sufficient for approx. 21 days.

EMO 1,2

Required coolant inventory in ESCW is maintained by raw make-up water supply from the pumping station in Male Kozmalovce. Raw water is accumulated in the water reservoir 2 x 6,150 m^3 on the site. In addition to this supply, ESCW system can be replenished from the CW system. ESCW pumps are seismically resistant.

After failure of the raw make-up water, level in the ESCW system will drop. ESCW circuit has total water inventory of 4,853 m^3. Reduction of amount of coolant depends on the operational regime and recovery actions started.

With regard to decrease of ECSW inventory the most unfavorable situation is the event during operation at power. Fast recovery of raw make-up water supply is not assumed; thus, both reactors should be shut down to regime 2 (within 6 hours), followed by establishment of shutdown boron concentration for 8 hours; then, residual heat is removed by:

- SDSC to MC to CW and to atmosphere;
- SDSA directly to the atmosphere, with sufficient demineralized water inventory for 10 days.

By this sequence the temperature 130℃ is reached. The further cool down of the RCS can be done through primary RHR system depending on the availability of the ESCW.

After failure of the raw make-up water to ESCW 4,853 m^3 are available in all three trains. Water inventory in ESCW systems is sufficient for covering losses from ESCW for 3 days from interruption of raw make-up water supply. After this time it is necessary to ensure make-up of ESCW trains from alternative sources.

Another procedure was developed enabling alternative make-up of ESCW system using a mobile pump independent on electrical power supply, with its suction connectable to the circulating water system that enables use of 44,000 m^3 from 4 CW pools. 13,620 m^3 water remains in CW to be used for ESCW, which is sufficient for another 9.4 days.

Water inventory from CW pools potentially may not be available after seismic event; therefore, use of off-site water inventory by truck cisterns is another possibility.

Forced draft cooling towers of the ESCW system provide for direct heat removal from ESCW system to the ultimate heat sink (atmosphere). In case of failure of several cooling towers, heat starts accumulating in ESCW system and relevant ESCW system will have to be switched off. Considering the design of ESCW system common for both units in the part of FDCTs, the neighboring unit can fully cover demand for ESCW cooling even in case of 2 failed FDCTs out of 4 in given system. Thus, loss of the ultimate heat sink due to FDCTs failure could occur only if none of the ESCW system would have at least two FDCT cells operating. However, if minimally one FDCT remains operating on two ESCW systems, no ultimate heat sink loss would occur, as reduced capacity of two working systems would be sufficient to cover cooling requirements. In winter, heat removal is sufficient even without working fans.

Integrity of RCP seals after loss of cooling

Possible loss of integrity of RCP seals is a serious consequence of ESCW failure. In case of ESCW loss, cooling of RCP seals will not be ensured due to loss of the RCP seal water flow and loss of the ESCW flow through coolers of the RCP, which, from the long-term point, may evoke the RCS coolant leakage through the RCP seals let-down lines.

Test results performed on full scope RCP seal model by the pump manufacturer showed that conditions endangering the seal integrity do not occur within 24 hours from loss of RCP cooling.

3.2.2.2 Availability of an alternate heat sink, dependence on the functions of other reactors on the same site

In case of loss of all ESCW systems, residual heat from the core can be removed directly by steam (via SG SDSA, SG SV) to atmosphere or via other systems independent on ESCW (SDSC, steam reduction stations), while ensuring feedwater flow to SG. Feedwater flow to SG is provided by EFWP from three demineralized water tanks. With this regard, the ultimate heat sink is ensured by normal heat removal system from the core using SG SDSA. This heat removal method is fully usable for regimes 1 to 5. In regime 6 with open reactor, residual power from the core can be removed for limited time by adding coolant to reactor/refuelling pool from other sources of coolant (coolant volume in RCS, emergency tanks, containment water trays) and after the reactor/refuelling pool level increase to +21m.

However, heat removal via the alternative system does not ensure residual power removal from auxiliary technological systems (cooling of intermediate circuits, vent systems, etc.), confinement and SFP and thus, it is not a full scope heat sink method to ESCW. However, it will ensure core heat sink without external FW sources for more than 10 days.

For containment and SFP heat removal for limited time various standard and non-standard interconnections included in the configuration database can be used.

3.2.2.3 Possible time constraints for availability of alternate heat sink and possibilities to increase the available time

In case of failure of all ESCW systems, residual heat from the core can be removed directly by steam release (via SG SDSA, SG SV) to the atmosphere or via other systems (technological condenser, steam reduction stations) to the circulating water and then to atmosphere, while ensuring feedwater flow to SG. The time of maintaining of this regime is limited. The power plant has coolant inventory for EFW pumps for 10 days (EMO) or 7 days (EBO) for both units. After this time, make-up of these tanks from an external source must be provided to ensure heat removal from the core.

If after the ESCW loss the coolant inventory for the SG make-up is exhausted, level in the SG will start to decrease. The time, during which the nominal coolant inventory in 6 SGs can ensure heat removal from the RCS depends on decay heat power, i. e. on time elapsed from reactor trip. Therefore it is dependent also on previous heat removal mode and used means. After SG drying they can be filled by gravity from the FWT. Gravity SG filling has limited capacity and when both feedwater tanks are exhausted, it is possible to continue supplying SG using low-pressure feedwater using mobile fire brigade pumps.

In case of open reactor (regime 6), residual heat from the core can be accumulated for limited time in the RCS coolant inventory, and also in inventory of ECCS tanks and containment trays. After all coolant accumulation capacity is exhausted, the decay heat can be removed by steam removal from SG and partial RCS coolant evaporation, whereas decreasing RCS and SG coolant inventory will be covered. In this case, establishment of required configuration takes several hours.

3.2.3 Loss of the primary ultimate heat sink and the alternate heat sink

Loss of the main UHS can occur only in case of loss of all ESCW systems in both units. Complete loss of operability of all three ESCW systems can be considered as an envelope case of UHS loss that is conservatively covered by SBO event analysis described in chapter 3.1. For evaluation of other scenarios leading to loss of ultimate heat sink, the event with interruption of raw make-up water supply of NPP site was considered.

ESCW system ensures residual heat removal form the core in some regimes and from SFP and containment in all regimes. It also provides supporting services for equipment used for reactivity control and core cooling. Therefore, trip of all ESCW systems has serious consequences on the reactivity control in the core and in the spent fuel pool, heat removal from the core and SFP, and may affect also containment integrity. Failure of all ESCW systems would lead to loss of cooling of the following systems:

DG, emergency core cooling systems, spray systems, SFP coolers, HVAC in respective rooms. Moreover, cooling of all operated systems that use ESCW will be lost: containment recirculation system coolers, containment room HVAC, cooling of the primary circuit normal make-up system, intermediate circuit coolers, auxiliary feedwater pumps, secondary RHR system.

Consequences of evaluated scenario on safety functions in individual unit regimes are described below.

Regime 3

Core reactivity control

In case of any event affecting heat removal from the core reactor is either tripped automatically or manually. Minimum subcriticality 2% is ensured even in case of one control rod stuck in upper position and RCS cool down to 240℃. For the events during which positive reactivity could be inserted in case of all ESCW systems failure, design systems for control of boric acid concentration in the primary circuit will not be available. The core reactivity control in this case is ensured using high pressure boron pumps. These pumps can establish cold shutdown boron concentration in RCS and maintain also the coolant inventory in the primary circuit, which will be reduced due to leakages from the primary circuit. After ESCW failure if the system boron system remains operable, the reactivity control in the core and RCS coolant inventory will be ensured in sufficient extent.

Heat removal from the core

Due to different water resources on the site and different assumptions and systems used for heat removal estimates of time margins, assessment is presented separately for NPP Bohunice V-2 and EMO1,2 units.

NPP Bohunice V-2

After loss raw water it is necessary to shut both units to regime 3. Heat from the core will be removed by steam from SG to the secondary RHR system operable in this stage. The unit cannot be cooled to cold conditions without ESCW, but it can be maintained in regime 3. The time for maintaining this regime is limited. Conservatively no ESCW make-up is assumed. In the evaluation also main feedwater pumps operation is not considered. After 72 hours level in ESCW basins will decrease to the minimum, and all three ESCW systems should be stopped. AFWP that are cooled by ESCW cannot be used for SG feeding and SG will have to be fed using EFWPs not requiring ESCW operation. The power plant has coolant inventory for the emergency feedwater pumps 920 m^3 for both units in each of the 3 tanks. This inventory cannot be maintained after raw water supply failure to NPP. Heat from the core will be removed by steam from SG via SG SDSA / SG SV directly to the atmosphere. This inventory 72 hours after the reactor shutdown is sufficient for heat removal from the core for another 7 days for both units.

After ESCW shutdown, the reactor is further cooled to 238℃ in order to enable gravity feeding and connection of HA to the RCS. After depletion of EFW tanks, SG can be further supplied by fire pumps. This heat removal mode is not time limited.

If SG make-up by fire pumps is not assumed after ESCW loss, nominal coolant inventory in six steam generators is sufficient for heat removal from the RCS for 50 hours. After SG drying it is possible to use gravity SG feeding for RCS heat removal. Gravity feeding of SG can ensure heat removal from SG for 60 hours.

After depletion of the gravity feeding, SG will be dried-out by residual heat and temperature and pressure in RCS start to rise. When the pressurizer relief valve or the pressurizer safety valve opening pressure is reached, loss of the RCS coolant continues and the core cooling deterioration continues as well. The reactor residual power is in this phase is removed by the RCS coolant evaporation to the containment.

Coolant in HA can be used in this phase for delaying the fuel cladding damage. In the optimum case, the coolant volume in the HA (160 t) can ensure the core cooling for 40 hours. HAs connected to the reactor upper plenum may not be optimally used for core cooling. Thus it is conservatively assumed that the HAs will ensure the core cooling only for 20 hours. After emptying of HA (if RPV is still full), the coolant volume in the RPV will ensure the core cooling for another approx. 10 hours.

The aforementioned estimations of time margins of the heat removal from the core at loss of UHS did not consider RCS coolant leakage through RCP seals, which could occur after failure of the RCP seals cooling for the time longer than 24 hours.

Time margins estimated for the above described processes are shown in the Figure 12.

Time margin to fuel damage following loss of UHS loss depends on scenario:

- With feedwater supply to SG from fire pumps – without real time limitation
- Without feedwater supply to SG from fire pumps – 380 hours

EMO1,2

In case of ESCW failure – either due to raw make-up water loss (after 72 hours) or ESCW unavailability, neither the RCS residual heat removal system, nor RCS and SC RHR are available and heat from the core cannot be removed even in the primary Feed & Bleed regime. Due to ESCW loss, primary circuit high-pressure make-up systems are not operable, and only low pressure boron pumps are available to maintain the minimum RCS coolant inventory needed for the heat removal from the primary circuit to the secondary circuit.

Heat removal from the core through the secondary circuit can be maintained by the normal heat removal system from SG through relief valves to condenser in the main header to cooling water and then to atmosphere. SG make-up will use normal feedwater pumps or emergency feedwater pumps, since the auxiliary feedwater pumps will not be serviceable due to ESCW loss. Conservatively no ESCW make-up is assumed (CW pools contain inventory for ESCW make up for at least 12-33days). For heat removal from the core to SDSC or SDSA / SG SV are used and SGs will be filled by EFWPs. (72 hours during which after initiating event the ESCW could be in operation is not considered in the evaluation). The unit cannot be cooled down and maintained in cold conditions, but it is possible to maintain it in semi-hot conditions), at which steam will be produced in the SG in the temperature range from nominal up to 100℃.

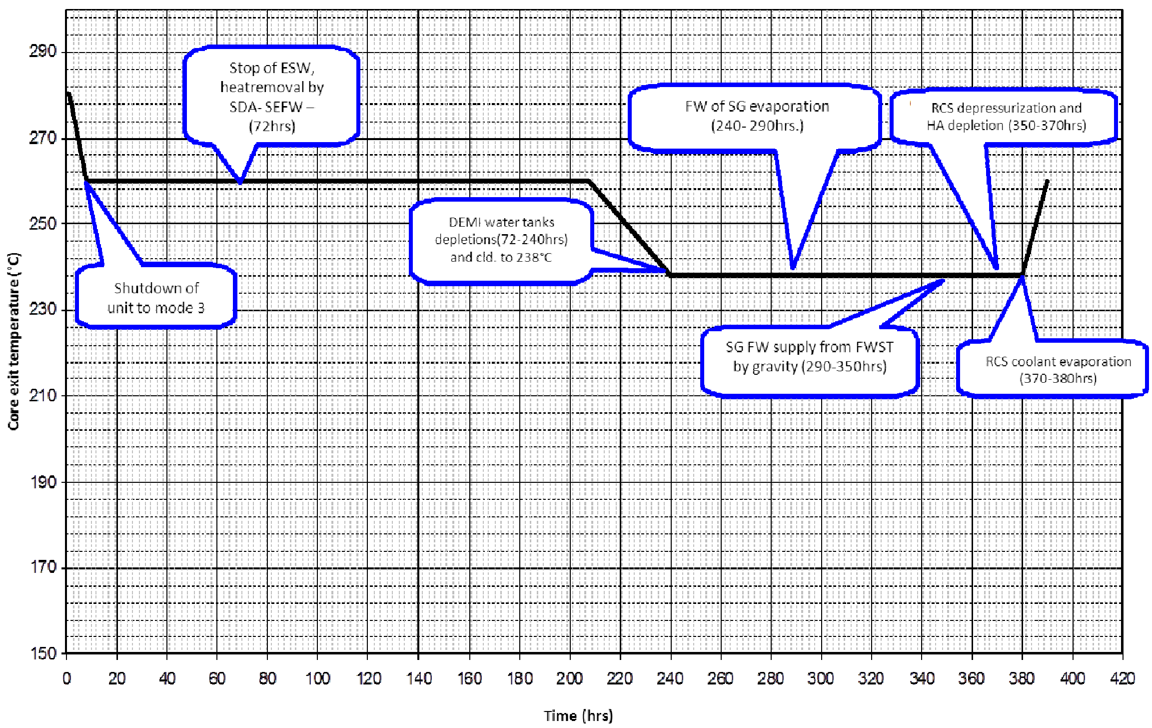

Figure 12: Temperature behaviour in core outlet during loss of UHS

Legend:
x-axis – time (hours)
y-axis – temperature on the core outlet (°C)

Note: The diagram is conservative because the possibility to make-up service water system volume from circulating water pools is not taken into account. This could however extend ESCW availability for additional 10-30 days.

The power plant has coolant inventory for operation of the emergency feedwater pumps for more than 10 days for both units when assuming inventory of 2,400 m^3 in three demineralized water tanks per unit. After this time, make-up of these tanks from an external source with the flow rate of about 7 m^3/hr for both units must be provided to ensure core heat removal. The design does not consider simultaneous unavailability of emergency feedwater pumps in both units, and one mobile source in the first 24 hours is not sufficient for both units.

If after ESCW loss, the aforementioned methods of maintaining the semi-hot condition of the RCS fail or are exhausted, i. e. the coolant inventory for the SG make-up is exhausted (after 10 days from the reactor shutdown) and no feedwater can be provided from external sources, level in SG will start to decrease. At this time, the nominal coolant inventory in 6 SGs after the emergency feedwater system loss is sufficient for the heat removal from the RCS for 35 hours. After SG drying it is possible to use gravity SG feeding for heat removal. Gravity SG feeding has limited capacity and can even result in non-design stress of SG tubes. When both feedwater tanks are exhausted, it is possible to continue supplying SG low-pressure feedwater to the emergency feedwater pump discharge by mobile fire brigade pumps.

If SG make-up by mobile fire brigade pumps does not start after exhausting of both feedwater tanks (after approx. 40 hours from commencement of the gravity make-up), the RCS will start to heat up by the reactor residual power, and pressure in the RCS will start to increase. When the pressurizer relief valve or the pressurizer safety valve opening pressure is reached, loss of the RCS coolant continues and the core cooling deterioration continues as well. The reactor residual power is in this phase removed by the RCS coolant evaporation to the containment. The long-term loss of heat removal from the primary circuit will gradually change to loss of the core cooling. If the heat removal from the core is not recovered on time, the initiating event in this scenario leads to the fuel damage.

Time margins estimated for the above described processes are shown in the Figure 13.

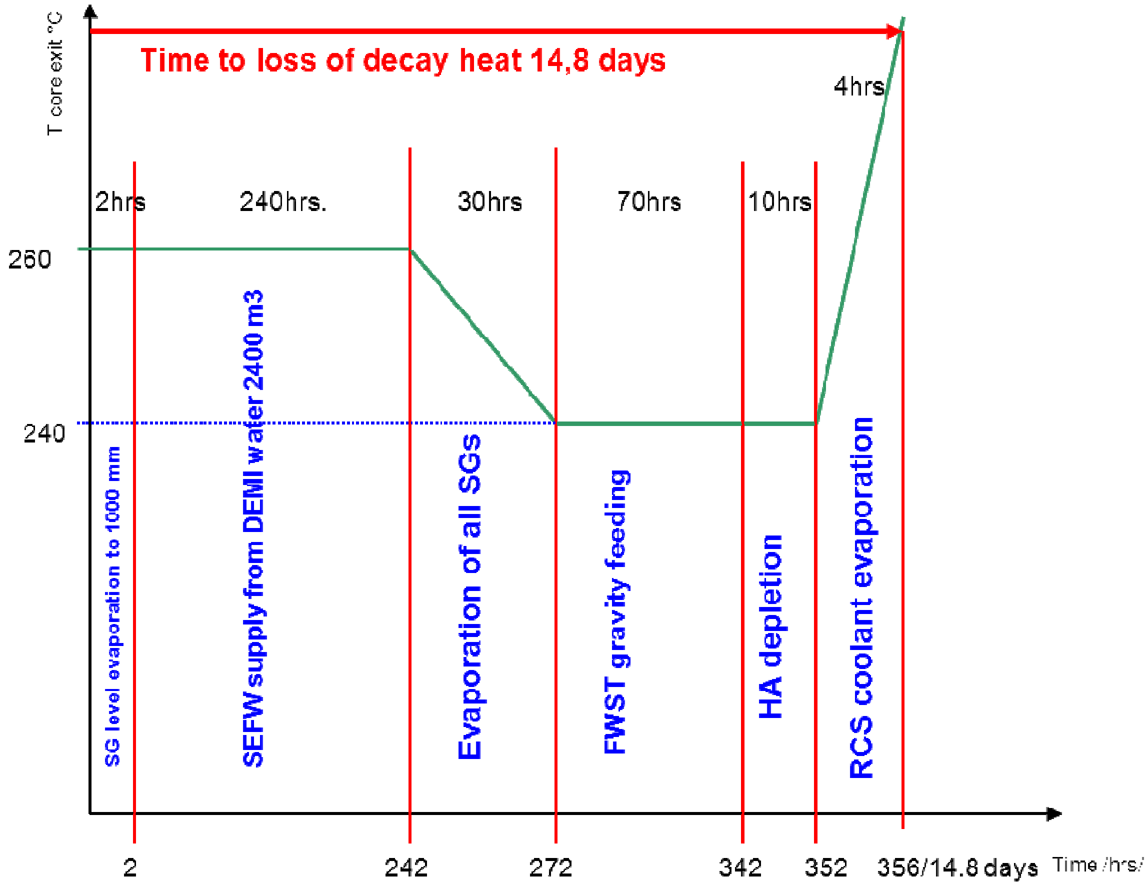

Figure 13: Temperature behaviour in core outlet during loss of UHS and normal FW

Legend:
x-axis – time (hours)
y-axis – temperature on the core outlet (°C)

Coolant in HA can be used for delaying the fuel cladding damaging. In the optimal case, the coolant volume in the HA can ensure the core cooling for more than 10 hours. Conditions for optimal utilization of coolant from HA must be formed even during the SG evaporation (RCS cooling to temperature corresponding to pressure in HA). If the RPV is filled after emptying of HA, the coolant volume in the RPV will ensure the core cooling for another approx. 4 hours.

Time reserve to fuel damaging at UHS loss due to ESCW loss is 8.3 days.

After ESCW failure in relation to the scenario, heat removal from the core can be maintained in relation to availability of the heat removal systems. In optimum case after ESCW failure, heat removal from the core can be maintained for a long time by the emergency feedwater system and make-up of demineralized water tanks. For this case, the MCR operator is able to maintain heat removal only with own sources for more than 14.2 days.

Time reserve to fuel damaging at UHS loss depends on event scenario:

– With feedwater supply to SG – without real time limitation
– Without feedwater supply to SG from fire brigade pumps – 14.2 days

Containment integrity

Due to long-term loss of raw water supply to NPP after 72 hours, all ESCW pumps will have to be stopped and heat removal from the containment is not available. No alternative system is available for containment cooling; thus, temperature in the containment starts to increase. Air in the containment will cause heating of concrete containment structure after certain time delay. After two days, expected temperature in containment wall center is 60°C. The containment integrity is not endangered at this temperature. According to the European standard Eurocode 2-1-1, concrete strength decreases by max. 6% at 127°C.

If the core cooling is lost during UHS loss (SG FW make-up sources are exhausted), PRZ RV opens to the containment that is supplied not only by RCS thermal losses, but the complete residual core power, the containment heating trend will increase about 3 times and its pressure will continue to increase as well. Containment integrity could be challenged after fuel damaging and subsequent hydrogen combustion. Further information is in chapter 3.

Regimes 4,5

Core reactivity control

In regimes 4, 5, the shutdown boric acid concentration is established in the primary circuit. Thus, the results of assessment of the reactivity control in the core and in the spent fuel pool at the UHS loss in regimes 1, 2, 3 can be considered a conservative estimation applicable also to the UHS loss in regimes 4 and 5.

Heat removal from the primary circuit

In regimes 4, 5 before the initiating event, heat removal form the primary circuit was in the water-water regime, or in the phase of its conversion to the water-water regime. In case of UHS in regimes 4, 5, it is not possible to continue with heat removal from the primary circuit in the water-water regime, which is impossible without ESCW, and thus it is necessary to transfer to the steam-water regime requiring draining of the secondary RHR system and RCS heating to temperature, at which such quantity of steam is produced that will be sufficient for removal of the current residual heat of the core.

The coolant inventory in SG in regimes 4, 5 is higher than in regime 3. In regimes 4, 5, the core residual power will be lower thanks to longer time from the reactor shutdown (more than 24 hours). Thus, the results of assessment of the heat removal from the RCS at UHS loss in regime 3 can be considered a conservative estimation applicable also to the UHS in regimes 4, 5.

Containment integrity

In regimes 4, 5, the coolant temperature in the RCS and the RCS structures is lower than in regime 3, and also the core residual power will be lower thanks to longer time elapsed from the reactor shutdown. Thus, the results of assessment of the containment integrity at UHS loss in regime 3 can be considered a conservative estimation applicable also to the UHS loss in regimes 4, 5. Therefore, containment integrity in regimes 4, 5 can be considered satisfactory from long-term point.

Regime 6

Core reactivity control

In regime 6, shutdown boric acid concentration is established in the primary circuit. Thus, the results of assessment of the reactivity control in the core and in the spent fuel pool at the UHS loss in regime 3 can be considered a conservative estimation applicable also to the UHS loss in regime 6.

Heat removal from the primary circuit

In regime 6, the primary circuit is depressurized and it can be also open (the RCS pressure boundary is disabled. Heat removal from the RCS before the event was in the water-water regime. After loss of all ESCW systems, heat removal from the RCS cannot continue in the water-water regime. The following alternatives are available for heat removal from the RCS:

– Heat removal from the core in boiling regime.

  Coolant is supplied to the RCS from tanks of emergency cooling system. Coolant inventory in tanks is 660-700 m^3, which is sufficient for the core cooling for 50-70 hours. In real case, coolant from containment trays that can be used for the core cooling will be also available. It is assumed that in the worst case, coolant from 9 trays should be available that can ensure the core cooling for another 90 hours.

  Time margin to fuel damage: 140hrs for NPP Bohunice V-2; similar estimate for EMO1,2 gives 160 hrs.

– Heat removal from the core partially by coolant boiling in RPV and partially by steam release from SG. RCS is supplied with coolant from inventory volumes in the primary circuits (emergency tanks) and SG is supplied by fire pumps.

  Time margin to fuel damage: depends on initial levels of coolant at the time of event. If water level in the RPV was high and water from containment trays was provided, time to core uncovery would exceed 13 days. In the worst case, if the RPV level was at the lowest operating value (0.5 m below the main flange) and the staff did not take any actions to make-up the RCS, there are about 3.5 hrs until the core uncovery.

Containment integrity

In regime 6, the containment pressure boundary is disabled. At UHS loss the containment boundary does not have to be recovered, since steam from the RCS will leak through opened partition walls to the reactor hall. The containment integrity will not be endangered, but at the same time, it is not possible to prevent fully activity release into the power plant vicinity.

Spent fuel pool

The surrounding atmosphere (air) is the ultimate heat sink. Residual heat from spent fuel is removed in heat exchangers of SFP cooling systems to ESCW systems and from there via ESCW cooling towers to the atmosphere. Loss of heat removal from SFP occurs only in case of all three ESCW systems failure. No back-up system is available for heat removal from SFP except for SFP cooling systems.

Considering the impacts on SFP cooling, total and immediate loss of ESCW pumps is an envelope case of UHS disruption (analyzed in SBO). Considering low probability of failure of all ESCW systems, the design scenario resulting in UHS loss due to raw make-up water loss was analyzed. Evaluation of safety functions was performed for SFP for the most conservative alternative of this scenario resulting after 72 hours in conditions requiring shutdown of all three ESCW systems.

After trip of all ESCW systems also SFP cooling systems capability is lost and thus, heat removal function in SFP is affected. Due to temperature increase in SFP, also sub-criticality of SFP fuel assembly will be decreased nevertheless the subcricatility is sustaining.

Spent fuel pool reactivity control

In the spent fuel pool sub-criticality is ensured by the boric acid concentration and by the spent fuel pool design itself, which does not allow formation of critical conditions in the spent fuel pool even after reduction of H3BO3 concentration to zero. After the ESCW failure, sub-criticality in the spent fuel pit is guaranteed. This characteristic is reached in EMO1,2 by the grid mesh size in SFP – 162mm with hexagonal absorption tubes. In NPP Bohunice V-2 the calculations indicate that for zero boron and coolant boiling, criticality would be possible. However, during loss of UHS subcriticality in the SFP is managed by supplying borated coolant either from emergency tanks or from the bubbler trays and so the sub-criticality in SFP is guaranteed within the design scope.

Heat removal from the spent fuel pool

With regard to SFP cooling at evaluated scenario, reliable SFP cooling is ensured for 72 hours, as ESCW fails only after this time. After the ESCW system trip, a standard heat removal from the spent fuel pit through the SFP system coolers chilled by ESCW is not ensured. In relation to residual power of fuel in the spent fuel pool, which can range from 1.25 MW to 5 MW, and coolant inventory in the spent fuel pool before the event (14,46m/21,27m), there are time reserves according to the table(without operator´s intervention). Assessment of time margins was performed separately for NPP Bohunice V-2 and for EMO1,2.

NPP Bohunice V-2

After ESCW failure, only time limited alternative SFP cooling is available (SFP make-up from emergency tanks and SFP drain). At this mode of cooling, heat removal from SFP considering heat up of the inventory in one tank from 30℃ to 60℃ i s provided from 2 to 8 hours depending on the power in SFP (minimally two tanks are at disposal in all regimes). For the SFP cooling, coolant inventory in containment trays could be used as well. If all 12 trays are used and heated from 40℃ to 60℃, SFP cooling could be ensured in relation t o power in the SFP for the next 5.6 to 22 hours.

Further heat removal from SFP after depletion of alternative cooling (together after 9.6 – 38 hours after ESCW trip) and coolant boiling in SFP, the heat can be removed only by SFP coolant evaporation. To maintain required coolant inventory in the SFP, it is necessary to ensure its make-up from other sources (fire pumps). Steam produced in SFP is to be removed to atmosphere.

Time margin to fuel damage in SFP depends on amount of spent fuel in SFP and initial coolant inventory. Estimates without considering staff actions (without alternative cooling) are seen from the next table. Alternative SFP cooling can extend these times by about 9.6 - 38 hours from ESCW failure, depending on the power. Time margins given in the table start from the ESCW flow loss. For scenario with complete and immediate loss of make-up water supply additional 72 hours should be added.

Note: The estimates are conservative because the possibility to make-up service water system volume from circulating water pools is not taken into account. This could extend ESCW availability and SFP heat removal capability for additional 10-30 days.

All fuel is extracted to SFP, level in SFP 21.27m

Fuel power	Level	Boiling in SFP	Coolant evaporation above the fuel	Complete coolant evaporation under the fuel and temperature 1,200°C	Summary
4.87MW	21,27m	2hrs 48min	+20hrs 45min	+6hrs 52min	=30hrs 25min

Only spent fuel from previous campaigns in SFP, level in SFP 14.46m

Fuel power	Level	Boiling in SFP	Coolant evaporation above the fuel	Complete coolant evaporation under the fuel and temperature 1,200°C	Summary
1,25MW	14,46m	5hrs 14min	+37hrs 33min	+19hrs 15min	=62hrs 2min

Only spent fuel from previous campaigns in SFP, level in SFP 21.27m

Fuel power	Level	Boiling in SFP	Coolant evaporation above the fuel	Complete coolant evaporation under the fuel and temperature 1,200°C	Summary
1,25MW	21,27m	10hrs 55min	+127hrs 55min	+19hrs 15min	=158hrs 5min

EMO1,2

Depending on residual fuel power in SFP ranging from 1.25MW to 5MW and thermal losses of working cooling pumps, the summary power is 1.3 to 5MW. Despite further thermal load caused by the pump, the time to boiling in SFP is extended from 3 to 10 hours (depending on coolant volume and number of assemblies) thanks to related system pipelines and possibility to use stratified lower coolant volume in SFP (20 m^3). After reaching the boiling point, the pumps are assumed to be stopped; thus, the times for evaporation till fuel uncovery in SFP are identical with SBO –from 23 to 42 hours (without operator´s intervention).

After loss of ESCW, only alternative SFP cooling is available by its filling and drainage:

Make-up from low pressure tanks by SFP pumps, auxiliary pumps, all bubbler condenser trays using available pump or by gravity to level +21m in SFP, thus extending the time to boiling by 5 hours for configuration without core off-loading (+14.7m);

SFP drain through the overflow at +21.17m to ECCS tanks or boron system tanks and to ensure back flow by pumps or by gravity. Use of coolant inventory heating will extend the time to boiling in SFP and can be used for temperatures from 40℃ (60° C for LP ECCS) to 90℃. SFP cooling will extend the time to boiling by 3 - 6 hours depending on power in SFP and using 300 m^3 (three containment spray system channels or 2 LP- tanks system).

Time to SFP boiling:

	IE – heating to the boiling point		Level increase to +21m		SFP drainage and heating LP ECCS or BC 300 m^3		Total	
Level	+14.7m	+21.17m	+14,7m	+21.22m	+14,7m	+21.22m	+14,7m	+21.22m
Heating time	11 h	3 h	5 h	0 h	6h	3h	22 h	6 h

Coolant evaporation from SFP

Further heat removal from SFP after exhaustion of alternative cooling (6 – 22 hours after UHS) and SFP heating to the boiling point can be ensured only to the detriment of coolant evaporation from the SFP. To maintain required coolant inventory in SFP, it is necessary to ensure its make-up from other sources (LP- tanks, bubbler condenser trays, CFT, fire pumps). SFP make-up need per unit at heat removal from SFP by coolant boiling ranges from 2 m^3/hr (power 1.25 MW) to 8 m^3/hr (power 5 MW). Steam generated in SFP is removed to the atmosphere via the reactor hall.

Resulting times without staff intervention

Event UHS	Fuel assemblies in both racks +21.17 m/ 4.8 MW Time [hrs]	Fuel assemblies in basic rack only +14.46 m/1.26 MW Time [hrs]
START OF EVENT	0	0
Reaching of saturation limit – boiling in	3	11

Event UHS	Fuel assemblies in both racks +21.17 m/ 4.8 MW Time [hrs]	Fuel assemblies in basic rack only +14.46 m/1.26 MW Time [hrs]
SFP		
Exposure of stored fuel assemblies	23	42,5
Damaging of fuel assemblies 1,200°C	31	63

Resulting times with staff intervention, the table shows how much the time will be extended

Event UHS	Fuel assemblies in both racks +21.17 m/ 4.8 MW Time [hrs]	Fuel assemblies in basic rackonly +14.46 m/1.26 MW Time [hrs]
Level increase in SFP	0	5
SFP drainage and heating LP ECCS 300 m^3	3	6
BCT / LP ECCS inventory 50% (600/300) evaporation	112	450
Filling by fire truck	unlimited	unlimited

3.2.3.1 External actions foreseen to prevent fuel degradation

External activities have to focus on ESCW make-up, demineralized water make-up and supply logistics. There are several alternative methods for compensation of ESCW circuit water losses either from internal or external sources. The basic time reserve till initiation of ESCW make-up resulting from water inventory in ESCW basins is 72 hours. Another internal water sources in the NPP (CW cooling tower basin and supply channels) contain water for more days depending on the event scenario (see chapter 3.1.3). This water can be pumped to ESCW basins by SCW pumps or by mobile pumps. SCW system is normal operational system without reinforcement against beyond-basis external events and without seismic classification. Water make-up by SCW pumps can be initiated within 1 hour; make-up flow rate is higher than needed for level maintaining. ESCW make-up from CW basins by mobile pumps was also trained during the stress tests using submersible pump supplied from electric power supply and floating pump with own petrol engine. It took 30 minutes to install the pump and start its operation from notification of the request.

In NPP Bohunice V-2 ESCW can be also supplied from V1 NPP using normal operational systems without seismic classification. Water make-up of ESCW pools from V1 NPP can be initiated within 3 hours; make-up flow rate is higher than needed for level maintaining in ESCW pools. In the ultimate case, water to ESCW can be provided by mobile means (truck cisterns or helicopters) from water reservoirs in NPP vicinity. Water make-up from external sources using mobile means was tested during emergency drills in 2011. Make-up of ESCW pools by these means can be initiated within 4 hours.

3.2.3.2 Time available to recover one of the lost heat sinks or to initiate external actions and to restore core and spent fuel pool cooling before fuel damage: consideration of various examples of time delay from reactor shutdown to loss of normal reactor core and spent fuel pool cooling condition (e. g. start of water loss from the primary circuit)

Times for individual states are given in the following table; description including analysis is in chapter 3.2.3 (data for EMO1,2 are provided):

Time available to recover one of the ultimate heat sinks

	Initiating Event	ESCW loss - time	Time between ESCW loss and core melting	Total time
1.	Raw make-up water loss without internal and external intervention	72 hours / 3 days	341 hours /14.2 days	413 hours / 17.2 days
2.	Raw make-upwater loss with internal intervention – available CW	12 – 33 days	341 hours /14.2 days	26.2 to 47.2 days
3.	Raw make-upwater loss with internal and external intervention	unlimited	-	unlimited
4.	ESCW loss	X	341 hours /14.2 days	341 hours / 14.2 days
5.	ESCW loss + unavailability of demineralized water	X	5,5h SG+16h FWT + 3h HA +3h core	27 hours
6.	ESCW loss + unavailability of demineralized water and FWT (very low probability – combination of three failures)	X	5,5h SG +2.7h HA + 2.9h core	11.1 hours

3.2.4 Conclusion on the adequacy of protection against loss of ultimate heat sink

The resistance of SFP in loss of UHS conditions (loss of make-up raw water) is adequate.

1. The nominal water volume of ESCW ensures at least 72hrs of ESCW availability after loss of raw make-up water.
2. Additional water inventory available on the site in CW pools provide for additional 10 -30 days of ESCW availability.

3.2.5 Measures which can be envisaged to increase robustness of the plants in case of loss of ultimate heat sink

Evaluation of safety margins of V213 design in the case of UHS loss proved the plant design ability to ensure protection of safety barriers for given type of events during considerably long time, thus providing sufficient time margin for accident management interventions to recover UHS. Despite the robustness of power plant design, its safety can be improved by the following modifications:

- To provide for additional mobile high-pressure source of SG feedwater supply for each unit, and to ensure the mobile source supply logistics.
- To provide for mobile pumps for ESCW make-up from CW
- To provide analysis of RCP seals' behaviour at long-term failure of cooling (more than 24 hours)
- To establish the logistic system for provision of emergency feedwater to suction of mobile emergency pumps from external water sources.
- To modify connection of emergency mobile source to EFWS suction and discharge to be accessible from level 0m, beyond the anti-freezing barrier (in EMO) in order to ensure emergency mobile supply in cases of internal and external floods and fires

- To construct a fixed line for maintaining the coolant inventory in SFP from a mobile source (fire pumps)
- To prepare measures for steam removal from the SFP in case of coolant boiling.

3.3 Loss of the primary ultimate heat sink, combined with station black out (see stress tests specifications)

3.3.1 Time of autonomy of the site before loss of normal cooling condition of the reactor core and spent fuel pool (e. g. start of water loss from the primary circuit)

Since in V213 design ESCW pumps are supplied from the emergency power supply which is unavailable after SBO, SBO always results with certain time delay in the loss of UHS. It means that consequences of this combination of events are the same as of SBO alone. See Chapters 3.1 and 3.2.

3.3.2 External actions foreseen to prevent fuel degradation

Since in V213 design ESCW pumps are supplied from the emergency power supply which is unavailable after SBO, SBO always results with certain time delay in the loss of UHS. It means that consequences of this combination of events are the same as of SBO alone. See Chapters 3.1 and 3.2.

3.3.3 Measures, which can be envisaged to increase robustness of the plants in case of loss of primary ultimate heat sink, combined with station black out

The measures proposed in Chapters 3.1.5 and 3.2.5 deal also with combination of UHS with SBO.

4 Severe accident management

Severe accident management is arranged for all operating units in a similar way, both from viewpoints of relevant technical means as well as organizational measures, with few exceptions related to different features of the respective site. For EMO3,4 currently under construction it is also planned to implement the similar arrangement. The text below is therefore valid for all units, with comments on differences between the units where appropriate.

4.1 Organization and arrangements of the licensee to manage accidents

Emergency planning and preparedness (EPP) belongs to the main responsibilities of NPPs. EPP process is completely provided and managed by professional departments of the specific plant based on the process documentation included in the integrated management system IMS. IMS clearly defines requirements and responsibilities for individual parts of EPP.

EPP is implemented in line with international requirements and IAEA methodologies. The system complies with all Slovak legislative requirements, in particular with the Act No. 541/2004 on the Peaceful Use of Nuclear Energy (Atomic Act) and on amendment and alterations of several acts and Decree No. 55/2006on details concerning emergency planning in case of nuclear incident or accident. The objective of EPP is to assure technical, personnel and documentation preparedness of plant staff and involved external organisations to efficiently manage extraordinary events. This strategic objective is in compliance with SE, a. s. policies at level of individual plants transformed to specific long-term and short-term objectives and tasks. EPP of nuclear units is integrated into the national emergency response organization of the Slovak Republic (see the Figure 14) with the Slovak government being responsible for emergency preparedness at the national level.

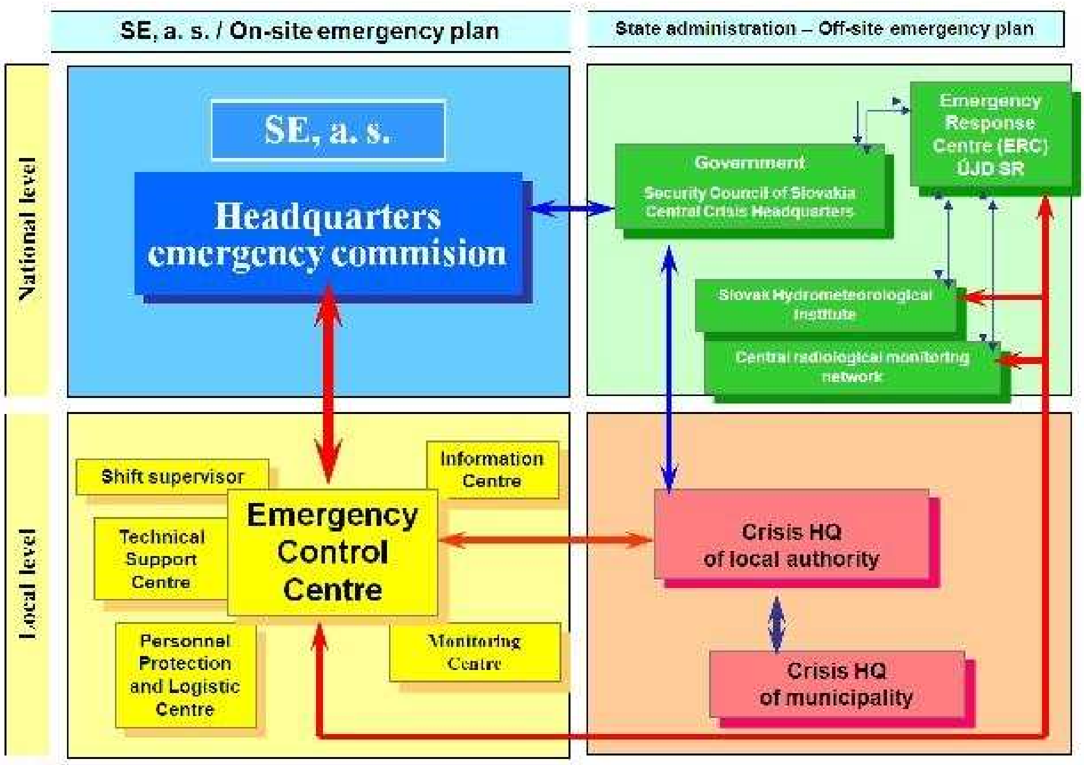

Figure 14: National emergency response organization of the Slovak Republic

The proposed emergency preparedness strategy is based on development of any event with potential external impact, with set of actions depending on its significance. The emergency response is organized in two basic phases. In the first phase of event, measures are adopted to manage the accident from the main control room (MCR) of the affected unit with actions performed by standard shift staff. In the second phase, management of the event is taken over by the Emergency Commission (EC) which should convene in the Emergency Control Centre (ECC) on site within 60 minutes during off-hours and within 20 - 30 minutes during working hours after the activation signal. Under specified conditions the EC convenes in the Back-up Emergency Centre in Trnava and Levice respectively.

EPP of each of the NPPs reflects relevant features of the specific site, including distribution of the population around the site. Bohunice site is located in vicinity of the village Jaslovské Bohunice, approx. 12km from the city Trnava and approx. 14km from the city Piestany. About285,000 people live in the zone with Emergency Planning Zone with 21 km radius. Similarly, Mochovce site is situated close to village Mochovce (village inhabitants moved out before construction started), approx. 12 km from the city Levice and approx. 14 km from Zlate Moravce and 11 km from Vrable. About 159,000 people live in within the Emergency Planning Zone with 20km radius.

In the Emergency Planning Zones of EBO and EMO with 21 km and 20 km radius respectively the off-site emergency plans are established. Radiological criteria (intervention levels) for introduction of emergency protective actions are defined in the SR Government Decree No. 345/2006 Coll. Off-site emergency plansare consistent with the On-site emergency plans of the NPP.

The Emergency Planning Zone is subdivided into 16 sectors. For the emergency response needs in the case of a specific accident the plant surrounding is split into the following areas:

- Exclusion zone
- Precautionary Action Zone
- Urgent Protective Action Planning Zone

Adequate measures in line with ERO procedures and documentation are taken in these zones based on the accident predictions. Emergency zones with evacuation routes are shown for both sites in the Figure 15 and Figure 16.

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Figure 15: Map of Bohunice site showing the zones and evacuation routes

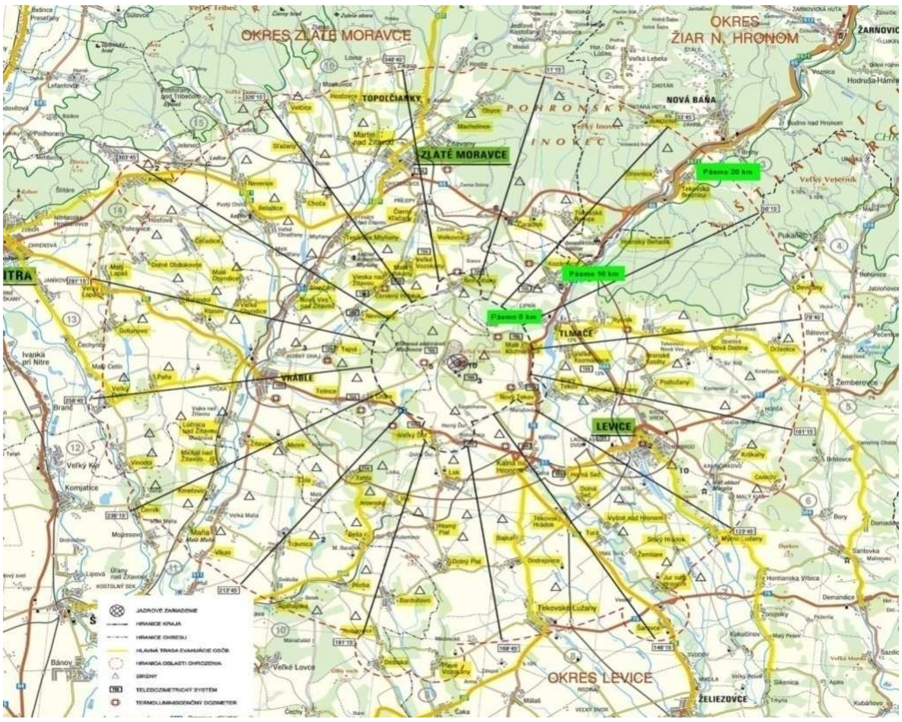


Figure 16: Map of Mochovce site showing the zones and evacuation routes

4.1.1 Organization of the licensee to manage the accident

4.1.1.1 Staffing and shift management in normal operation

Shift operation management

Operation of both units for each of the plants is provided by the plant employees in shift operation. Minimal number of shift personnel and its professional composition is approved by UJD SR. The shift supervisor (SS) has full authority and responsibility for the safe operation. He directly manages reactor unit supervisors (RUS), shift foremen of RCS, SC, electric part, technical workers in water management system, I&C, radiation monitoring and chemistry technician.

The main control room (MCR) is the most important working place in the NPP. There is a temporary working place in the MCR for the SS for his activities during extraordinary operational events.

Emergency control room (ECR) is a back-up working place in case of inhabitability of the MCR or if the reactor and emergency systems cannot be controlled from the MCR.

The shift staffing includes also other departments:

- Physical protection staff– provides for physical protection and operation of the physical protection control centre (PP CC), availability of escape routes from endangered objects and areas, tracking of individuals on the site.
- Plant fire brigade (PFB) which is in charge of readiness of fire fighting equipment, operation of the fire announcing centre and announces fire alarm. Shift PFB has staff in the following positions: Shift commander PFB (1), fire squad commander (2), fireman rescuer (13 in NPP Bohunice V-2 and 9 in EMO1,2), fireman – operator of the fire announcing centre (1).

4.1.1.2 Measures taken to enable optimal intervention by personnel

There are instructions and procedures in place for the staff for management of emergency situations.

The basic ERO principles and procedures are covered by the on-site emergency plan (on-site EP), emergency operating procedures (EOP), emergency instructions for implementation of on-site EP, severe accident management guidelines (SAMG) and related plant technical documentation. These procedures define responsibilities and competencies of the plant staff and ERO members. EOP and SAMG are described more in detail in section 4.1.1.5.

Non-technological intervention groups – PFB, PP, police corps are promptly available on the site and are used for rescue, localization and recovery activities immediately after the event. Protection of intervening personnel with regard to irradiation and contamination during emergencies is one of the most important parts of emergency response. After event announcement, measures for protection of plant employees and other persons on the site are implemented based on the event significance and pursuant to ERO documentation.

Short-term civil protection (CP) assembly points

CP assembly points situated in plant premises serve for assembly of plant staff. These facilities provide for conditions for short-term stay if using personal protective equipment. All CP assembly points are equipped with basic personal protective equipment in quantity corresponding to the capacity so that enabling evacuation from the assembly points to evacuation transportation means. CP assembly points are also equipped with communication means, portable dosimeters for measurement of surface contamination and dose rate, sanitary material and potable water. Total capacity of assembly points is about 500 people in NPP Bohunice V-2 and 800 people in EMO1,2.

Permanent CP shelters

Permanent shelters are used for sheltering employees and rescue staff. They also serve for distribution of individual protection means and special equipment for rescue teams. Permanent CP shelters meet conditions for long-term stay of rescue staff, in compliance with Regulation of MV SR No. 532/2006 on details for assurance of building and technical requirements and technical conditions of CP facilities. Capacity of shelters is 600 people in NPP Bohunice V-2 and 1,200 persons in Mochovce.

CP shelters are equipped with filtering and venting equipment. They are also equipped with water system with separate storage tanks for service / potable water, with emergency illumination system, decontamination part, communication means and manual dosimeters for surface contamination and dose rate measurement. Sanitary material, bottled water and PPE are prepared in the shelters.

Protection of intervening personnel within ERO

ERO centres

For ERO activities the site is equipped with facilities for emergency response with tools for detection and evaluation of emergency events and for logistics.

Unit control rooms

Main and emergency control rooms situated in the reactor building at +9.6 m level are the primary centres for emergency response management. They have sufficient illumination, they are vented and air-tight; they assure stay for the time required for control of plant during accidents without overexposure of personnel. Emergency control rooms are available in case of evacuation from MCR with capability to provide for fundamental safety functions. The MCR and ECR are located in separate fire sections and they are over pressurized to prevent penetration of hazardous substances. MCR and ECR are equipped with filtering and venting devices with filters intended for capture of radioactive substances. The control rooms are equipped with communication means (telephone, fax, radio station, public address system), water reserves and PPE.

Emergency Control Centre (ECC)

There are emergency control centres with necessary supporting facilities established on each site. The centres are located in resistant and hermetic shelters and meet criteria set by the Notification of MV SR No. 532/2006 on details for provision of civil-technical requirements and technical conditions for CP facilities. They are seismically resistant and protected against penetration of radioactive substances in case of severe accident or other dangerous substances.

Neither MCR, nor ECR enable long-term stay of personnel in case of a severe accident. Therefore NPP Bohunice V-2 ECC building that was constructed as part of the SAM implementation project, is equipped with workplace of operational staff of both units MCR3, MCR4 providing conditions for long-term stay. Similar workplace will be established in the premises of TSC of EMO1,2 within the SAM project.

ECC has means for communication with other involved working places involved in emergency response. It is equipped with technological information system providing operational data from the both reactor units, TDS, on-line transfer of technological and radiation data to UJD SR, ESTE software for determination of the source term, event classification, prognosis and evaluation of accident consequences. Telecommunication technology consists of telephone lines with an access to public telephone network, emitters for use of mobile phones, fax machines, radio and radio-communication network. Members of the Emergency Commission have at their disposition operational documentation for management of emergencies, emergency operating procedures, emergency instructions and related operational plant documentation.

ECC contains also a workplace for MCR operation staff and SS in duty which can be used in case of a severe accident. This workplace will be eventually completed within the SAM project.

ECC provides conditions for long-term work of the EC for at least 5 days. The ECC is usable also in case of extreme natural conditions with access either by external roads (provided that they are open to traffic) or by alternative transport out of road means (armoured personnel carrier).

Back-up ECC

It serves as the back-up ECC workplace instead of ECC in case of unfavourable radiation or weather situation on the site. It is situated in off-site radiation monitoring LRKO centre in Trnava and Levice, respectively and enables short-term stay of EC members. Back-up ECC has available on-line information from the Technological Information System of both units and from the teledosimetry system, ESTE software for determination of the source term, event classification, prognosis and evaluation of accident consequences.

It also provides the connection means (phone, fax, radio stations) and technical documentation. The building has autonomous electric power supply. Radiation situation monitoring uses portable dosimeters for dose rate and surface contamination measurement. Considering the distance from the site, the facility is not protected against penetration of radioactive and dangerous substances and it is not seismically reinforced.

Monitoring centre – external evaluation centre

The centres are situated in the off-site radiation monitoring centre in Trnava and Levice, respectively. They serve for monitoring, assessment and forecasting of radiation situation in the respective site and in its vicinity. The centres are equipped with TDS, ESTE software for specification of the source term, forecast and assessment of accident consequences, and GIMSOR and back-up RMMS application for monitoring the movement of monitoring vehicles. LRKO is equipped with communication means (telephone, fax, radio stations) and documentation for management of emergencies, for rescue staff, potable water and PPE. In case of power supply loss, the building is equipped with independent emergency power supply– diesel generator isolated from the external grid. The off-site radiation monitoring centre building fulfils only basic functions for short-term stay of persons. The building is without filtering and venting equipment, i. e. it is not protected against penetration of radioactive and hazardous substances, it is not seismically reinforced and is without water inventory for decontamination of rescue personnel. The building does not meet conditions for long-term stay in case of an accident or under extreme weather conditions.

Personal Protective Equipment

Personal protective equipment (PPE) include means for protection of breathing ways, eyes and body surface to assure adequate protection against radiation effects. These means are available for all people on the site.

Continuous operation workplaces – plant operation, PP CC, PFB, SE Protection & Security and Fire Protection, shelters and civil protection assembly points are equipped with protective masks with filters for hazardous and radioactive substances, with personal protective packs, iodine pills and personal dosimeters. Shift staff and ERO rescue squad members participating in management of the event in contaminated area have special means, including special protection suit and breathing apparatus. If necessary, staff intervening in the controlled area is equipped with breathing apparatus. Use of special PPE enables the staff and persons in duty to stay in contaminated environment and to perform required technological and rescue works.

Water Needed for Operation of the Access to Controlled Area

Water reserves needed for the operation of the controlled area access compartment and for decontamination are available. In NPP Bohunice V-2 water reserves are stored in tanks of the water system with the total volume of 30,000 litres. In EMO1,2 water is stored in tanks with 3,200 litre volume. The tanks are permanently filled with water and prepared for immediate use. Water quality is regularly inspected.

For decontamination, there is a storage service water tank with volume of 11,000 litres installed in the NPP Bohunice V-2 ECC. The tank is permanently filled with water and water quality is regularly checked. Water reserve for decontamination 2,000 l/day complies with legislation and it is sufficient and independent from the service water distribution system in EBO. As service water reserves, PFB means (4 PFB cisterns, with the total volume of 22,900 litres), cooling water, ESCW and clear water inventories may be used.

In EMO1,2 another option to ensure water needed for decontamination is to use firewater inventory usable through PFB means with the volume of 36,000 litres. The operational building ground floor is provided with couplings for connection of fire hoses from discharge of truck cistern pump. Considering needs of service water for decontamination (2.5 litre – hands, 40 litres – shower), and utilisation of water pumped from the truck cisterns, the inventory serves for about 922 persons/day.

Another option is to use potable water sources filled in vessels in shelters.

Potable water and food for intervening staff

NPP Bohunice V-2 has instantly available water inventory in shelters and CP assembly points, operational areas, LRKO and gatehouses with volume approx. 645 litres. Additional water is available from the plant buffets and canteens – approx. 900 litres. NPP Bohunice V-2 ECC is provided with potable water in bottles – 90 litres. After completion of the potable water system in NPP Bohunice V-2 ECC and considering potable water needs in compliance with the legislation, 3 l per day and person, the potable water reserve will be sufficient for 3 days. Frozen meals for shift operation are ensured in the NPP Bohunice V-2 canteen. The existing frozen meals stock is about 500 pieces. The next stock of meals, about 50 pieces, is in NPP Bohunice V-2 ECC structure; it is intended in particular for NPP Bohunice V-2 EC members and MCR operation staff.

In EMO1,2 instantly available water inventory in shelters and CP assembly points, operational areas, LRKO and gatehouses is 552 litres. Water available from the plant buffets and canteens is ~ 1,500 litres. EMO1,2 ECC is provided with potable water in bottles 165 litres. Another potable water inventories are in vessels in shelters with the volume of 41,950 litres. The vessels are normally empty. When shelter team members are called to the shelter and a classified event is raised, the team will fill in the vessels by opening main valves. Considering recommended potable water needs in compliance with the legislation (3 litres person/day), the aforementioned inventory is sufficient to assure drinking regime of 1,000 persons for about 14 days. If only bottled water is at disposal, the water reserves will guarantee the drinking regime for 739 persons for one day. Frozen meals for shift operation are ensured in the EMO1,2 canteen. The existing frozen meals stock is about 3,000 pieces. If needed, packed meals in buffets may be used as well.

On-site radiation situation monitoring and radiation protection of workers

Information of radiation situation in operational and other selected areas is obtained by the radiation monitoring system and TDS detectors. The site territory is equipped with detectors for dose input measuring on operational buildings (5 or 6 places). Measuring in other areas is performed by portable instruments.

Dose rate is measured continuously on CP assembly points, in CP shelters, back-up ECC, MCR, RMCR, SS, PP CC and the gatehouse. Workers coming to the plant for intervention or shift change receive their PPE in the main gatehouse. External units of fire brigade, medical service, police corps, evacuation vehicle drivers and others are equipped in the same way. PFB has its own independent dosimetry equipment for monitoring of received doses.

In case of a radiation accident, there is a risk of overexposure for employees performing rescue and localisation works (intervention teams). Exposure limits for such situations are determined in line with relevant Slovak legislation.

4.1.1.3 Use of off-site technical support for accident management

The method and extent of cooperation with external state authorities involved in emergency planning is determined by the valid legislation (organizations involved are UJD SR, Ministry of Interior of the SR, Ministry of Health of the SR - Public Health Authority of the SR, Civil Protection department and regional directorate at the county office in the emergency planning zone).

To ensure professional technical and personnel assistance in case of accidents, co-operation agreements have been concluded with qualified external organizations, in particular with VUJE, a. s., and AB Merit. In Bohunice, the company SE, a. s., assures specialized services for area monitoring by emergency monitoring groups, guarding services and decontamination services for accidents.

Co-operation agreements were concluded with external organizations in the area of complementary radiological monitoring of NPP vicinity, medical services, fire services etc. An agreement on mutual cooperation was also signed with the County Directorates of the Fire and Rescue Corps (Trnava and Levice) for fighting fires, elimination of consequences of accidents, natural disasters and other extraordinary events.

Bodies and organizations involved in technical support have their own equipment and employees trained for this purpose.

The Headquarters of SE, a. s. ensures contractual relations with clinics specified by the Ministry of Health of the SR for permanent preparedness of the specified clinics to provide specialized medical services in case of extraordinary events in NPP or during radioactive material transport. Similarly SE, has an agreement with the Ministry of Interior of the SR (Agreement on mutual cooperation on provision of the civil protection information system and on provision of organizational units of the Fire and Rescue Corps) for provision of aid by the Corps to SE, a. s. plants at execution of activities needed for control and removal of consequences of fires and nuclear accidents, at recovery of affected area, including on- site support of these plants.

4.1.1.4 Dependence on the functions of other reactors on the same site

Both NPPs NPP Bohunice V-2 and EMO1,2 are designed and operated as twin units. On the level of the design basis and beyond design basis all required safety functions are provided by unit specific equipment without the need for the supporting functions from the neighbour unit. The only relevant safety related interconnection is within the Essential Service Water System and Emergency Feedwater System where part of systems (parts needed for raw make-up water, tanks and part of the pipelines are common for both units). In general, partially shared or common systems are exclusively dedicated for normal operation (cleaning of media, drainage systems tanks, auxiliary operational systems). There is a possibility to share resources (media, coolant) between units through supporting systems pipelines but this feature is considered only as a contingency for very low probability beyond design basis situations.

Design modifications for severe accidents are designed for each particular unit with the exception of tanks of SAM external water source and emergency power supply (SAM DG) which are common for both units. The adequacy of such solution was approved by the SAM project principles where the severe accident was anticipated in only one unit. Appropriateness of such solution may be reconsidered in the future.

4.1.1.5 Procedures, training and exercises

Symptom oriented EOP and comprehensive SAMG consistent with adequate hardware provisions for execution of the required actions represent essential components for procedural support of accident management and for decisions taken by MCR and ERO groups.

Implementation of symptom oriented EOP

Development of the severe accident and beyond-design basis accident management tools is a controlled process implemented in stages since 1995. Symptom-oriented EOP covering design basis and beyond-design basis conditions (up to the core melt) were fully implemented in both in NPP Bohunice V-2 and EMO1,2 in 1999 (for events initiated during power operation) and in 2006 (for events initiated at shut-down reactor or in the SFP). This was the first necessary step allowing development of the severe accident management programme.

Development and implementation of symptom oriented SAMG – SAM project

After completion of EOP the next objective was to extend AM to mitigation of severe accidents. The effort started by the complex analytical project PHARE 4.2.7a Beyond Design Basis Accident Analysis and Accident Management, implemented in 1996-1998. Main objectives of this project were analyses of VVER 440/213 type NPP response, identification of containment failure mechanisms under severe accident conditions and review of applicability for V213 containments the basic strategies identified for Western containment types. This project was followed by two other projects – PHARE 2.06 Analysis of the Need and of Alternatives for Filtered Venting of Containments and PHARE 2.07 Hydrogen Control during Severe Accidents, which were finished in 1999.These three projects jointly performed by Westinghouse and research institutes from Slovakia, Czech Republic and Hungary represent a comprehensive study of vulnerability of V213 units in severe accident conditions and a preparatory phase for implementation of AM in severe accidents initiated by internal events.

Based on analyses from the aforementioned projects, the probabilistic PSA Level 2 study for NPP Bohunice V-2 was prepared in 2000 as one of basic inputs for development of plant specific severe accident management guidelines (SAMG).

SAMG were prepared in co-operation with Westinghouse in the common NPP Bohunice V-2 and EMO1,2 project during the period from 2002 to 2004. Unlike similar projects in Western NPPs it was decided to mitigate or eliminate all identified containment vulnerability mechanisms by suitable modifications or extensions of V213 basic design. Proposals of such key modifications have been prepared in several stages and several analytical projects were implemented for verification of feasibility and of efficiency of developed strategies.

The project for implementation of modifications needed for severe accident management was proposed in compliance with updated requirements of Slovak legislation in 2006 - 2008. The modifications were reflected in the Integral Corrective Action Plan from periodic safety assessment of NPP Bohunice V-2 and EMO1,2 (completed in 2008and 2009, resp.) approved by UJD SR decision permitting the operation for next 10 years following the Periodic Safety Review. The SAM implementation project was initiated in 2009 as the common NPP Bohunice V-2 and EMO1,2 project with deadline in 2013 in NPP Bohunice V-2 and 2015 in EMO1,2.

In the initial stage of the SAM implementation project a safety concept was prepared defining overall safety objectives, the project scope and design principles, design basis for newly installed and modified equipment. The safety concept was approved by UJD SR.

Modifications and changes within the project are being implemented during unit outages under strict quality management rules. Installations and project related activities are assigned to the following groups:

- Modifications related to controlled primary circuit depressurization ability
- Modifications needed for reactor cavity flooding and external reactor vessel cooling
- Modifications related to hydrogen management in the containment
- Installation and improvement of I&C needed for severe accident management
- Modifications enabling prevention of excessive under-pressure in the containment
- Modifications enabling coolant make-up from external source to the reactor and spent fuel pool and reliable, time limited containment spraying from the external source
- Modifications enabling coolant make-up to the reactor cavity, spent fuel pool and external source tanks using mobile source connected to the external connection point on walls of the reactor building and auxiliary building.
- Installation of independent dedicated 6kV DG and relevant electric devices enabling supplying SAM consumers and selected critical unit consumers under SA conditions in case of complete loss of power supply.

The project also includes preparation of documentation related to the licensing basis (complete deterministic and probabilistic justification), SAMG update according to real project situation after installation of modifications and of new equipment, MCR staff training and training of specialized ERO teams, and SAMG validation.

Long-term heat removal from the containment after severe accident is solved by recovery of operability of design unit equipment (containment spray system). A study was prepared for use of alternative systems and feasibility study for heat removal recovery from the containment.

Considering the SAM implementation the project focuses on reinforcement of the in-depth protection level 4. Requirements for design principles were defined during the project preparation that must be consistently applied to specific hardware solutions. These principles comply with currently nationally and internationally valid safety requirements. In line with valid approaches to severe accident management at the time of SAM project initiation, the project is based on assumption of severe accident occurring on one of two units only. SAM modifications include active components assigned to a specific unit; passive components (tanks, pipes, etc.) and consumables (coolant, fuel, etc.) can be used for both units.

Long-term aspects of severe accidents can be managed by the existing systems. Any survived equipment for normal operation, safety systems assigned for management of design-basis accidents or severe beyond design-basis accidents is used. It is possible to use equipment common for two units or interconnection between them.

Organizational provisions for use of the procedures and the guidelines

Procedures and guidelines, emergency instructions and other documentation are available in working places of intervening shift. The staff is trained for use of procedures in regular intervals. Relevant documents clearly define responsibilities and rules of use. The main documents dealing with extraordinary events include:

- Abnormal operating procedures
- Emergency operating procedures
- Severe accident management guidelines
- Fire procedures
- Emergency instructions.

Abnormal and emergency operating procedures are used by operators in MCR in case of failures of NPP components and systems including accidents and external threats. The procedures are specific for the given unit and aim at prevention of the core damage. MCR operational staff strictly follows EOP.

When the EC is called and TSC is activated their members evaluate and monitor accident progression, fulfilment of critical safety functions and provide advice for actions. For these activities the TSC is equipped also with a special document (the TSC manual).

In case of transition from a design basis accident to a severe accident, actions of EOPs are not applicable and further decisions are made using SAMGs. Decision on transition from EOP to SAMG is based on specified criteria. Overall SAMG goal is to maintain integrity of the containment and to prevent or mitigate releases of radioactive substances to the environment.

NPP have developed the staff training plan ensuring that all involved plant and SE, a. s. employees are adequately prepared for execution of required measures. Special preparation, exercise and training are provided for the emergency response organization members.

The training regarding the emergency plan forms part of the induction training of all newly hired employees. In the subsequent period, employees are included in the periodical training programme for detailed familiarization with ERO organization. The training also covers the principles of radiation protection.

Training of ERO members

Staff training is the introductory stage of emergency preparedness. General theoretical preparation in form of induction, introduction and periodical training is obligatory for all persons working on the site. Moreover, staff assigned to ERO is trained for specific activities corresponding to their assignment. Theoretical preparation is followed by practical exercises.

In order to maintain necessary skills and to follow software and hardware modifications in the emergency and support centres, the training includes two exercises of ERO emergency shifts in ECC, TSC, SLOP, MS, IS per year. The training can be combined with emergency drills or testing of technical means. Connection and communication, fire suppressing, radiation situation monitoring, evacuation from endangered areas are examples of such exercises. Shift intervention team is trained in activities aimed at medical assistance, PFB assistance and preparation of CP shelter. Various intervention groups and police special units have preparation programmes associated with their specific activities. They are also trained as members of ERO. Firemen and operational staff exercise activities associated with e. g. emergency make-up of steam generators or supply of water at simulated raw water loss by mobile means.

MCR operators pass regular training and verification in line with operator´s license. They are trained at full-scope simulator.

Exercises of members of ERO and EC (all shifts) are performed twice a year at least. Simulator training is performed together with MCR staff according to the annual time schedule.

Plant exercise including ERO departments and other persons working on the site is performed once a year to demonstrate emergency preparedness in line with the Emergency Plan.

Complex exercise including external organizations and authorities is performed once per three years.

Education, training and exercises of ERO staff are regularly supervised by UJD SR during inspections.

4.1.1.6 Plans for strengthening the site organization for accident management

Emergency response organization (ERO) considers wide spectrum of postulated events from those with negligible impact on the environment up to severe accidents. Classification of events into three severity levels is defined by the regulation of UJD SR No. 55/2006 Coll. on details concerning emergency planning in case of nuclear incidents or accidents:

1. Level 1 – ALERT - a situation where fulfilment of safety functions is endangered or violated, safety barriers are damaged or non-functional, there is a risk of radioactive substances release or they have already released, which can lead or leads to an unpermitted exposure of people in nuclear installation structures, and there is a risk of radioactive substances release out of the structures in case of an adverse development of the situation.
2. Level 2 – ON-SITE EMERGENCY – a situation which can lead or leads to radioactive substances release out of the nuclear installation structures and on the site.
3. Level 3 – OFF-SITE EMERGENCY– a situation which can lead or leads to serious radioactive substances release to the surroundings of the installation.

Besides technological and radiological events, also large natural catastrophes are considered (earthquake, high windstorms, storms, thunderbolts, flooding, extreme cold) together with other external impacts (external grid failure, lack of cooling water from external sources, aircraft crash on important objects).

In case of an emergency event classified at level 1, 2 or 3, its management is performed by the plant Emergency Response Organization(Figure 17). The director of the plant is a designated head or ERO delegating his rights to the shift supervisor in duty and to EC shift manager. Decisions taken by EC are binding for all plant and SE, a. s. employees and for all persons on the site. SS is permanently responsible for performance of all interventions in technological objects.

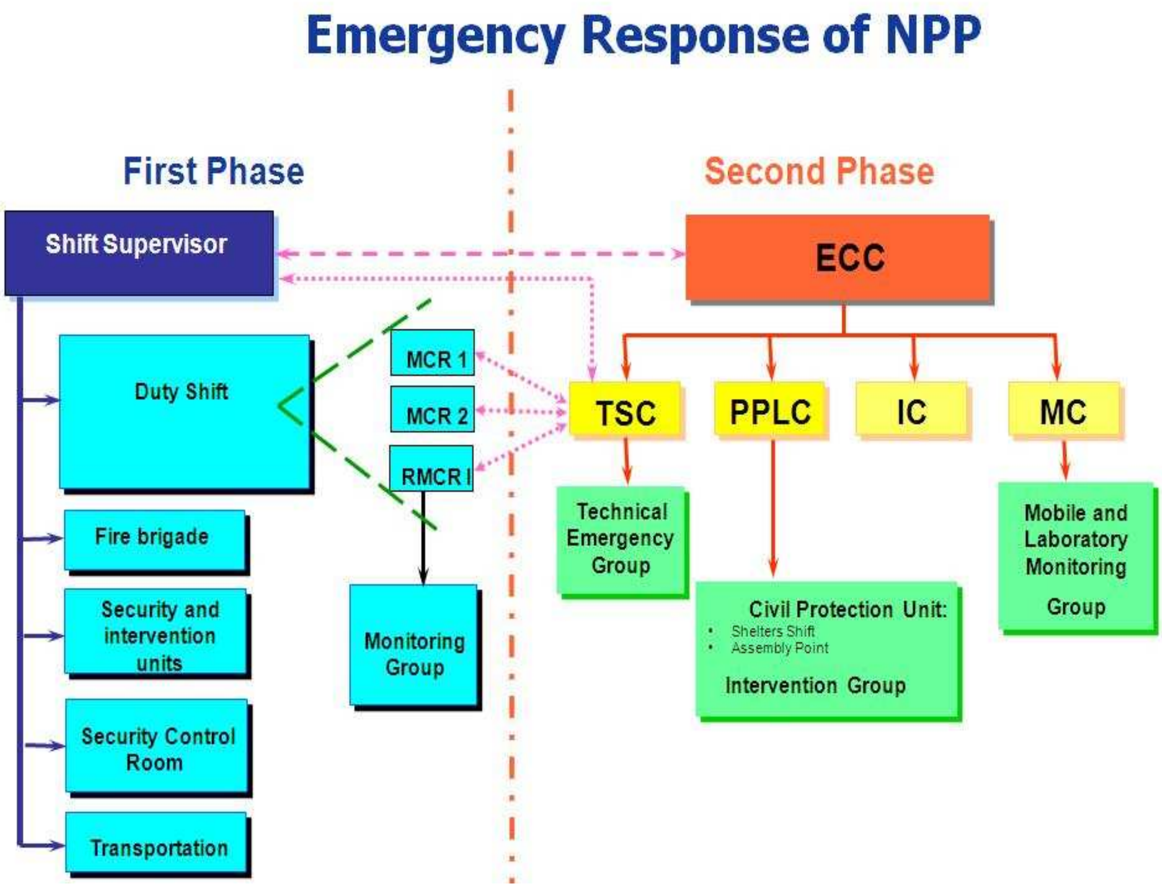


Figure 17: Two phases of the Emergency Response

The emergency response is performed in two phases according to the Figure 17.

Emergency response – phase I

In case of an event, the shift supervisor takes over management of ERO. The first phase of ERO is provided by the shift personnel headed by the SS on duty. Activities in this phase focus on stabilization of situation on the unit and on the site, and on initiation of necessary protective measures on the plant territory and its vicinity.

At the beginning SS on duty makes an initial assessment and classification of the event, ensures announcement of event on the site or in vicinity, activates required ERO components, in particular the EC and informs the SE, a. s. emergency service. He also ensures implementation of immediate protective measures for employees and, if needed, also for population in the plant vicinity, in particular warning, notification of respective bodies and organizations (UJD SR, MV SR, UVZ SR and crisis staffs in regions in the plant emergency zone).

Emergency response – phase 2

Phase two is initiated at the moment when EC is gathered in the emergency control centre (ECC) and ERO support centres and coordinates activities of individual ER components from there. In phase 2, management of all on-site activities is taken over by the Emergency Commission.

Main tasks of the EC are:

- Management and coordination of all activities according to the IEP;
- Management and coordination of all ERO components;
- Announcement of protective measures for persons on the site;
- Approval of emergency doses for rescue team members;
- Delivery of the initial report and subsequent reports to regulatory and supervisory authorities including proposal of protective measures for the plant surroundings.

EC members are subdivided into the working groups located in different premises as follows:

Emergency Control Centre (ECC) – a workplace for the team coordinating work of the ERO groups at performance of measures mitigating incident or accident consequences

Technical Support Centre (TSC) – workplace for support of affected unit is MCR personnel. It performs analysis of status of the affected unit and determines the event prognosis, and manages MCR activities at severe accident pursuant to SAMGs

Personnel Protection and Logistic Centre (PPLC) – workplace for coordination of rescue, localization, removal and recovery works and for preparation and implementation of adopted protective measures

Monitoring Centre (MC) – workplaces (both on-site and off-site) performing monitoring and prognosis of radiation situation, estimation of on- and off-site doses, preparation of input information for determination of protective measures both on- and off-site

Information Centre (IC) – workplace for preparation of input information for informing public and media and SE, a. s. groups, UJD SR, civil protection and state administration bodies.

EC members keep standby duties in weekly intervals. In case of event, EC members are activated on SS´s instruction via the independent paging radio network and via the announcement server (automatic voice message, sms, e-mail) with return confirmation of received information.

After event announcement attending EC shift gathers in the ECC or back-up ECC in Trnava or Levice. Time limit from signal receipt for gathering of EC members on dedicated workplace is 30 minutes during working hours and 60 minutes during off-hours.

4.1.2 Possibility to use existing equipment

4.1.2.1 Provisions to use mobile devices (availability of such devices, time to bring them on site and put them in operation)

Various mobile devices are available on the NPP sites:

- Submersible pumps (administered by the fire brigade and operation support group)
- Portable generators (administered by the fire brigade)
- Mobile DGs (for SBO) – currently in procurement process
- Mobile fire pumps (administered by the fire brigade), additional ones in procurement process
- Mobile (portable) transformer 6kV / 0.4kV (administered by electric department.)
- Portable rectifier (administered by electric department).

These devices are administered by individual departments. The final stage of the on-going SAM implementation project – validation of SAMG procedures – will identify the need for and possibility to use such mobile devices and a programme will be introduced for their testing and maintaining in conditions corresponding with procedure validation.

4.1.2.2 Provisions for and management of supplies (fuel for diesel generators, water, etc.)

Working media inventory for DGs as the emergency power supply sources

There are two reactor units on each site and each unit has three independent emergency power supply sources – diesel generators (DG). One DG unit operation is required for heat removal.

Each DG as an independent emergency power source is equipped with its own 6 m^3 fuel tank and two external fuel tanks 100 m^3 each. This fuel inventory is sufficient for 240 hours i. e. 9-10 days for operation at its full power.

Inventory of other materials for accident management

Granulated boric acid inventory out of the technological circuits is 1,000kg in each plant.

Anti dot (KI) inventory at designated places in NPP Bohunice V-2 is approx. 8,000 packages, in EMO1,2 approx. 6,500 packages.

4.1.2.3 Management of radioactive releases, provisions to limit them

The principal design means for management and limitation of radioactive releases is preservation of containment functions. All mechanisms endangering the containment functions during severe accidents are addressed in specific guidelines of SAMG package. Use of newly installed systems and modifications for fulfilment of the above goals is as follows:

Integrity of containment boundary	Vacuum breaker Spraying from dedicated external emergency source of coolant Passive Autocatalytic Recombiners In-vessel retention Primary circuit depressurization
HPME	Primary circuit depressurization Mobile pumps via EFWS
Activity decreasing in the containment	Spraying from dedicated external emergency source of coolant
Long-term pressure management in the containment	Spraying from dedicated external emergency source of coolant Passive Autocatalytic Recombiners
Isolation of routes through the containment wall	Original design solutions, improved monitoring of radiation situation parameters

As described in details in chapter 4.2, SAM implementation project also includes installation of a set of design modifications or addition of new systems increasing reliability of SAMG strategies. General description is given in relevant sections of this chapter.

Limitation of radiation releases from NPP is supported by implementation of ESTE system enabling not only the prediction of source term for emergency planning purposes and its update based on monitoring of real on-site and off-site radiation data, but also prediction of radiation situation and optimization of long-term interventions.

Radiation monitoring system is divided into:

- Environment radiation monitoring
- Measuring of gamma radiation dose input in operational areas, reactor building, auxiliary building and NPP site,
- Measuring of volumetric activity of gases by continuous air sampling system from individual rooms,
- Measuring of aerosols volumetric activity in operational areas by continuous measuring using BDBA sensors and portable instruments for continuous aerosols measuring,
- Technological radiation monitoring

Radiation monitoring technological system (RMTS) is an autonomous unit. It works continuously and independently from other NPP systems; it contains 400 measuring channels. Besides RMTS, radiation situation is monitored also by independent stable radiation monitoring instruments. Sensors are installed in operational areas and important technologies and perform additional measurement not covered by RMTS. Signal-measuring units of independent instruments are located at the measuring place, in the radiation monitoring control room (RMCR) or in MCR.

4.1.2.4 Communication and information systems (internal and external)

In case of non-functional mobile and stationary telephone networks, walkie-talkies will be used for communication. The radio stations are situated namely in the departments for operation, dosimetry, electro, I&C, maintenance, physical protection and PFB. For communication with rescue staff, there are radio stations in ERO facilities, i. e. in ECC, in back-up emergency control centre in Trnava and Levice and in civil protection shelters. Totally about 300 walkie-talkies (400 in Mochovce) are used for communication. PFB is connected by a radio station and phone line equipped with local accumulator with the Regional Fire and Rescue Corps operational centre.

Technical hardware of the notification system intended for notification of operational staff and persons assigned to ERO are pagers ensuring one-way receipt of information.

After a successful completion of comprehensive tests and trial operation, Slovenské elektrárne put into operation a new modern system of warning and notification of 21 km around the power plant Bohunice V-2. There are about 400 pagers used in NPP Bohunice V-2. There are also 308 pagers distributed to mayors of cities and villages in the NPP Bohunice V-2 emergency zone for one-way informing. These receivers are intended for informing municipality and state administration representatives within the 21km NPP Bohunice V-2 zone. Pagers are part of NPP Bohunice V-2 notification system. The notification paging radio network is in case of off-site power supply loss supplied by fixed UPS, accumulators enabling uninterrupted operation for 10 hours. Paging system transmitters and repeaters are not seismically reinforced.

EMO1,2 has 300 pagers available; another 203 pagers are distributed to mayors of cities and villages in the EMO emergency zone for one-way informing. These receivers are intended for informing municipality and state administration representatives within the 20 km EMO1,2 emergency zone. Pagers are part of EMO notification system. Paging, together with transmitting infrastructure, is system independent on public communication networks.

The second notification system hardware is the NPP Bohunice V-2 ZUZANA phone notification system or the EMO notification server ensuring notification of persons assigned to ERO and representatives of self-administration and state administration in case of emergency to their mobile phones and fixed phones via voice messages, sms and e-mails. NPP Bohunice V-2 ZUZANA system and EMO notification server ensures feedback for the sender about delivery of respective information. In case of overloaded public phone networks, delivery of sent information is not guaranteed. The equipment is not seismically reinforced.

Plant staff is notified of an extraordinary event by plant broadcast integrated into the internal warning system. If needed, sirens (internal plant warning system) can be used for informing the plant staff about an imminent danger.

Staff informing of the situation in EBO uses manual megaphones stored in shelters and collection points, in SE Protection & Security, Fire Protection and PFB vehicles. There are total 8 hand megaphones and 15 megaphones installed in vehicles at disposal in NPP Bohunice V-2. Warning of employees and citizens within the EMO emergency zone or Bohunice V-2 in case of occurrence of an extraordinary event uses the EMO warning system, or the Bohunice V-2 system, which has about 186 or 353 end components respectively – electronic sirens, with back-up power supply for minimally 72 hours. Sirens can broadcast the warning signal and citizens can be informed of an imminent danger also by the local control module through microphones.

ERO information system installed on the site and in the LRKO building in Trnava and Levice consists of the following components:

- Plant network with internet, electronic mail and dedicated electronic mail for crisis communication
- TSC technological information computer network
- Radiation monitoring central computer system with TDS
- PP information system for recording movement of persons and ERO members
- Software prognostic and classification tool (ESTE).

The information system provides real time data about condition of technological systems and radiation situation in the unit, on the site and its vicinity, current information about weather conditions, condition of persons. Terminal information systems are located in ERO centres, on ERO workplaces, back-up ECC and in SE, a. s. headquarters and in UJD SR. ERO information system devices have back up power supply.

4.1.3 Evaluation of factors that may impede accident management and respective contingencies

4.1.3.1 Extensive destruction of infrastructure or flooding around the installation that hinders access to the site

ERO members perform their activities in the emergency control centre located on the plant territory. Its construction is robust and meets gas-tight shelter requirements on CP facility.

The shelter is protected against penetration of radioactive substances in case of severe accident on plant territory and hermetically protected against dangerous substances, it is equipped with water system with separate service / potable water tanks, emergency illumination, decontamination part, dosimetry probe for dose rate and iodine volume concentration measurement, medical material, food, bottled water and PPE. Autonomous diesel generator power supply is installed there. Equipment of ERO centres creates conditions for long-term activity of EC. The workplace is usable also in case of extreme natural conditions provided that external roads are open to traffic or it can be accessed using alternative transport out of roads.

NPP Bohunice V-2

Transport in NPP Bohunice V-2 vicinity is organized so that the main roads (highway D1, main railway route Bratislava – Zilina with Trnava and Leopoldov nodes) pass approx. 6km from the site. The main roads and railway routes in the region are free of hard transit sections in case of extreme natural conditions, but there is risk of extraordinary events in case of accidents of means transporting dangerous harmful substances. These sections can be bypassed considering the dense traffic network around the plant.

Considering large geodetic differences in altitudes, geographic relations and position of the waterworks Slnava with regard to NPP Bohunice V-2 position, minimally one road will enable transport of staff and material to the plant even in case of local flooding. This also applies to local floods due to extreme rains and down rush from adjacent rural areas to the power plant.

In case of larger damage of road surface and their flooding, on-duty members of NPP Bohunice V-2 EC and intervention staff can be transported out of the roads using the transport means of the Ministry of Interior of the SR – CP based on a cooperation agreement. To ensure rescue, liquidation, and salvage works, 2 cranes and 2 platform cars can be used; today they are available in the maintenance department.

To ensure work of 12 NPP Bohunice V-2 ERO members and to transport them to their workplace in case of an event in the plant there have been 4 passenger emergency vehicles assigned to transport also other on-duty members of NPP Bohunice V-2 ERO. Procedures for transporting staff in case of abnormal and extreme situations are described in EWP.

EMO1,2

The plant is located in the territory of the village Kalna and Hronom, close to former village Mochovce, approx. 12 km from the city Levice and approx. 14 km from Zlate Moravce and 11 km from Vrable. Kozmalovce waterworks and the river Hron are the nearest sources of water.

Considering large geodetic difference in altitudes, geographical conditions and the Kozmalovce waterworks position in consideration of the Mochovce NPP site, flooding evoked by the river Hron and the Velke Kozmalovce waterworks is not possible. Similarly, flooding of Mochovce NPP site due to damage of tanks 2 x 6,000 m^3 of the raw water reservoir may be excluded with regard to the relief and position of this object.

Considering altitude and layout arrangement of the NPP site, there is no risk of the site flooding due to inflow of rainfalls from adjacent power plant rural areas.

Access roads to the site can be endangered by the river Hron. Potentially endangered access roads to the site are from Levice and Tlmace directions. In case of larger damage of road surface and their flooding, on-duty members of EMO1,2 EC and intervention staff can be transported out of the roads using the transport means of the army units in Levice based on a cooperation agreement with the army. To ensure rescue, liquidation, and salvage works, 2 cranes and 2 platform cars can be used; today they are in the maintenance department.

To ensure work of 16 EMO1,2 ERO members and to transport them to their workplace in case of an accident, there have been 4 passenger emergency vehicles assigned to transport also other on-duty members of EMO1,2 ERO. Procedures for transporting staff in case of sub-standard and calamity situations are described in the procedure HO/8707 "Gathering of staff at abnormal and extreme situations".

4.1.3.2 Loss of communication facilities/systems

Communication means in ERO – stationary network and radio network

Communication equipment of stationary plant network is powered from redundant sources and, in case of grid supply loss – backed up by accumulators for 10 hours. Independent communication equipment for direct stationary connection between the MCR and dedicated points in unit technology are backed up by accumulators for 10 hours in case of power supply loss from the grid. All shift staff, i. e. unit control rooms and intervention shift staff are equipped with walkie-talkies enabling communication for 10 hours without recharging.

In case of non-functional mobile and stationary telephone networks, walkie-talkies will be used for communication.

The walkie-talkies (radio stations) are available in NPP Bohunice V-2 ERO facilities, i. e. NPP Bohunice V-2 ECC, back-up ECC Trnava, in CP shelters and on CP assembly points and in PFB. It is necessary to ensure battery charging after elapsing the mentioned time. Totally about 300 walkie-talkies are used for communication in NPP Bohunice V-2. For communication with rescue staff, there are radio stations in NPP Bohunice V-2 ECC, in Trnava back-up emergency control centre and in civil protection shelters. Totally about 300 walkie-talkies are used for communication in NPP Bohunice V-2. EBO PFB is connected with the Regional Fire and Rescue Corps operational centre via a radio station with own power source and phone line with local accumulator. Besides EMO1,2, walkie-talkies are also in EMO1,2 ERO facilities, i. e. EMO1,2 ECC, back-up ECC Levice, in CP shelters and CP assembly points and in PFB. Totally about 400 walkie-talkies are used for communication in EMO1,2. EMO PFB is connected by a radio station with local accumulator with the Regional Fire and Rescue Corps operational centre.

Announcement and information system

Technical hardware of the notification system intended for notification of operation staff and persons belonging to the ERO are pagers ensuring one-way receipt of information; similar notification is used for villages and state administration representatives within 20km from the emergency zone. The notification paging radio network is supplied by fixed back-up power supply sources (accumulators) in case of grid supply loss enabling uninterrupted operation for 10 hours. Paging, together with transmitting infrastructure, is system independent on public communication networks.

4.1.3.3 Impairment of work performance due to high local dose rates, radioactive contamination and destruction of some facilities on site

SAMG consider unavailability of certain equipment or its failure due to the severe accident. Therefore, strategies are developed with alternative actions. Equipment installed or credited within the SAM project is designed so as to keep their operability under severe accident conditions with high confidence.

Extreme situations related to failure or damage of also newly installed systems are covered in the SAM project by installation of three pipelines with nozzles installed on the exterior surface of reactor building and auxiliary building providing for possibility of coolant make-up from external mobile sources: a) to the reactor cavity to keep heat removal from RPV and prevention of ex-vessel corium impact; b) to the SFP from the top, independently from the pool cooling system; and c) to make-up of coolant emergency source tanks (that can be also used for coolant make-up to the reactor and containment spray system for long-term heat removal from the containment).

Local radiation conditions in technological structures can affect performance of activities required for recovery of equipment needed for long-term SAM (e. g. heat removal from the containment). Currently, no adequate information is available for complete solution of this issue. The issue will be addressed in the final stage of the SAM implementation project.

4.1.3.4 Impact on the accessibility and habitability of the main and secondary control rooms, measures to be taken to avoid or manage this situation

Habitability of the main control room and emergency control room (in smaller scope) was reinforced in the project by installation of the following design modifications:

- Innovation of the MCR HVAC system and provision of its recirculation regime (formation of over-pressure in the control room for minimization of penetration of external radioactivity)
- Addition of iodine filters
- Sealing of the complete MCR area and walling of windows
- Sealing of cable areas under MCR and ECR against smoke leakages.

High radiation load could endanger habitability of MCR, namely during hypothetical severe accidents with an open reactor. Therefore, a possibility was arranged to control selected newly installed SAM equipment required in long-term horizon, as part of reconstruction of ERO emergency and support centres with radiation protection (shelter type). Required I&C system and power supply of these consumers form a part of the SAM implementation project.

4.1.3.5 Impact on the different premises used by the crisis teams or for which access would be necessary for management of the accident

Newly constructed spaces for the crisis team (ECC) is in an underground shelter resistant against all foreseeable severe accident impacts occurring at open reactor regimes; a relevant source term was used for the design shelter dimensioning. The shelter is equipped with technical air source for internal circuit and filters for CO2 removal and oxygen supply, thus ensuring possibility of autonomous existence during critical phases of severe accident (at leaks of inert gases). Shelter dimensioning is sufficient for two ERO shifts and MCR staff from both nuclear units.

In case of large accident, ERO members gather in back-up ECC.

4.1.3.6 Feasibility and effectiveness of accident management measures under the conditions of external hazards (earthquakes, floods)

Majority of activities needed for severe accident management are controlled from the MCR or ECC that are not directly threatened by effects of extreme external events. Equipment installed as part of the SAM project is located in buildings resistant against external effects (seismicity to SSE level); thus, their usability and availability will not be largely affected by the external event. This means that management of severe accidents caused by extreme external events is identical with the case of internal initiating events.

Internal floods caused by external flooding are solved by already adopted measures and it can be assumed that escalation of an event into a severe accident is prevented.

4.1.3.7 Unavailability of power supply

Unavailability of power supply sources during severe accident is one of assumptions of SAM implementation project and is solved preventively by increased redundancy of sources with robust design (also against extreme weather conditions). All consumers installed within the SAM project are – besides standard power supply from existing systems – also supplied from the dedicated SAM DG independent from existing safety systems, thus serving as redundant power source.

4.1.3.8 Potential failure of instrumentation

Assumption of potential unavailability of certain measuring devices is one of the SAM project bases. SAMG strategies are designed so that to enable their execution and monitor their efficiency based on diverse measurements to decrease their vulnerability in case of failure of some measurements.

I&C design principles and requirements for newly installed systems were defined at initiation of the SAM project. Even though qualification of instruments for severe accident conditions is not required, it is necessary to prove its survivability in such conditions. Analyses were prepared for determination of thermal-hydraulic and radiation parameters in areas where new I&C is to be installed serving as basis for definition of requirements on installed I&C equipment.

The potential for availability of the instrumentation needed for execution of SAMGs is significantly increased by implementation of a new SAM DG as the ultimate power supply for all I&C installed in the frame of the SAM project, specifically I&C related to major modifications.

4.1.3.9 Potential effects from the other neighbouring installations at site, including considerations of restricted availability of trained staff to deal with multi-unit extended accidents

SAM implementation project is based on the assumption of severe accident occurrence on only one of nuclear units, in line with the existing rules. Certain design solutions (e. g. SAM DG) are assumed to cover both units, so that it is not possible to exclude interferences between the units and resulting effects on SAM. Similar mutual interdependencies are also in the technological part and due to potential influence of a severe accident in one unit on other unit due to relatively close location of the MCR and ECR, common turbine hall and common reactor hall shared by both units. Such interrelations between the units should be considered in future stages of the SAM project.

4.1.4 Conclusion on the adequacy of organizational issues for accident management

The organizational aspects of accident management of DBA, BDBA and severe accidents as reflected by the respective procedural guidance complies with all applicable recommendations and requirements for accident management in NPPs, follows best practice in the industry and, therefore, the organization issues are considered as adequately covered. However, it should be noted that the structure and scope of the emergency response teams, especially SAMG team is currently defined from the perspective of a severe accident in one unit only, in line with the SAM project principles.

4.1.5 Measures which can be envisaged to enhance accident management capabilities

At present, implementation of comprehensive SAM is on-going in accordance with the programme established in 2009. No additional measures beyond this project are currently envisaged. It should be however taken into account that in accordance with the currently valid requirements the measures have been developed considering occurrence of a severe accident only on one of two units; this assumption should be reconsidered.

SAM project is being currently implemented in both NPP Bohunice V-2 and EMO1,2 based on originally defined scope with assumptions for severe accident management on one of two units. The project completion will be followed by evaluation of possible extension to management of a severe accident on both units. Further SAMG improvement and preparation of additional supporting documents for decision making by SAMG and MCR teams will be adopted based on SAMG validation results at project completion.

4.2 Accident management measures in place at the various stages of a scenario of loss of the core cooling function

4.2.1 Before occurrence of fuel damage in the reactor pressure vessel/a number of pressure tubes (including last resorts to prevent fuel damage)

The accident management measures belonging to the preventive phase of AM are systematically built into the plant specific symptom oriented EOPs which follow the Westinghouse approach. The EBO and EMO EOPs cover all operational regimes of the plants, i. e. full power or shut-down regimes. EOPs package of both EBO and EMO NPPs has been adequately validated and there is a continuous cooperation with Westinghouse providing for maintenance and upgrading of EOPs in the frame of the world-wide cooperation between WOG NPPs.

4.2.2 After occurrence of fuel damage in the reactor pressure vessel/a number of pressure tubes

After identification of fuel damage based on measurable symptoms the AM enters the mitigative phase. The transition between the preventive and mitigative phases is described and justified in the SAMG documentation and a specific procedure/guideline SA CRG-1 has been developed to provide guidance for control room staff until the control of the severe accident is transferred to the SAMG team. The SAMG team is a part of experts convened to the ECC. The SAMG team should take over the responsibility within 1 hour of the severe accident course. All AM measures aimed at protecting the containment and preventing/ mitigating the consequences of severe accident on environment and public are built into the SAMG package. SAMG cover all operational regimes of the plant consistently with the respective EOP.

In addition to the generally adopted approach to build the response to severe accident mainly by usage of all available equipment, safety as well as non-safety, a set of dedicated hardware modifications and installation of new hardware extends the scope of potentially applicable measures and significantly increases the probability of the success of the strategies in SAGs and SCGs guidelines.

4.2.3 After failure of the reactor pressure vessel/a number of pressure tubes

The prevention of reactor pressure vessel failure by installation of in-vessel-retention hardware modification and development of respective guideline SAG-3 of SAMG package is considered adequately reliable. The failure of vessel can be therefore considered as negligible residual risk.

Should the reactor vessel fail the major relevant failure mode of the containment is the failure of entry door into the reactor cavity due to thermal attack and long term over pressurisation of the containment due to molten core concrete interaction. SAMG provide guidance to partially limit the consequences of long term over pressurisation by usage of containment spray system as well as usage of external injection system installed in the frame of SAM project.

SAM implementation project does not include any modifications directly dedicated to limitation of impact of reactor pressure vessel failure.

4.3 Maintaining the containment integrity after occurrence of significant fuel damage (up to core meltdown) in the reactor core

4.3.1 Elimination of fuel damage / meltdown in high pressure

4.3.1.1 Design provisions

Original design

Severe core damage can occur in several scenarios at escalation of BDBA. Among them there are scenarios caused by loss of heat removal from the primary to the secondary circuit, when the RCS integrity is maintained and the core degradation followed by corium relocation takes place at high pressure. In this case, the reactor pressure vessel is loaded with high pressure and high temperature, its own weight and weight of corium. The top priority is to decrease pressure in the primary circuit and prevent RPV melt through at high pressure resulting in high pressure melt ejection (HPME), as it could result in damaging the reactor cavity door, transport of melted fragments to the containment, thermal endangering of its walls and fast containment heating. Another benefit of reduced pressure is lowered probability of SG tube failures and possibility to make-up coolant from low-pressure sources.

In the original design the RPV failure at high pressure could be prevented by two sets of the main safety valves and one relief valve of the PRZ. PRZ safety valve part power supply is provided from the vital power supply. All valves are controlled remotely manually from MCR. PRZ SV system equipment has seismic classification.

Installed modification

Considering the high priority of RCS de-pressurization, the SAM implementation project includes installation of redundant independent system qualified for severe accident conditions. Redundant de-pressurization line is to be used before the accident escalation to a severe accident, so that probability of failure to open due to previous thermal stressing or by other mechanism is minimal. Installed system forms part of RCS pressure equipment. Part non-separable from the RCS including the isolation valves is seismically resistant. The system is classified to safety class 1.

The system is supplied from SAM DG dedicated for power supply of equipment required for SAM. System operation during design basis accidents is not required. The depressurization system is qualified, highly reliable back-up with full capacity usable at failure of standard lines for RCS depressurization (PRZ RV, PRZ SV).

The depressurization of the primary system is the highest priority activity in the preventive as well as mitigative AM. The respective proceduralised actions are consequently built into the symptom based critical safety function restoration guidelines from the EOPs package (procedures FR-C.1 and FR-C.2), secondly the depressurization action (if needed) is one of the transfer steps between EOPs and SAMG. In addition the SAMG package itself contains a specific guideline SAG-1 dedicated to response to the primary system pressure exceeding 2.5MPa.

4.3.1.2 Operational provisions

RCS depressurization procedures are included in EOP procedures FR-C.1 and FR-C.2 and the guidelines SA CRG-1 and SAG-1 of the SAMG package providing for high reliability of required functions. Installation of additional qualified depressurization line and strategies in SAMGs provide for high reliability of RPV failure prevention at high pressure.

4.3.2 Management of hydrogen risks inside the containment

4.3.2.1 Design provisions, including consideration of adequacy in view of hydrogen production rate and amount

Original design state

During a severe accident large amount of hydrogen produced due to exothermic reaction between zirconium and steel and water vapour. In case of further accident escalation with failure of the reactor pressure vessel, additional significant amount of flammable gases (hydrogen and CO) would be produced due to corium interaction with reactor cavity concrete. Total production of flammable gases during this ex-vessel phase exceeds several times their production during the in-vessel phase, even though its rate is lower than during the in-vessel phase.

Zirconium weight in the reactor is approx. 18,000 kg. According the calculation the amount of hydrogen generated during the in-vessel phase ranges from approx. 300kg (LB LOCA) to 500kg (SBO) depending on the scenario. Heat production from the exothermic reaction is approx. 6,400kJ / kg of reacted zirconium, i. e. generated heat significantly contributes to the requirements for heat removal from the containment. Original V213 design does not provide means for reliable hydrogen removal at severe accidents. Theoretical possibility to ensure controlled early hydrogen ignition by discharges in installed electric consumers in the containment is unreliable and unavailable for certain scenarios (SBO).

The hydrogen production rate during severe accident depends on many factors. From the sensitivity studies in the past follows that the peak hydrogen production rate in the early phase of a severe accident can be more than 1 kg per second.

Hydrogen generated during severe accidents is the most critical and earliest risk for V213 containment integrity. With regard to ensuring containment integrity the most significant is rate and amount of hydrogen released from the primary circuit to the containment and resulting time course of hydrogen concentration in the containment, which in turn depends on steam concentration, and total amount of generated hydrogen.

Installed modifications

One of presumptions of managing the hydrogen issues during severe accidents is reliable prevention of the transition to the ex-vessel phase. This issue is covered by installation of group of modifications enabling retention of the molten corium inside the RPV and its reliable external cooling.

Technical solution of the hydrogen issues consists of installation of 28 passive auto-catalytic recombiners RF1-1500T and 4 passive auto-catalytic recombiners FR1-750T of the company AREVA. Installation of recombiners in the containment is a standard solution; recombiners have been installed in more than 100 NPPs in various countries. Recombining ability of the recombiners was proved also by experiments on experimental stand PHEBUS and at large-scope tests on THAI facility.

Threshold hydrogen concentration for recombination commencement is ~ 2% vol. at atmosphere temperature of 50℃. At reference parameters provided by the manufacturer, recombiners are capable to ensure total hydrogen recombination rate of approx. 160kg/hour. Selection of capacity and location of installed PAR is based on results of studies of hydrogen distribution performed by various organizations. Generally, the total capacity of recombiners provides for recombination of hydrogen in all analysed sequences below 4-5% in less than 1 hour. For the scenarios with maximum rate of hydrogen release into the containment (e. g. LOCAs) the period when the steam inertization of containment is credited is less than 30 min.

PARs are designed so as to resist expected emergency temperatures and are seismically resistant. Possible failure (e. g. mechanical damage) of a single PAR has no effect on operability of other

PARs in the system. Considering their installation in various containment areas, failure of several PARs is unlikely. The overall system capacity is designed with sufficient margin; thus, failure of several components does not cause failure of the system as a whole.

4.3.2.2 Operational provisions

SAMG consider hydrogen management in strategies defined in several SAG and SCG guidelines. Hydrogen management procedure in the first SAMG revision was based on controlled hydrogen combustion at sufficiently low concentration using electrically supplied igniters. Implementation of PAR based solution with significantly lower demands for staff actions requires updating of the hydrogen management strategy in SAMG.

4.3.3 Prevention of overpressure of the containment

4.3.3.1 Design provisions, including means to restrict radioactive releases if prevention of overpressure requires steam / gas relief from containment

Original design state

Radiation leaks are minimized by keeping the containment pressure boundary integrity dimensioned both to internal over- and under-pressure. Besides the civil part, containment pressure boundary also includes equipment providing for isolation under accident conditions or ensuring its hermetic status.

The containment is dimensioned for the design-basis accidents in the following ranges:

Maximum design pressure:	245 kPa
Minimum design pressure:	80 kPa
Maximum temperature:	129℃
Integral ionizing radiation dose:	10^5Gy in 10 years

Containment pressure boundary tightness for NPP Bohunice V-2 (constantly being improved):

- Initial design leakage rate<13% vol. / 24 hours at 150 kPA over-pressure
- Actual value is approx. 5% vol. / 24 hours.

Containment pressure boundary tightness for EMO1,2 (constantly being improved):

- Initial design leakage rate<5% vol. / 24 hours at 150 kPA over-pressure
- Actual value is approx. 2% vol. / 24 hours.

The containment is integrated with the reactor building into a common structure. Internal hermetic compartments include SG room, bubbler condenser tower with four air traps, HVAC centre and refuelling pool. In order to maintain integrity and tightness of the pressure boundary, it is necessary to prevent excessive over- and under-pressure in the containment.

Prevention of excessive over-pressure in the containment

Management of pressure in the containment is ensured by two systems:

- **Passive pressure suppression system** – its aim is to limit over-pressure at relevant initiating events (e. g. LOCA, steam line rupture). This fully passive function is provided by bubbler condenser trays used for condensing of expanding coolant. Current V213 design does not include a system for controlled filtered venting as a mean for prevention against long-term over-pressurization following loss of the containment heat removal. At the same time the system also provide for capturing fission products in the water pools of the condenser.

- **Containment spray system** – its aim is to decrease pressure and to remove heat from the containment to ESCW via the spray system cooler in long-term recirculation operational regime. Operation of minimally one spray system train can assure permanent containment heat removal even after a severe accident. Based on existing analyses it can be extrapolated that the containment withstands complete loss of heat removal for 3-5 days until reaching the limiting pressure defined for SAM project (350 kPa abs).

Prevention of excessive under-pressure in the containment – installed modification

SAM project includes installation of a system enabling prevention of excessive under-pressure, by controlled return of part of non-condensable gases from the air traps back to the containment (to the space in front of condensing trays) and prevention of deep under-pressure. This is done by installation of four electric operated valves and two check valves with interconnecting and exhaust piping.

The system is controlled manually by the operator. Advantage of the adopted solution is prevention of interruption of integrity of external part of the containment as only internal compartments are mutually interconnected.

4.3.3.2 Operational and organizational provisions

Prevention of containment damage due to excessive static over-pressure, dynamic over-pressure resulting from hydrogen combustion and impermissible under-pressure is ensured by strategies described in several guidelines of SAMG package. Strategies use original design containment equipment, but their feasibility is significantly supported by new systems installed as part of the SAM project.

4.3.4 Prevention of re-criticality

4.3.4.1 Design provisions

Prevention of criticality is ensured by injecting into the primary system or containment only coolant with boric acid concentration exceeding 12g/kg. SAMG explicitly prohibits make-up of unborated coolant during SAM, which is one of differences from generic WOG SAMGs. To increase the coolant source redundancies, an external coolant tank is installed as part of SAM implementation enabling coolant make-up to:

- The primary circuit / reactor
- Spray collector
- Spent fuel pool.

Besides provision of the safety function – criticality control, the external source also provides for the function of heat removal form the reactor and SFP and from the containment atmosphere by spraying. Containment spraying from external source increases reliability of pressure control in the containment and decreases releases of radioactive substances by reducing the pressure and in particular by washing-out fission products from the containment atmosphere.

External coolant source in NPP Bohunice V-2 consists of three tanks containing boric acid solution 12g/kg, with total usable volume 1,250 m^3 and two pumps with pressure heads 0.85MPa (LP) and 2.5MPa (HP). The system is located mostly in the auxiliary building. Location of tanks in EMO1,2 has not been fixed yet, but the design similar to NPP Bohunice V-2 is preferred in order to provide for maximal use of experiences. Functioning of the system and applicable requirements will be identical.

4.3.4.2 Operational provisions

The injection into the primary system and prevention of further degradation of the reactor core during severe accident is the main goal of the guideline SAG-2. The guideline provides all necessary instructions on usage of existing plant systems and new installed external SAM source of water allowing injection of borated coolant directly into the primary system. The explicit prohibition of usage of unborated water is stated in the SAG-2. The operational provisions to prevent recriticality can be considered adequate.

4.3.5 Prevention of basemat melt through

4.3.5.1 Potential design arrangements for retention of the corium in the pressure vessel

Original design condition

According to the original V213 design, the long-term core cooling phase during LOCA is based on coolant recirculation from the SG box via the spray system heat exchanger after exhausting all coolant from the emergency system tanks (in about 30 minutes for some kinds of events). Coolant released from the broken reactor coolant system is collected on the floor of the SG box and is available for recirculation core cooling mode.

Rupture of the reactor pressure vessel is considered unrealistic due to strong conservatism of the vessel design and strict inspections, so that reactor cavity is not included in the recirculation loop – V213 design does not enable controlled coolant flow to the cavity or coolant return from the cavity to SG box. Thus, original V213 design did not enable external RPV cooling or controlled corium cooling on the cavity bottom during the ex-vessel phase in case of RPV failure.

Analyses within the project PHARE 4.2.7a showed that the reactor cavity is endangered shortly after transition to the ex-vessel phase of the accident. Limiting structure is the cavity access door assumed to fail either due to corium thermal attack or due to sudden pressure increase resulting from HPME. There is also risk of radioactive coolant leak via non-isolable drainage piping and via induced leaks through the sealed penetrations in the cavity wall.

Implementation of external RPV cooling requires the following in order to prevent the basemat failure: a) early reactor depressurization; b) early flooding of the reactor cavity; c) ensuring contact between RPV wall and coolant before corium relocation to the reactor bottom; and d) sufficient venting of steam generated in the reactor cavity back to SG box. Design solution is identical for existing as well as for new units.

Modifications required for flooding of the reactor cavity and provision of external RPV cooling:

- Modification of the drainage system of bubbler condenser trays - SAM project provides for the reliable power supply of the bubbler condenser system valves from SAM DG, thus providing coolant availability from the bubbler condenser trays also under severe accident conditions initiated by SBO.
- Filtrating sieve structures – coolant inlet line to the reactor cavity and towards the external RPV surface is equipped with two-stage filtration of impurities as prevention of clogging of the narrowest sections of the cooling pathway around the reactor vessel.
- Installation of passive opening mechanism in RPV thermal insulation – installation of circular intake opening with removable cover controlled by special float opening device installed on the bottom of the RPV thermal shield in the reactor cavity.
- Installation of a door in the reactor thermal insulation at the level of reactor nozzles in order to reduce hydraulic resistance for steam outflow from the cavity.

– Coolant make-up line to the reactor cavity from the external mobile source – installation of a line (dry channel) mouthed on external reactor building wall enabling coolant supply to the reactor cavity from a mobile external source. The line allows for the use of the back-up coolant source for external RPV cooling without necessity of coolant on SG box floor.

Modifications required for isolation of the reactor cavity and prevention of non-returnable coolant leak:

– Isolation "siphon" on two horizontal air ducts with flooding structures– modification of both HVAC ducts of the reactor cavity cooling system. Flooding structures will be installed on the siphon down coming pipe enabling the cavity flooding at severe accidents (see the Figure 18). They are installed on both sides in interconnecting corridor between SG box and bubbler condenser tower and protected against undesirable accident consequences (flying objects, hitting by coolant flow, insulation fragments). Flooding valves are controlled actively from MCR. They are assumed to be opened by the operator at transition between the EOP and SAMG.

– Improving of hermetic door sealing – provision of sufficient resistance of reactor cavity hermetic door seal to long-term load caused by increased radiation, heat and pressure for longer time (including contribution from hydrostatic pressure in flooded reactor cavity).

– Isolation of special sewage inlet from the reactor cavity floor - installation of closing plug on the special sewage collector in the reactor cavity.

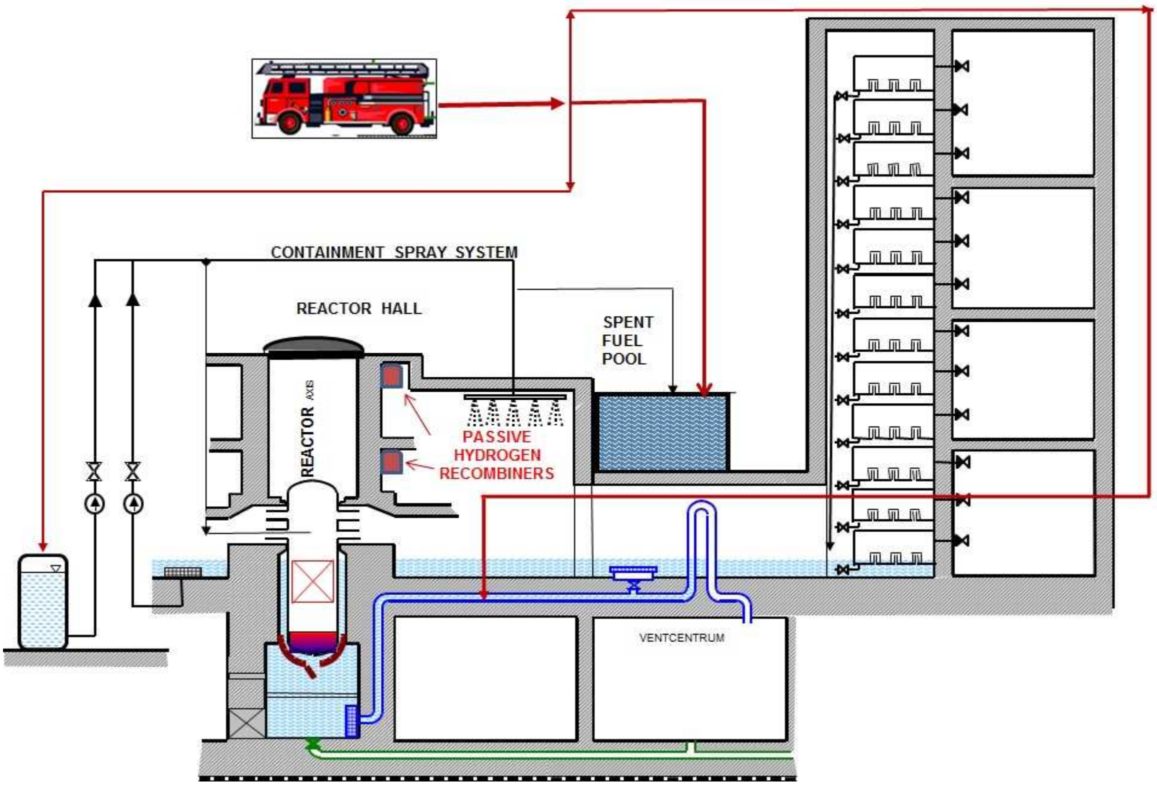


Figure 18: Overall arrangement for reactor cavity flooding and containment spraying

4.3.5.2 Potential arrangements to cool the corium inside the containment after reactor pressure vessel rupture

Considering limited strength of the reactor cavity in case of RPV failure, regardless of coolant presence in the cavity, it is unlikely to prevent failure of doors. The failed door enable leak of radioactive medium, and possibly also corium, to the areas out of the containment and serious worsening of the accident progression.

Therefore, no special additional measures were assumed for hypothetical corium cooling on the cavity bottom. Existing measures included in the external RPV cooling strategy implementation, namely the coolant feeding from SG room to the reactor cavity by gravity and steam removal from the cavity back to SG room present the maximal achievable protection of the cavity bottom following RPV failure. Stabilization of the melt composition, termination of concrete degradation and long-term preservation of the cavity integrity cannot be guaranteed by the above mentioned heat removal method. This significantly increases the importance of RPV failure prevention. On the other hand it can be stated that the implemented modification provides for stabilization of molten corium with adequately high confidence.

4.3.5.3 Cliff edge effects related to time delay between reactor shutdown and core meltdown

Operator´s failure to perform actions in line with the developed strategies, failure of equipment or unexpected development of the accident differently from considerations in the strategies (or equipment design) could hypothetically result in the failure of the containment integrity during the severe accident. To eliminate possibility of such scenarios the following principles and rules are observed in the SAM project and in SAMG:

– Preference is given to dedicated passive equipment or equipment not used prior the severe accident phase of the event, and mostly supplied from the dedicated electric power source;
– All actions important for maintaining containment integrity are in addition to the provisions of the original VVER 440 design supported by additional new design features (highly reliable modifications).

Majority of early (short term) personnel actions included in SAM are included in the procedure SA CRG-1 that is the only one performed by staff from MCR before ECC activation. Actions in SA CRG-1 are prepared as algorithm in form of clear instructions and are included in the basic MCR staff training. Therefore the required actions should be performed very reliably.

Staff actions and effective use of available systems enable RPV integrity control as well as pressure and temperature control in the containment for several days. During this period, regular spraying of containment helps to maintain minimum internal over-pressure, together with fission products washing out the main means for mitigation radiological consequences. Considering the passive design solution adopted for hydrogen management only monitoring of its successfulness is needed.

In case of unavailability of the containment spray system, recovery of minimally one containment spray system train for long-term containment heat removal has to be provided within approx. 5 days, during which the residual power and heat from chemical reactions can be accumulated in the containment structures and walls. In addition a study has been developed on possible containment heat removal by operation of the containment ventilation systems.

4.3.6 Need for and supply of electrical AC and DC power and compressed air to equipment used for protecting containment integrity

4.3.6.1 Design provisions

Original design state

Current power supply sources are designed for reliable control of design-basis accidents; back-up is mostly optimized for managing SBO events caused by failures of electric equipment.

Installed modification

In order to increase reliability of SAM, the SAM project contains a partial project “Emergency power supply source” focusing specifically on power supply during severe accidents. Installed SAM DG is independent from the existing normal operation systems, abnormal operation systems and safety systems for management of DBA. The emergency source is planned as common for two units.

In NPP Bohunice V-2 SAM DG has container design; the container contains one diesel generator with electric power up to 1,200kW and accessories (transformer, catching basin under DG, fuel tank with 3,000 l volume, air intake opening, exhaust). SAM DG home consumption will be supplied from independent external substation 0.4kV for power supply of DG electric heaters, fuel pump and outlet for cooling water supply in case of severe accident.

The layout arrangement of SAM DG and relevant 6kV substation 0BG was selected with regard to the need for SAM DG connection to close cable channels connecting also the 3rd grid source – Madunice hydro power plant. SAM DG electric power is supplied to new external 6kV substation 0BG.The substation 0BG is equipped with transformer 6 / 0.4kV (1,000kVA) for supplying consumers in case of severe accident, and also with outlet for emergency ECC object supply during severe accident.

SAM DG boundary consists of the SAM panels installed in unit MCR and identical panels on the back-up workplace in ECC object. Use of SAM DG at power loss supply depends on decision of SAMG specialists from TSC. SAM DG can be used in appropriate scope (i. e. without endangering its full operability for management of potentially severe accident) already for prevention of the core damage, e. g. under SBO conditions. From this point, it represents another power supply redundancy for managing SBO events.

In EMO1,2 the emergency power supply is in the design preparatory phase. The solution will take into consideration plant specific electric connection to the grid and concept home supply of four EMO1,2,3,4 units. Therefore, the detailed solution will differ from the solution developed for NPP Bohunice V-2. Nevertheless, the solution will be functionally similar to NPP Bohunice V-2 design; SAM panels will be installed in EMO1,2 unit MCR and identical panels will be installed on the back-up workplace installed in the ECC building.

4.3.6.2 Operational provisions

Recovery of failed essential power supply, extension of life of existing DC resources (batteries) and initiation and control of SAMDG is included in the normal operating procedures, EOPs and SAMGs and TSC documentation. The feasibility of required local interventions is a part of SAMG verification and validation.

4.3.7 Measuring and control instrumentation needed for protecting containment integrity

Original design

Consumers and measurements installed as part of the SAM project were not included in the basic design.

Modification in progress:

SAM project contains also a partial project “SAM information system and control SAM elements and components” containing implementation of reliable I&C system for newly installed systems and information system in the scope needed for implementation of strategies foreseen in SAMG.

The information system for SAM support relates with PAMS - Post-accident monitoring systems in line with recommendations of US NRC RG 1.97.

From technical point of view it includes implementation of a set of measuring sensors, relevant cabling and evaluation devices installed mostly inside existing objects in the RB, auxiliary building and ECC.

Proposal of the design considered requirements on scope of information needed for implementation and monitoring of successfulness of strategies in SAMG. Systematic evaluation covered all SAMG strategies, diagnostic diagrams, set points in strategies from view point of availability of reliable data and redundancy of their provision in the information system accessible to teams deciding of SAMG use, SAMG team in the emergency commission and MCR team.

NPP Bohunice V-2 design also included analytical determination of qualification requirements on newly installed I&C and measuring equipment. Environmental qualification requirements were set based on existing severe accident analyses and new prepared radiation situation analyses in selected RB areas. Analogical requirements will be applied to project implemented in EMO1,2.

4.3.8 Capability for severe accident management in case of simultaneous core melt/fuel damage accidents at different units on the same site (multi-unit events)

The accident management concept is currently based on assumption of severe accident evolving only in one unit, in line with existing legislation and recommendations. The capability to respond to severe accident in two units simultaneously is, however, affected only in few areas and only in quantitative aspects. Detailed analysis of increased need for additional personnel and increased needs for make-up depleted external water sources are analysed in the plant specific stress tests technical reports. Installed modifications (pumps, pipelines, valves) provide sufficiently for capacities to manage the situation.

4.3.9 Conclusion on the adequacy of severe accident management systems for protection of containment integrity

The SAM project involves installation of several groups of major plant modifications which has a whole provide for better prevention of escalation of severe accidents, enhance the capability of NPP personnel to mitigate the consequences of severe accident and increase the probability of maintaining the integrity of the containment. The scope of the on-going project has been defined based on detailed vulnerability study of V213 behaviour and identification of challenges during severe accidents. The approved scope of the SAM project is considered as adequate.

4.3.10 Measures which can be envisaged to enhance capability to maintain containment integrity after occurrence of severe fuel damage

Other possible measures extending the current scope of the SAM project will be analysed after the project completion, based on results of SAMG validation and analytical justification of strategies for management of representative severe accident scenarios.

4.4 Accident management measures to restrict the radioactive releases

4.4.1 Radioactive releases after loss of containment integrity

4.4.1.1 Design provisions

An airtight zone is arranged in compartments around the containment inside the reactor building with ventilation systems equipped with filters capturing the fission products escaping through possible containment leakages. This zone performs the function of the secondary containment.

Implementation of SAM project also includes connection of the fans of the vent system to dedicated power source to ensure their operation also during severe accidents caused by the loss of power supply. This measure significantly contributes to mitigation of radiological consequences in the plant vicinity.

Part of the primary containment pressure boundary is not provided with the secondary containment and pertinent leakages from this part would result in direct activity release to the environment.

As the leak size is roughly proportional to internal containment pressure, all modifications installed within SAM project aimed in improvement of containment spray system reliability and containment heat removal from the containment or keeping the lowest possible over-pressure in the containment contribute to lowering radiation leaks to the environment. These are:

- Improvement of the spraying system reliability, removal one of two FCVs at the containment inlet, reinforcement of the spray pump against radiation and measures aimed at system recovery in the case of failure;
- Installation of emergency external water source with tank volume 1,250 m^3, pump supplied from SAM DG enabling containment spraying. Tanks will be continuously filled by a route (dry channel) from mobile water source. In order to ensure reliable access to the route during emergency conditions, it is mouthed on the outer sheathing of the auxiliary building.

Operability of the containment sprays will reduce radioactive releases even in the case of loss of containment integrity.

4.4.1.2 Operational provisions

The mitigation of the loss of containment integrity and consequent releases of radioactive releases is described in SAMG severe challenge guideline SCG-1. All relevant operational provisions are included in the guideline in sufficient detail.

The minimisation of impact of radioactive releases on plant personnel and public is the main concern of emergency planning and response. Detailed procedures are available for all activities of emergency response organisation and their adequacy and compliance with legislation has been verified during the Periodic Safety Review in 2008 and 2009.

4.4.2 Accident management after uncovering of the top of fuel in the fuel pool

4.4.2.1 Hydrogen management

Assessment of possible hydrogen concentration in the reactor hall formed due to fuel degradation in the spent fuel pool was performed as part of the hydrogen management. It was concluded that there is no need to install PARs in the reactor hall, since the resulting hydrogen concentration, considering the reactor hall volume of 160,000 m^3, is below the PARs operational limit. However, this assessment did not consider possible imbalance in hydrogen distribution and possibility of higher concentration above the pool. Such detailed analyses are not available yet.

Currently, safety of the spent fuel pool is solved by reliable prevention of severe accident occurrence that could cause dangerous hydrogen concentration in the reactor hall. The SAM project includes installation of two mutually independent routes enabling make-up of borated coolant into the pool. The first one is a route from the external emergency coolant source supplied to the spent fuel cooling piping. The other route is the connection to the external reactor building wall and leads to the storage pool from the top, i. e. without relation to the pool cooling piping. Both newly installed routes (in addition to previously existing ones) are dimensioned so as to provide for fast recovery of level in the pool in case when its integrity is preserved.

4.4.2.2 Providing adequate shielding against radiation

V213 original design considered isolation and covering of the spent fuel pool by providing sufficient protective coolant layer above the fuel. Thus, the protection against radiation is provided by sufficient capacities of systems recovering the coolant inventory in the pool. This is addressed in SAM projects by installation of two independent pipelines for water injection.

4.4.2.3 Restricting releases after severe damage of spent fuel in the fuel storage pools

Ventilation system exhausting the air from above the storage pool is not equipped with iodine filters and so it cannot be used for the radiation situation management above the pool. Therefore, also limitation of radioactive leaks after fuel degradation (severe accident in SFP) can only consist of recovery of sufficient level above the fuel to provide for efficient washing of fission products from steam leaking to the reactor hall.

4.4.2.4 Instrumentation needed to monitor the spent fuel state and to manage the accident

The storage pool is equipped only with instrumentation needed for supporting normal operation: level measurement and coolant temperature measurement. Two new dosimetry measurements will be installed in the reactor hall as part of the SAM project (1 measurement / unit) supplying signals to PAMS that could be indirectly used for monitoring of the spent fuel pool conditions.

4.4.2.5 Availability and habitability of the control room

No input data are yet available for assessment of MCR accessibility and habitability in case of severe accident in the spent fuel pool. Such assessment will be subject to further investigation.

4.4.2.6 Conclusion on the adequacy of measures to restrict the radioactive releases

Considering the spent fuel pool structure and its connection with the reactor hall, no possibilities have yet been evaluated to increase the pool reinforcement against severe accident and its isolation from NPP ambient with another barrier.

5 National Organizations (Regulator, TSO, Operator, Government)

5.1 Legislative and Regulatory Framework

5.1.1 Structure of regulatory bodies

Regulation over peaceful use of nuclear energy is performed by the ministries and other central bodies of state administration and organizations within their competency as stipulated by the relevant laws according to the structure as illustrated on Figure 19.

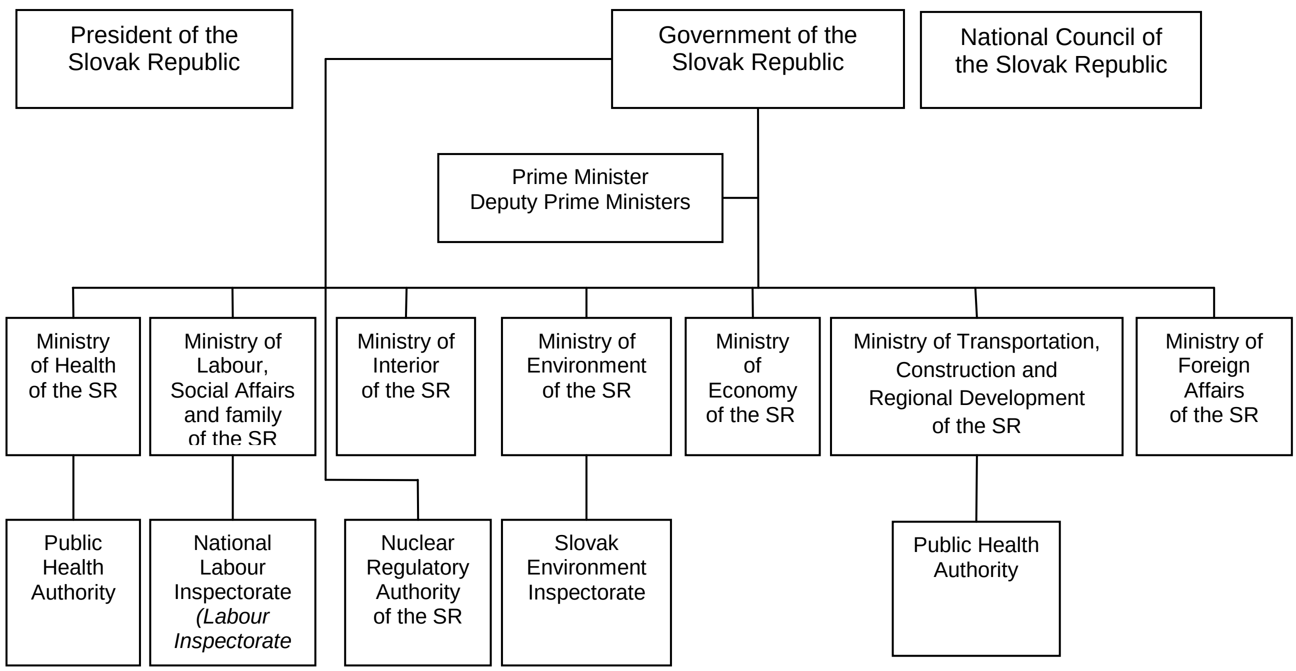


Figure 19 Structure of regulatory bodies

Nuclear Regulatory Authority of the Slovak Republic (ÚJD SR)

ÚJD SR is a central state administration authority. It executes state regulatory activities in the field of nuclear safety of nuclear installations, including management of radioactive waste, spent fuel and other parts of the fuel cycle, as well as transport and management of nuclear materials including their control and record keeping system. It is responsible for the assessment of goals of nuclear energy program and of quality of the classified equipment, as well as for commitments of the Slovak Republic under international agreements and treaties in the said field.

Ministry of Health of the Slovak Republic (Public Health Authority of SR)

Ministry of Health of the Slovak Republic is a central body of state administration for health care, health protection and other activities in the health service. State administration in the field of health protection is executed by the Ministry of Health and the Public Health Authority of SR. The Ministry's competences include establishing exposure limits and conditions for treatment and disposal of radioactive waste in terms of potential impacts on health. The Public Health Authority methodologically directs the health protection against ionizing radiation effects and licenses activities leading to exposure, performs state health regulation at nuclear installations and is a point of contact for the EU bodies on health protection against ionizing radiation (radiation protection). The role of the Ministry is to ensure medical services by health care facilities specified for provision of forced medical care to persons affected by potential radiation accident or radiation release.

Ministry of Environment of the Slovak Republic (MŽP SR)

The Act No. 372/2010 Coll. l. of 7 September 2010, amending Act No. 575/2001 Coll. l. on organization of government activity and organization of the central state administration divides the Ministry of Agriculture, Environment and Regional Development of the Slovak Republic and again creates the Ministry of Environment (MŽP SR).

MŽP SR is a central body of state administration of the Slovak Republic (inter alia) for the creation and protection of the environment. The following bodies report to the Ministry of Environment:

- The Slovak Environmental Inspectorate, through which MŽP SR fulfils the role of the main state regulator in environmental matters.
- The Slovak Hydro-meteorological Institute and others.

Ministry of Environment secures, inter alia, the process of assessment of impacts of strategic documents and projects on the environment also according to the Protocol on Strategic Environmental Assessment and the Process of Assessment of Impacts of Proposed Activities on the Environment according to the Convention on Environmental Impact Assessment in a Transboundary Context. The aim of this procedure is to provide a high level of environmental protection, including health aspects, that is:

- Providing for careful consideration of environmental aspects including health considerations in preparation of policies, legislation and proposed activities;
- Setting clear, transparent and effective procedures for assessment of strategic documents and proposed activities;
- Providing for public participation in the assessment of strategic documents and proposed activities; and
- Through subsequent integration of environmental considerations, including health considerations to be included in the measures and instruments proposed to promote sustainable development."

Ministry of Interior of the Slovak Republic (MV SR)

The Ministry of Interior is a central state administration authority for, amongst others, the conceptual management and control of fire prevention, the preparation of an integrated rescue system including civil protection of the population and property, public order and personal security. In case of accidents at a nuclear installation it is involved in management and carrying out rescue works, organizes and provides for the operation of the notification and warning centre of the Slovak Republic, development, operation and maintenance of information systems for collection of radiation data, operation of the integrated meteorological system, etc. It provides for a 24 hours permanent service, which fulfils the role of the national point of contact of the Slovak Republic vis-à-vis the International Atomic Energy Agency in Vienna and a competent body of the European Commission (ECURIE) in Luxembourg.

Ministry of Economy of the Slovak Republic (MH SR)

The Act No. 403/2010 Coll. l. of 13 October 2010, amending and complementing the Act No. 575/2001 Coll. l. on organization of government activity and organization of the central state administration as amended as at 1 Nov. 2010 the Ministry of Economy and Construction of the Slovak Republic is divided and subsequently the competencies are subdivided. At the same time the name of the ministry was returned back to the Ministry of Economy of the Slovak Republic. The role of construction authority was taken over by the Ministry of Transport, Construction and Regional Development of the Slovak Republic.

The Ministry of Economy of the Slovak Republic is a central state administration authority for, amongst others, nuclear energy industry, including the management of nuclear fuel, storage of radioactive waste, prospecting and exploration of radioactive raw materials and their extraction, and authorization of exports of special materials and equipments as dual-use goods.

Ministry of Labour, Social Affairs and Family of the Slovak Republic (MPSVR SR)

The Ministry of Labour, Social Affairs and Family is a central state administration authority for, among others, safety and health protection at work and labour inspection. State administration on labour inspection is executed by state administration bodies MPSVR SR, the National Labour Inspectorate and labour inspectorates.

The Ministry of Labour, Social Affairs and Family of SR oversees and controls the National Labour Inspectorate (NLI) and is responsible for the execution of labour inspection. The National Labour Inspectorate is a governing body for labour inspectorates, which performs (inter alia) also labour inspection in nuclear sector and regulation pursuant to special regulations.

Ministry of Transport, Construction and Regional Development of the Slovak Republic (MDVRR SR) and the Public Health Authority of the Ministry of Transport, Construction and Regional Development of the Slovak Republic (ÚVZ MDVRR SR)

MDVRR SR is the central body of state administration for rail, road, water and air transport and other activities in the field of transport. In terms of shipments of fresh and spent nuclear fuel, MDVRR SR is one of the bodies that participate in the authorization process. According to Section 28 par. 13 letter c) of the Atomic Act, the Ministry of Transport approves the emergency transport rules that contain measures during an incident or an accident in transport of radioactive material, and that is in a form of the Minister’s Decision on approval of the subject emergency rules.

The Public Health Authority ensures execution of state administration of the Ministry of Transport within the public health care for the area of air transport, shipping, posts and telecommunications. Its activity is performed in compliance with Section 7 of the Act No. 355/2007 on the protection, promotion and development of public health as amended. The Public Health Authority is managed by the chief hygienist of the Ministry of Transport, who is responsible for its activity. The chief hygienist is appointed and recalled by the Minister of Transport. The Public Health Authority is a budget organization connected through its financial relations with the budget of the Ministry of Transport.

In terms of its scope of operation the Public Health Authority in the area of use of nuclear energy determines the conditions for activities leading to irradiation and activities relevant to radiation protection (radiation protection in transport), and issues authorizations for transport in accordance with the Act No. 355/2007.

Technical Support Organisation (TSO)

One of the main pillars of safe use of nuclear energy is also services by the technical support organizations (TSO), universities and the Slovak Academy of Sciences (SAV) providing broad spectrum of necessary technical skills, which the operator or the regulator are unable to secure with their own capacity.

TSO works partially for license holders and partially for the regulator in those areas, where it is assured that there is no conflict of interest.

The activities of these TSOs focus on the area of nuclear safety in the whole spectrum, including radioactive waste and decommissioning of nuclear installations in a form of various analyses, technical reports, opinions, etc.

These organizations participate mainly on activities focusing on:

- Proposals of systems linked with design, construction, operation and reconstruction of nuclear installations;
- Development of supporting analyses focusing on, e.g. modernization of control and management system for NPP of VVER-440/V213 type, unit uprating, probabilistic analyses, etc.;
- Services in the field of computational modelling of design basis and beyond design basis accidents (including severe accidents with core meltdown) of nuclear power plants;
- Elaboration of accident analyses for Safety Reports;
- Consultancy in the area of safety of nuclear power plants (fire protection, improving wiring, seismic and other external events);
- Elaboration of basic technical and EIA documentation;
- Preparation of safety reports;
- Inspection of nuclear installations by using custom made manipulators and remote controlled trolleys.

5.1.2 Interactions among Organizations

5.1.2.1 Nuclear installation licensing procedure

The licensing procedure for the nuclear installation consists of five main phases, that is: siting of the nuclear installation, its construction, commissioning, operation and decommissioning. Before granting an operating license the regulatory body performs inspections according to the approved schedule of program of individual phases of commissioning the nuclear installation (tests, fuel loading, physical start up, energy start up, trial operation). The main regulatory authorities and the licensing procedure in issuing operating license are illustrated in Figure 20 (not siting):

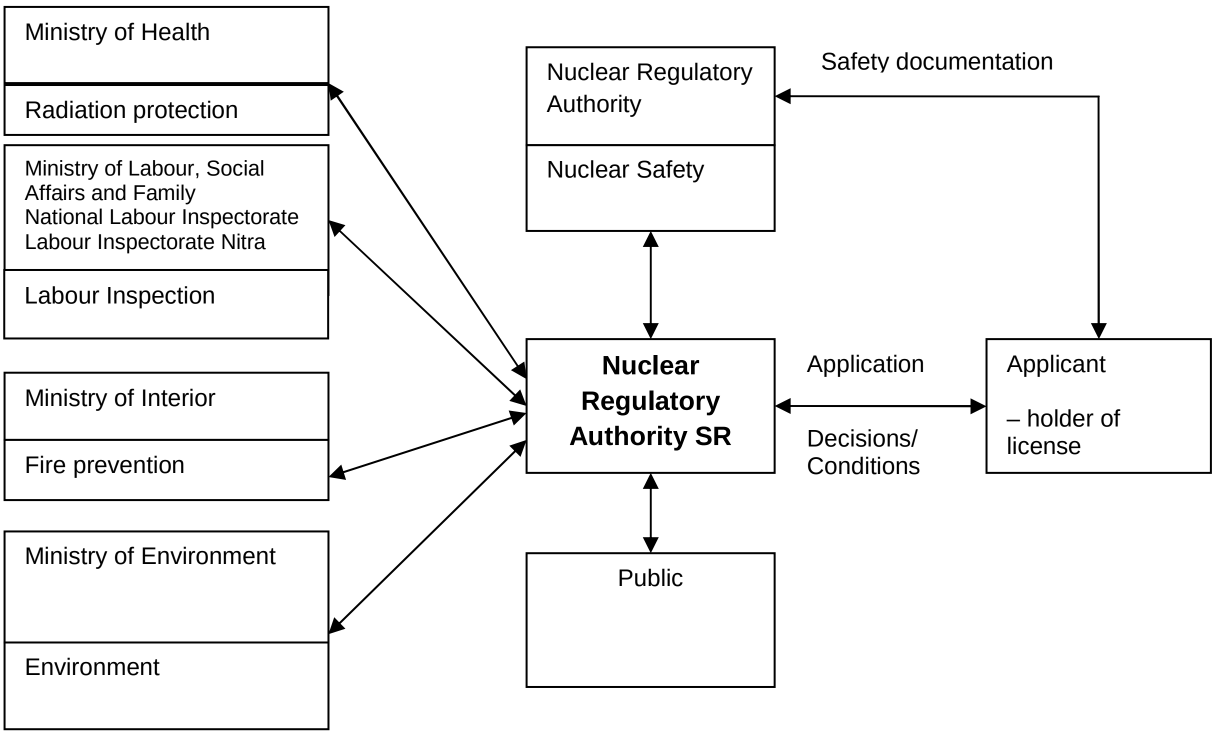


Figure 20 Licensing procedure for construction, commissioning, operation and decommissioning (not siting)

The basic condition for authorization granting is the elaboration and submission of safety documentation listed in annexes of the Atomic Act necessary for issuance of particular types of decisions and meeting of legislative requirements for nuclear safety. An essential criteria is also the fulfilment of conditions of preceding approval procedures and decisions of regulatory authority.

During siting of nuclear installation construction and its decision-making pending the approval of UJD SR and of other regulatory authorities (Public Health Care Office of SR, labour inspection bodies). Authorization for nuclear installation construction, permission for temporary use of the facility instruction (including authorization for trial operation) and decision on construction approval (including authorization for operation of nuclear installation) are issued by UJD SR already as a construction authority. UJD SR exercises its competency as a construction authority and state administration authority for nuclear safety. Its decisions are based on its own partial decisions (partial approval of safety documentation), as well as on the opinion of relevant regulatory authorities - Public Health Care Office of SR (radiation protection), Labour Inspectorate (labor inspection and safety and health protection at work) and other bodies and organizations of state administration (fire prevention, civil defense).

Documentation, attached to the application for issuance of certain decisions of UJD SR and essential for submission, is listed in annexes No. 1 and 2. of the Atomic Act. Details concerning the scope, content and method of preparation of nuclear installation documentation needed for certain decisions are defined in the UJD SR Decree No. 31/2012 Coll.

5.1.3 Transparency - Openness

The access to information is guaranteed by the Constitution and other instruments on human rights since the early 1990´s. The Act No. 211/2000 Coll. (Freedom of Information Act) provides the citizens with a statutory way of obtaining necessary information. This Act along with Act No. 541/2004 Coll. (Atomic Act) and Act No. 24/2006 Coll. (Act on Environmental Impact Assessment) constitutes the legal framework for public relations with respect to nuclear energy. The operator shall be obliged by course of Act No. 541/2004 Coll. (Art. 27 (4)) to notify UJD SR of occurrences at operated installations and, in case of an incident or an accident, pursuant to Art. 27 (4) (f) there of also to inform the public.

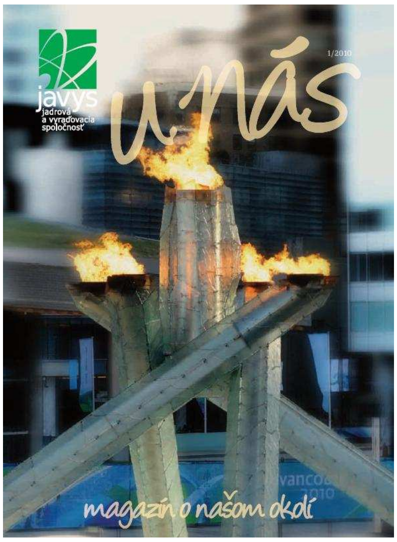
A licensee´s obligations under the Atomic Act (Art. 10 (1) (m)) include the duty to inform the public also on the assessment of the state of nuclear safety of nuclear installations operated by them.

The operation of NI´s as well as completion of Mochovce Units 3 and 4 have strongly affect the life in the regions, which necessarily called for intensification of mutual communication with the NI surrounding area regions and at national level. Transparent information about all aspects of NI construction, operation and decommissioning and making the information publicly accessible via information channels have become an integral part of the operators´ and regulatory authorities´ open policy on informing and participation by the stakeholder in decision-making processes. The most important communication channels include:

- Mochovce and Bohunice information centres plus on-site excursions. As many as 10 000 visitors from across the country and abroad make a visit to the premises of the Bohunice and Mochovce plants plus external lectures in schools; a new visitor centre isunder construction at Mochovce that shall be open to the public in the 1st half of 2013;
- The monthly Atóm.sk distributed free of charge in the Mochovce and Bohunice regions and other printed matters (newsletters and leaflets at Infocentres and websites of the operators) where information is processed in an accessible and comprehensible format;
- Websites of the operators – www.seas.sk, www.javys.sk;
- Mochovce and Bohunice Civil Information Commissions (hereinafter referred to as CIC) composed of elected and other representatives of the regional public. CIC members have

regular meetings with the operators management and thus obtain qualified first-hand information;

- Regional associations of municipalities which communicate and tackle their problems in concurrence with NI operators in a given region;
- Operator´s social responsibility – including sponsorship programs helpful in areas which need it most and bring in generally useful benefits (education, health care and charity, culture, sports, the environment);
- Open Plant Days for personnel and the public held annually at both NI´s;
- Others: seminars for journalists, mayors and local-government officials; press conferences and briefings, press releases for the media, active involvement in domestic and foreign exhibitions, conferences, etc.



UJD SR provides information upon request and at the same time makes public information on the state of nuclear installations in the Slovakia and on its regulatory activities, thereby allowing the public and the media to check data and information on both nuclear installations and UJD. The Authority´s website (www.ujd.gov.sk) publishes in addition to the above information started, ongoing and completed administrative procedures under Act No. 71/1967 Coll. on administrative proceedings, as amended, as well as decisions issued by UJD SR unabridged with reasoning.

UJD SR holds competencies in respect to keeping the public informed on nuclear safety matters and monitors other media sources with a view to getting the necessary overview of information policy on a given subject. UJD SR independently from nuclear installation operators provides information on nuclear safety of nuclear installations, including information on the management of radioactive wastes, spent nuclear fuel, nuclear materials, control and accounting for thereof, as well as information on other fuel cycle phases.

Under the Atomic Act, UJD SR prepares annually a report on activities and on safety of nuclear installations in Slovakia for the past year to be submitted for discussion of the Government and of the National Council. Also issued is a Slovak-English-language annual report to be distributed to libraries, ministries, other central state administration authorities, foreign countries´ diplomatic missions in Slovakia, Slovakia´s diplomatic missions abroad, foreign regulatory authorities, international and other organizations, and schools.

A special emphasis is put on communication with the public in nuclear installation regions, seeks to continually improve it through co-operation with CIC´s, municipal officials and distribution of information materials such as annual reports, leaflets and contributions to the regional press and television.

UJD SR sends out annually to Slovak news agencies, dailies and e-media contributions on its domestic and foreign activities and organizes press conferences for journalists. Along with the Czech State Authority for Nuclear Safety (SÚJB) are the publisher of the journal "Bezpečnosť jadrovej energetiky" focusing on the presentation of the latest knowledge on nuclear safety in Slovakia and the Czech Republic.

6 Emergency preparedness & Response and Post-accident Management (off-site)

6.1 Implementation of Legislation in the Field of Emergency Preparedness

6.1.1 National Organization on Emergency Preparedness

Acting under its material competence as the executive body of the Slovak Government, the Central Crisis Staff (hereinafter referred to as CCS) is the supreme crisis management authority in accordance with Act No. 387/2002 Coll. All government departments and other central authorities of state administration are represented on CCS which co-ordinates activities of state administration, self-government and other components while handling a crisis situation, i.e. in dealing with a nuclear installation incident or accident or during transport. The Crisis Management System (whose part is CCS) consists, in addition to the Government, ministries and other central state administration authorities, of local state administration and self-governing bodies.

To ensure necessary measures to cope with a nuclear installation emergency and measures to protect the public and the economy in an occurrence with environmental impacts, the National Emergency Preparedness Organization (Figure 21) is structured into three levels as follows:

<u>The first level</u> is formed by emergency committees of nuclear facilities with the prime function made of management of works and measures on nuclear installation sites so as to enable identification of the technological equipment conditions, and the management of measures to cope with emergency and to mitigate the consequences on personnel, plant, environment, and population.

Another function of this level is the informative function for activities of state administration bodies on the level of local state administration, which will provide for information concerning the equipment conditions and the possible impacts on surrounding.

<u>The second level</u> is organized on the regional level and is formed by crisis staffs of local state administration and corresponding radiation accident committees, whose territory stretches to the area at risk, where danger can be posed to life, health, or property, and where the public protection measures are planned. This territory is determined by a radius of 25 km around NPP V-1 Jaslovské Bohunice, 30 km around NPP V-2 Jaslovské Bohunice and 20 km around NPP Mochovce.

<u>The third level</u> is formed on the national (state-wide) level by the CCS with its support components (i. e. Emergency Response Center of UJD SR – ERC, Operation Control Group - OCG and The Slovak Center of Radiation Monitoring Network - SCRMN). The task of CCS is to manage the emergency situation, when its range extends beyond the territory of the district. In the present day also CRA SR exists, whose task is especially to coordinate and manage preparation of measures focusing on protection against consequences of radiological event, when the possibilities on the level of local state administration are trespassed.

A part of this level are Failure commissions of operator of nuclear installation, which closely cooperate with ERC of UJD, but also with local state administration. The main task of Failure commission is mainly to organize and coordinate quick liquidation of major and emergency events in corresponding production and distribution facilities.

6.1.2 Central Crisis Headquarters (CCH) - professional and technical means

The UJD´s Emergency Response Centre (hereinafter referred to as "ERC") is a technical support vehicle to monitor NI operation and assess technical condition and radiation situation in the event of a nuclear or radiation emergency, and to forecast emergency evolution and consequences. In the area of evaluation of the radiation situation UJD SR works together with the Public Health Authority of SR (the Centre of Radiation Monitoring Network), the single body responsible for proposing measures to protect the health of the public.

The Slovak Centre of Radiation Monitoring Network (hereinafter referred to as "SCRMN" is a technical support body intended to provide an effective monitoring system involving the monitoring systems of the respective government departments.

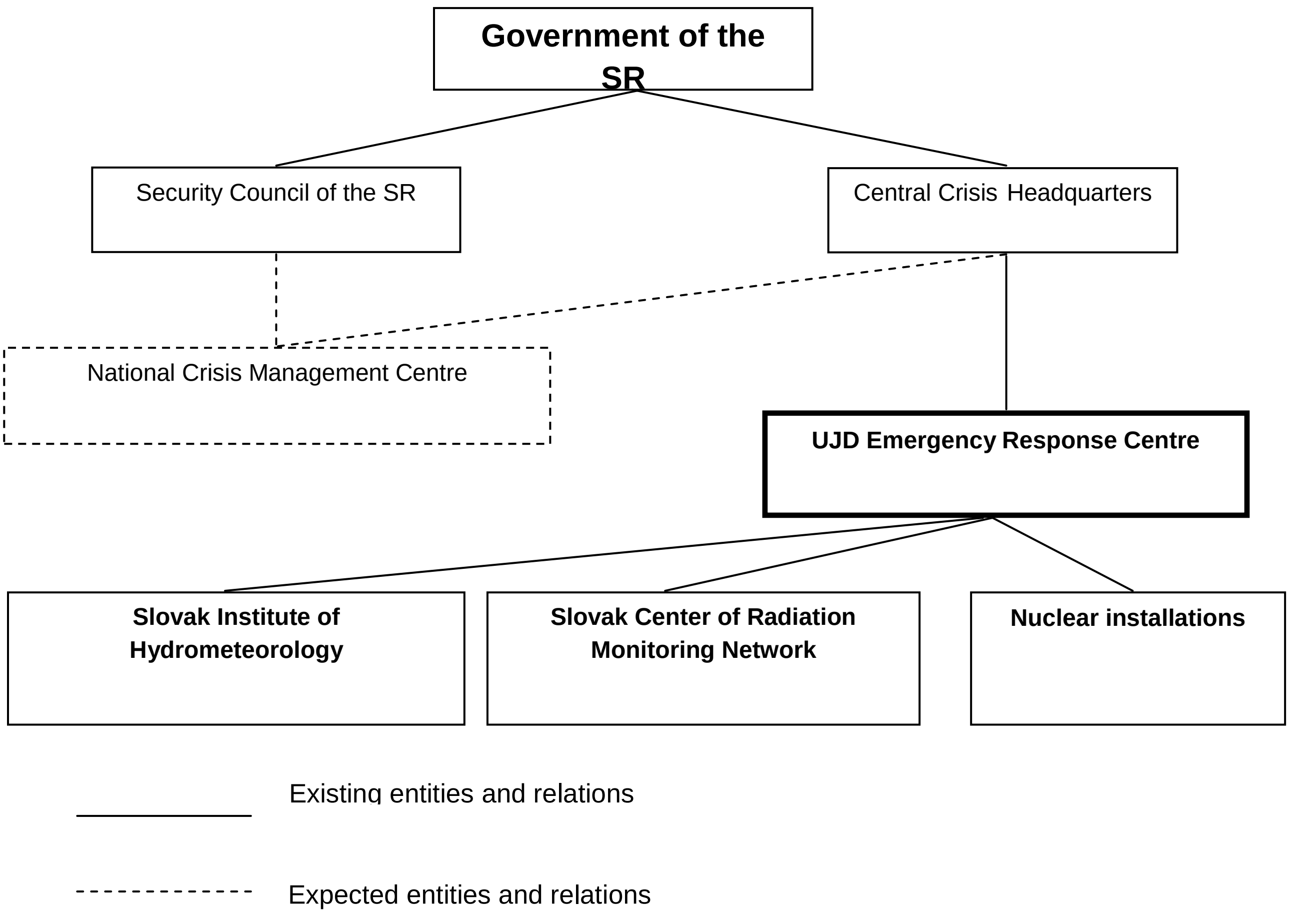


Figure 21: National Emergency Response Organization

Emergency Response Centre (ERC)

In line with the current legislation UJD SR has established the Emergency Response Centre (ERC) as a vehicle to assess the course and consequences of NI incidents and accidents of relevance to their possible impact on the surrounding area, preparation of draft measures or recommendations on further course of action. The ERC is included in the Slovak Emergency Preparedness System and co-operates with the CCS on the preparation of recommendations. The latter can invite specialists from various ministries to deal with an event. The relationship among the respective entities for management of public protection measures in an incident or an accident involving radioactive substance environmental impacts is shown in Fig. 21.

UJD SR has set up an emergency Staff from among its employee specialists and other employees to work within the ERC. The main functions of the Emergency Staff are to:

– analyze the state of a nuclear installation in case of an occurrence,
– make forecasts on the evolution of an occurrence - accident or an accident and radiological impacts on the public and the environment,
– propose recommendations on public protection measures and refer them to the CCS, the appropriate local offices in the region seat and other authorities concerned,
– prepare background documents and recommendations for the Authority Chairman who is a member of the CCS and the Security Council of the Slovak Republic,
– carry out supervision over activities of the NI operation licensee during an emergency,
– inform the EC, the IAEA and neighbouring countries under the Slovak Republic´s commitments whose co-ordinator is the Authority (multilateral and bilateral agreements), inform the media and the public.

The Emergency Staff is professionally staffed and can operate in three sequences so as to ensure continuity of its work even during real occurrences which may last in excess of 8 hours. Each of the sequences has its management composed of a chairperson, assistant and expert work leaders. These are the following groups:

- Reactor Safety Group;
- Local Inspectors Sub-Group;
- Radiation Protection Group;
- Mobile Dosimetry Sub-Group;
- Logistic Support Group;
- News Service Group (public relations).

  This group is charged to gather, co-ordinate and prepare general information and particular information in compliance with commitment of the Slovak Republic and international agreements in force. This group assures preparation and provision of information and messages for governmental and parliamentary organizations, public and media and assures monitoring and evaluation of news from media needed for office Emergency headquarters. The group informs, according to bilateral agreements, neighboring countries and emergency centers of EU and IAEA.

  The licence holder is responsible to inform the public about the measures and procedures in case of emergency. Details are contained in UJD SR Decree No. 55/2006 Coll.

6.1.3 On-site emergency plans

On-site emergency plans of operator and related documents are developed so as to provide for the protection and preparation of personnel in case of a major leak of radioactive substances into the working environment or surrounding area and it is necessary to take action to protect health of individuals at the nuclear installation or of the public in its surrounding area.

The purpose of the on-site emergency plan is to provide for the preparedness of NI employees for planned measures implementation in case of an occurrence at NI, emphasizing the accomplishment of the following basic goals:

- reduce risk or mitigate the consequences of the NI occurrence on equipment, employees and public in the NI surrounding area directly at its source,

- prevent severe health damages (e. g. death or severe injury),
- reduce the risk of probable occurrence of stochastic effects on health (e. g. cancer and serious hereditary phenomena).

The aim of the on-site emergency plan is to provide for Emergency Response Organization (hereinafter referred to as “ERO“) activities, i. e. planning and preparation of organizational, personnel, material and technical means and measures to successfully manage crisis and emergency situations according to the classified event. The ERO comprises for licensees the following units:

- Emergency Control Centre (ECC),
- Technical Support Centre (TSC),
- Personnel Protection and Logistic Centre (PPLC),
- Monitoring Centre (MC),
- Information Centre (IC).

The information flow itself during an emergency includes in addition to the operator management regulatory authorities (UJD, the Slovak Ministry of Health, the Slovak Public Health Care Authority), the SCRMN, and crisis staffs at local state administration level.

Events concerning Several Units

Referring to Regulation No. 55/2006 Coll. on details concerning emergency planning in case of nuclear incident or accident, the on-site emergency plans must contain information about measures for the nuclear facilities operating simultaneously at the same time, or for construction of other units on the site of nuclear installation in operation, with an impact on emergency planning and radiation incident on a nuclear installation. On-site emergency plan also contains information about other risks which are important in terms of nuclear safety (explosion, fire, leak of flammable gases or other toxic and chemic substances, flooding, strong wind, or extreme cold)

At present, only one NPP is in operation at NPP Bohunice (two units). The same situation is at the locality of NPP Mochovce. After the commissioning of NPP MO 3,4, which is also located at NPP Mochovce site, the actions which must take place in case of events at both plants will be supplemented in the On-site emergency plans of both facilities. In case that emergency situation will occur at both facilities simultaneously at the same site, the two Control room technologists, are ready to solve situation at each unit.

6.1.3.1 Emergency Preparedness Equipment and Means

They consist of the units referred to in Chapter 6.1.3 and are supplemented with the following equipment:

- Backup Emergency Centre (BEC) serves as a substitute workplace of the emergency commission in case of an extremely severe radiation situation. It is located at the off-site dosimeter premises in the Bohunice (Trnava) and Mochovce (Levice) sites.
- Civil protection shelters are used as the primary shelter for shift and intervention personnel and serve for handout of individual protection means and special kit for intervention units.
- Civil protection assembly points serve for personnel and other persons staying in the NI territory. Thanks to their equipment they create conditions fore a short-term stay of personnel while using individual protection means.
- In-house Medical Centre (IHMC) is intended for basic medical provision, giving pre-medical and medical aid and preparation for transfer of those afflicted to specialized health care facilities. Also part of IHMC is a decontamination point and workplaces to measure individual internal contamination.
- On-site communication facilities and equipment:
  a) Slovak Telecom´s public telephone network,
  b) power telephone network,

c) mobile telephone sets,
d) Motorola special-purpose radio network,
e) paging network,
f) in-house radio and operational (unit) radios.

6.1.3.2 Emergency Preparedness Maintenance Systems

The Bohunice a Mochovce personnel are classified into four categories by the scope of emergency training:

Category I	- personnel with a short-term stay at NI (nature of visits, excursions, etc.),
Category II	- personnel permanently working at NI,
Category III	- personnel involved in ERC,
Category IV	- mayors of municipalities and cities in the emergency planning zone.

The training includes two parts:

- theoretical training,
- hands-on training.

The power plant personnel emergency training is conducted according to the respective categories in the form of a presentation, explanation, group seminars, practical demonstrations and hands-on training sessions - drills. Emergency training of shift personnel constitutes a separate part of the training. In both sites of licensee (SE, a. s.) shift drills are performed twice a year, site-wide emergency drills with all site personnel involved are held annually and a collaboration emergency drill laid on in concurrence with local state administration and self-governing authorities, UJD SR ERC, and other ERC components, as appropriate (fire brigades, heath care, army, etc.), is undertaken on a three-year cycle basis. The most recent collaboration drill with participation by UJD SR ERC and local state administration authorities was held within a radius of 25 km from the Bohunice area at risk in October 2009, as was within a radius of 20 km from the Mochovce area at risk in March 2009.
Each drill is attended by observers and jury who upon completion of the drills evaluate their course and measures are taken to improve activities of the respective ERC components based on their conclusions. These measures are subsequently reviewed and the plant management and Authority inspectors deal with their implementation.

6.1.4 Radiation protection

6.1.4.1 Public Protection Plans (Off-Site Emergency Plans)

Protection plans are a part of public protection plans which are developed by state administration authorities and municipalities having territorial jurisdiction located in the area under threat by a nuclear installation defined by a radius of 25 km and 21 km and 20 km in radius for the NPP V-1 Bohunice, the NPP V-2 Bohunice and the NPP Mochovce, respectively. (N.B.: The Nuclear Regulatory Authority of the Slovak Republic approved in 2007 under the provision of Art. 4 (2) (a) (12) and Art. 28 (5) of Act No. 541/2004 Coll. on peaceful uses of nuclear energy for JAVYS, a. s., the size of area under threat by the NPP V-1 as a circle with a radius of 25 km of the original 30 km). The aforesaid public protection plan are linked to the off-site emergency plan of the licensee that shall be obliged to present the public protection plans elaborator with documents relating to the public protection in the area of threat.

Public protection plans developed for the region territory are subject to the process of assessment by UJD SR and of approval by the Slovak Ministry of Interior. They describe in detail the method of implementing measures, with selected measures containing activity by severity level and time behaviour of an incident or an accident including available and usable worforces and means to carry out rescue works and ensure the implementation of public protection measures. Also part of documentation are activity methodologies, databases and aids necessary for effective and proper decisions.

In the occurrence of an emergency being a nuclear installation radiation event in nature, local state administration bodies provide for measures resulting from off-site emergency plans. This activity is done by the respective crisis staffs that co-operate with the CCS, as necessary. To prevent the risk of delay in fulfilling tasks related to the public protection, the appropriate commissions are part of the national emergency response organization (hereinafter referred to as “ERO“).

In line with the on-site emergency plan, the public protection plan and based on the assessment of the technology situation, identification of the source member, values measured by the teledosimetry system, first measurements of the radiation situation in the NI environment and the meteorological situation, the licensee provides for notification of the appropriate authorities and organizations in the area at risk and for immediate warning of the public in the occurrence of a level 2 event and of a level 3 event, respectively. Thereafter, state administration authorities, local state administration authorities and municipalities provide for further urgent and follow-up measures consisting particularly in iodine prophylaxis, taking shelter and/or evacuation, a.o. These measures are to be implemented in the territories affected by the radiation event consequences, including those where the emergency consequences may spread in terms of forecast.

In the case of an incident or an accident in a nuclear installation involving a leak of radioactive substances, the authority that manages rescue efforts within its territorial competence, provides lower level for material and technical arrangements and prepares draft measures for handling a crisis situation and background documents for decision-making for effective solution to the situation in the territory at risk is the competent authority designated to handle a crisis situation in accordance with Act No. 42/1994 Coll. on public civil protection, as amended:

- municipality and municipality mayor if an event does not extend beyond the municipality territory,
- district office and district office principal if an event extends beyond the municipality territory and does not extend beyond the district territory,
- district office in the region seat and the district office principal if an event extends beyond the district territory and does not extend beyond the region territory,
- the Government and the Prime Minister, if an event extends beyond the region territory.

6.1.4.2 Radiation Monitoring Network of SR

Slovak Centre of Radiation Monitoring Network (SCRMN)

The core of the monitoring system in a normal situation consists of permanent monitoring components within selected public health care offices, the Slovak Hydrometeorological Institute, civil protection systems, the Slovak Army, the Nitra-based State Veterinary and Food Institute, Nuclear Installation Environs Radiation Control Laboratories, university specialized workplaces, research institutes, some other organizations, and accredited privately-owned facilities, as appropriate.

In case of accidents, in addition to permanent components, also other mobile and laboratory components will get involved in operative monitoring, as instructed by the Centre of Radiation Monitoring Network.

The whole of the Slovak Republic´s territory is continuously monitored for radiation situation by stationary systems:

- teledosimetric system of the NI operation licensee at EBO and EMO within a distance of 30 km (or 20 km),
- stacionary monitoring systems - Slovak Interior Ministry SKMCO, the Slovak Army, the Ministry of Health, the Slovak Ministry of Environment (SHMÚ).

Real-time monitoring data is also provided to the EURDEP network run by the European Commission whose data is available to all the member states via a protected website.

The Radiation Monitoring Network consists of two levels, represented by the management and executive components. The executive component is the Radiation Monitoring Network (RMN), consisting of permanent and emergency components. Among the permanent components of RMN are the organizations, authorities and institutions in the following sectors:

- Ministry of Health, securing 4 mobile monitoring groups, stationary monitoring systems and laboratory groups of the Public Health Authority (ÚVZ SR), regional ÚVZ Banská Bystrica and Košice and SZU in Bratislava;
- Ministry of Interior, securing departmental evaluation centre, stationary monitoring system, mobile monitoring groups, 3 supporting laboratory KCHL groups;
- Ministry of Defence, securing departmental evaluation group (RCHBO OS SR centre, Trenčín), stationary network of ARIS system, mobile monitoring groups;
- Ministry of Environment, securing stationary network of early warning, short, medium and long-term weather forecasts;
- Ministry of Economy, which through the operator of NPP Jaslovské Bohunice and NPP Mochovce secures its own monitoring centres with the local radiation monitoring networks, rapid monitoring groups for EBO and EMO, mobile monitoring groups and 2 support laboratory groups.

Emergency components of RMN include mainly the support laboratory groups of PF UK, FMFI UK, VÚVH, VUJE and laboratories of sanitary and veterinary service.

Securing financing of the activities of individual permanent and emergency components of RMN is the obligation individual ministries participating on the monitoring, on the basis of resolution of the Government No. 614/1995, and based on the Act of NC SR No. 387/2002 on governance in crisis situations outside the time of war and war status.

The activity of RMN is running in two modes:

- At the time outside of radiation accident, or nuclear accident or incident (so called “standard monitoring mode“), when the nationwide monitoring of the current radiation situation is secured, including monitoring and evaluation of consequences of previous extraordinary events (Figure 22),

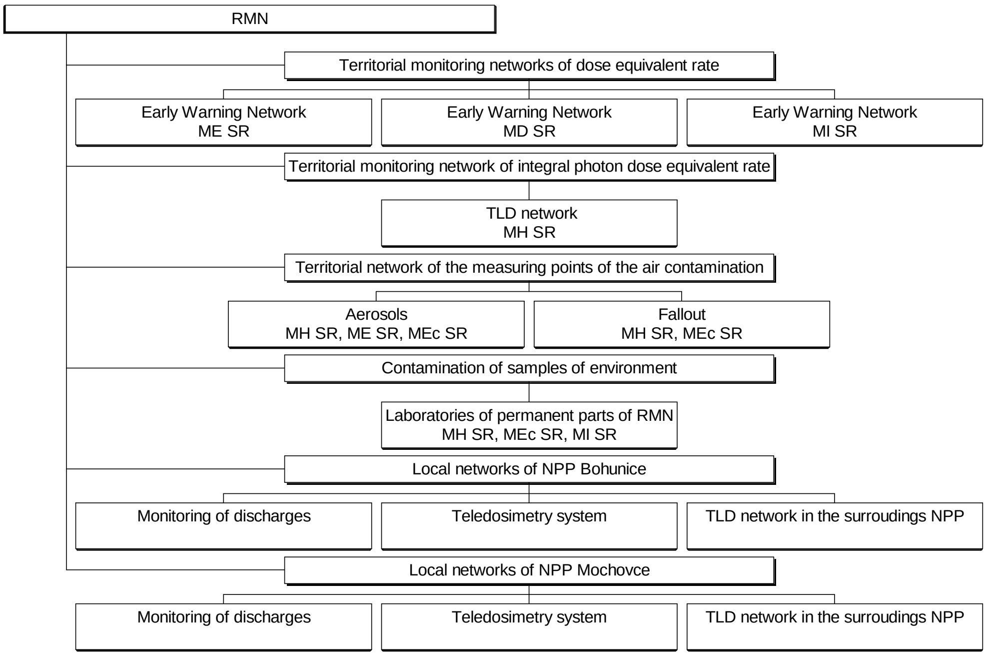
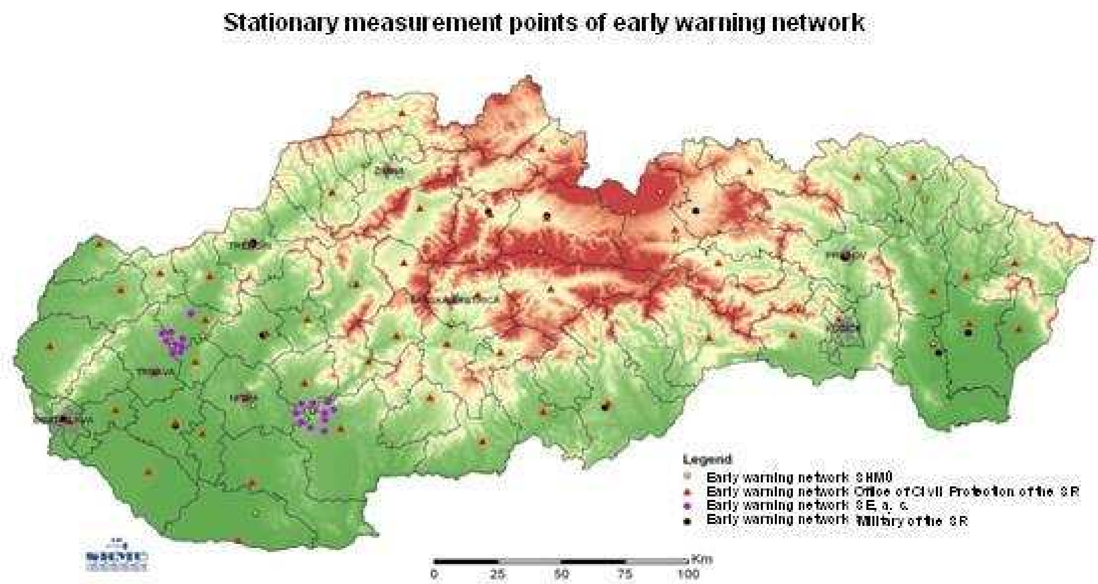


Figure 22: Activity of the Radiation Monitoring Network at the time outside of radiological risk

- In case of nuclear accident or extraordinary event associated with release of radionuclides into the environment, or when suspecting their origination either on the territory or outside the territory of SR.

Monitoring under standard mode is secured by RMN SR in compliance with the monitoring plan approved by the chief hygienist of SR and is a source of data for monitoring and assessing of radiation status of the population from the sources of ionizing radiation in the environment.



6.1.5 Incident Response

6.1.5.1 Communications, Warning and Notification Systems of Population and Personnel

The communication, warning and notification of public authorities, organizations and personnel is performed in accordance with Act No. 42/1994 Coll. on Public Civil Protection, as amended and Decree of the Ministry of Interior SR No. 388/2006 Coll. on Details of Ensuring Technical and Operating Conditions for an Information System of the Civil Protection.

Design, installation of the new electronic sirens and construction of a communication infrastructure in the 21 kilometre radius around the Nuclear Power Plants Bohunice V2 lasted less than three years and the volume of investment exceeded Euro 11 million. The system of warning and notification secures early warning and notification of all employees and persons within the premises of the power plant through a network of electronic sirens and at the same time also all people around the Nuclear Power Plants Bohunice V2. It is fully interlinked with the nationwide system, but if necessary it can be activated and used also locally, for example in case of floods. Technicians of Telegrafia a. s. installed 330 sirens in the area and 23 at the power plant.

After completion of comprehensive tests and trial operation, the new system was handed over to Slovenske elektrárne and put into permanent operation on 1 Jan. 2012, thus becoming another of many comprehensive solutions for early warning and notification of the public in case of natural disasters or technical accidents.

Technical arrangements of the public warning and authorities, organizations and personnel notification in locations are as follows:

a) Bohunice within a radius of 21 km for the public:

To speed up and to automate the system, the notification computer equipment of automatic telephone notification to persons ZUZANA NPP Bohunice V-2 is used for the staff.

The system of warning and notification uses a network of electronic sirens for early warning and notification of all employees and persons at the premises of the power plant, and at the same time for all the population in the vicinity of the Nuclear Power Plant Bohunice V-2. It is fully interconnected with the national system, but if needed it can be also activated and utilized locally, for example in case of floods. There are 330 sirens around the power plant and 23 within the power plant site. Internal notification system for the employees uses the in-house radio, radios network and the notification equipment ZUZANA of NPP Bohunice V-2. The shift supervisor of the affected Unit decides about initiating the warning of the public and notification to the authorities, organizations and the personnel. Regular testing of the means of notification and of the warning system is carried out once a month.

b) Mochovce within a radius of 20 km

1. a warning system built based on radio controlled electronic sirens. The system can run for 72 hours without connection to the electricity grid, allows for slective control of the sirens, transmission of voice information and continuous control of status and serviceability of the respective sirens.
2. a notification system based on a paging radio network. ERO - EMO members on alert, mayors of municipalities and cities and members of emergency commissions and staffs are equipped with the receivers. The system is also supplemented with a notification server. Both systems at the NPP Mochovce are controlled from the control centre VYR-VAR or the backup control centre VYR-VAR. The shift engineer or the HRS head decides on their start-up. The systems are periodically tested and kept in serviceable condition.

The Decision 2007/162/EC,Euratom: Council Decision of 5 March 2007 establishing a Civil Protection Financial Instrument establishes a Civil Protection Financial Instrument in the EU to support and complement the efforts of the Member States for the protection, primarily of people but also of the environment and property, including cultural heritage, in the event of natural and man-made disasters, acts of terrorism and technological, radiological or environmental accidents and to facilitate reinforced cooperation between the Member States in the field of civil protection.

This Decision lays down the rules for the provision of financial assistance for:

a) actions in the field of the Community mechanism to facilitate reinforced cooperation in civil protection assistance interventions (the Mechanism);

b) measures to prevent or reduce the effects of an emergency; and (c) actions designed to enhance the Community's state of preparedness for responses to emergencies, including actions enhancing EU citizens' awareness. The Instrument shall cover the period from 1January 2007 to 31 December 2013.

Based on the Lisbon Treaty Article 196 for civil protection policy, the aim of the recent revision of 2007/162/EC, Euratom is to support, coordinate and supplement the actions of the Member States in the field of civil protection in improving the effectiveness of systems for preventing, preparing for and responding to natural and man-made disasters of all kinds within and outside the Union. Specific objectives include (a) to achieve a high level of protection against disasters by preventing or reducing their effects and by fostering a culture of prevention (b) to enhance the Union's state of preparedness to respond to disasters (c) to facilitate rapid and efficient emergency response interventions in the event of major disasters.

6.1.5.2 Post-accident management

In compliance with legislation, the license holder must notify state administrative immediately after the classification of incident as Level 1 - emergency. After that, the license holder must subsequently inform the government authorities about the status of the incident. In case that the event develops to the level 2 – on-site emergency, the On-site System of Notification and Warning is activated and at level 3 of Off-site System of Notification and Warning is activated in specified sectors of emergency planning zone.

State administration authorities in the emergency planning zone have their own emergency plans. According to these plans, authorities take following measures for public protection:

Period (Phase)	Measures
Threat/ Emergency	Notification of emergency staff (Emergency response organization) and preparation for public notification
	Preparation for taking urgent measures in emergency planning zone in early phase of the accident
	Notification of public about measurement taken during emergency phase
Early Phase	Warning of emergency staff (Emergency response organization) and also public warning
	Monitoring of radiological situation
	Acces regulation (persons and vehicles)
	Sheltering
	Iodine prophylaxis
	Evacuation
	Use of individual protection means and special individual protection means
	Partial sanitary cleaning of persons and objects
	Ban of non-protected food, water and feed consumption
Intermediate and Late Phase	Control of persons and vehicles movement
	Control of consumption of food, water and feed contaminated by radioactivity
	Relocation of population according to the evaluation of current radiation situation and prognosis of its development
	Deactivation of impacted area

In 2011 UJD SR with the group of specialists from Ministry of Interior, Ministry of Environment – Slovak Hydrometeorology Institute, Ministry of Defense, Ministry of Health, district offices of Trnava and Nitra municipalities and State administration authorities of the emergency planning zone finished works on projects:

1. Handbook for management of contaminated populated areas
2. Handbook for management of taken measurements after the change of event status
3. Handbook for management of drinking water after contamination
4. Handbook for management of contaminated populated areas after the event

These Handbooks are prepared especially for Slovak Republic and include rehabilitation/recovery of contaminated territories during the late phase of an accident at NPP.

Individual procedures concerning introduction of emergency management provisions targeted to mitigation of radiation accident consequences, factors affecting realization of these measures, establishment of recovery strategy, calculations of cost necessary for forces and means as well as economic, politic and social impact on society are elaborated in these handbooks. Developed model scenarios of different types of accidents with release of radioactive substances and decision-making scheme are a part of handbooks. All* guides are prepared to be delivered for Ministry of Interior and other government bodies.

Securing health care

Securing health care is a legal obligation based on the Act of NC SR No. 576/2004 on health care Section 45 par. (1) letter v), the Ministry of Health ensures uniform training of health services for the national defence. Also the basic provisions of the Constitutional Act No. 227/2002 on national security and state of emergency, in Article 1 par. 2) the basic role of the health care sector to undertake all necessary measures to save lives and the health of persons.

State of emergency can be declared by the government only on condition that it occurred or there is an imminent threat on the life and health of persons, environment or a threat on substantial assets as a consequence of natural disaster, industrial, traffic or other operational accident; state of emergency can only be declared on an affected area or an area that is under imminent threat. State of emergency can be declared to the extent necessary and for a necessary time, maximum up to 90 days. During the time of state of emergency to the extent necessary and for a necessary time, depending on the seriousness of threats the fundamental rights and freedoms can be restricted and obligations imposed on affected or on imminently threatened areas, such as:

- Imposing obligation to work to secure supplies, maintenance of roads and railways, transportation, operation of water mains and sewerage systems, generation and distribution of electricity, gas and heat, health care, maintaining public order or removal of damages;
- Restricting freedom of movement and residence by curfew in a specified time and no access to the affected area or area under imminent threat;
- Ensuring access to broadcasting of radio and TV combined with the calls and information for the public.

At the time of state of emergency the President, upon proposal from the government, may order the professional soldiers, the pre-service soldiers and the national service soldiers performance of extraordinary service, to call to an extraordinary service soldiers in ambush.

The Government by its resolution No. 819 dated 19 December 2011 approved measures to support national defence for the period 2012 – 2017. Part of this document, among others, shall ensure support and maintenance of the medical support system, services and activities within the scope and the structure according to the requirements of armed forces within the defence system of the SR. Currently there are negotiations being held at ministerial level to improve the status for securing health care in case of nuclear or radiation accident.

6.1.5.3 Transparency

The UJD´s Emergency Response Centre (hereinafter referred to as “ERC“) is a technical support vehicle to monitor NI operation and assess technical condition and radiation situation in the event of a nuclear or radiation emergency, and to forecast emergency evolution and consequences by course of Act No. 541/2004 Coll. The Centre at the same time serves as a CCS technical support vehicle.

Under Act of the NC SR No. 42/1994 Coll. on public civil protection, district offices and municipalities permanently post up information for the public on a website or a notice board, with the public concerned being allowed to make comments over a 30-day period. Justified comments shall be reasonably taken into consideration in developing the public protection plan. Information is reassessed and updated, as needed; once updated, it is published as a minimum on a three-year basis. The public information includes in particular information about the source of threat, the possible scope of an emergency and the consequences in the territory and environment affected, hazardous properties and identification of substances and preparations which might give rise to an emergency, information on the method of public warning and rescue efforts, tasks and actions in an emergency, particulars of where further information relating to the public protection plan can be obtained. State administration authorities and self-governing bodies issue manuals for the public containing advice for the public which are aimed to furnish as much as possible information on how to act and behave in natural disasters, accidents and calamities. Since 1999 the Ministry of Interior has issued the popular and educational periodical "Civilná ochrana, revue pre civilnú ochranu obyvateľstva" addressed to all who are actively involved in the performance of tasks under Act No. 42/1994 Coll. on public civil protection, but also to all readers interested in the public civil protection issues. The revue brings in the respective columns up-to-date information, runs methodical supplements devoted to practical performance of civil protection tasks, etc. A separate space is devoted to local-government as well.

6.1.5.4 European Union Information System (ECURIE)

Following its admission to the European Union, the Slovak Republic has become a part of the ECURIE system. UJD SR is a point of contact in this system and a competent authority with a 24-hour permanent service. The ECURIE point of contact is identical to that for the purposes of the IAEA Convention on Early Notification of a Nuclear Accident. The ECURIE point of contact is backed-up by point of contact - at the Ministry of Interior. A national coordinator and his deputy have been appointed for ECURIE. In 2009, the quality of the Slovak Republic´s involvement in ECURIE improved by putting in place a secured programme for sending and receiving CoDecS messages (until then the information exchange had taken place through faxes only).

6.1.5.5 The Slovak Republic´s Participation in International Drills

CONVEX series drills

In July 2008, the international exercise ConvEx-3 was held to simulate an accident of a Mexico-based nuclear installation. The Authority´s emergency staff was convened based on the evolution of the situation being drilled. Within the drill communication with the point of warning (Slovak Interior Ministry), the Slovak Ministry of Foreign Affairs, and the Slovak Meteorological Institute was examined. Given the nature and place of the occurrence being drilled, the notification of the Slovak Republic´s representative authorities in Mexico and neighbouring countries was examined through the Diplomatic Service of the Slovak Ministry of Foreign Affairs.

Laid on under the Vienna-base International Atomic Energy Agency´s co-ordination, CONVEX-series exercise are aimed to verify the system of warning and notification of IAEA member states under the Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or a Radiological Emergency. As required by these conventions, the Authority is a point of contact and at the same time a competent body representing the Slovak Republic. The Slovak Interior Ministry provides for a 24-hour service of the national warning point for needs of the Slovak Republic´s point of contact (UJD).

In 2009, the exercise ConvEx-2d took place with the focus on a radiation event in an unknown non-European country in which assistance was sought to provide for experts on exposure diseases and teams who could be instrumental in measuring contamination in the contaminated territory and assistance in investigation into the occurrence. The exercise has shown that the Slovak Republic has contingent capacities (in particular as regards dispatching specialists who could ensure monitoring), which could be used in such a situation, however the action by such components (notably with respect to insurance of dispatching teams and liability for damage incurred on the receiving state´s territory) is not adequately addressed by the national and international legislation. Though the exercise has shown a lack of specialised medical personnel and health care

establishments in the Slovak Republic that would be able to diagnose and treat exposure diseases on a massive scale.
In addition to ConvEx-3 and ConvEx-2d exercises also routine ConvEx-1 exercices had been undertaken between 2008 and 2009 with a view to test communication in varied forms (fax, sms, e-format, etc.).

ECURIE exercices

In addition IAEA-led exercices, at least one major international exercise is held annually to examine the functionality of the European Union´s system of early notification in the case of a nuclear accident or a radiological emergency (ECURIE).

In 2009, a radiological emergency was simulated on the Greek island of Corfu which was followed by activation of ECURIE and at the same time of EURDEP. The Authority partially activated the emergency staff in order to test the functioning of the software CoDecS sending messages within ECURIE and operation of the platform EURDEP, in co-operation with the Slovak Hydrometeorological Institute. In 2010, an exercise was held in co-operation with the German Nuclear Power Plant Brockhausen.

Besides these major exercises, the points of contact in the member countries is tested for preparedness at least twice a year through checkup of communication and an early response. Over the last three years the Slovak Republic in these exercises had a 100% success of early responses.

7 International Cooperation

7.1 Conventions &Communications

7.1.1 Conventions in deposit of the International Atomic Energy Agency

The Slovak Republic is a signatory of international Conventions on Early Notification in Case of a Nuclear Accident and on Mutual Assistance in Case of a Nuclear Accident, thereby ensuring international cooperation in minimizing consequences of a nuclear accident.

The guarantor for the performance of the Conventions provisions is UJD, which is at the same time the Slovak Republic’s contact point for early notification of a nuclear accident. The Slovak Republic takes part on a regular basis through UJD SR in international drills. Since the Conventions coming into force no such accident has occurred in the Slovak Republic’s territory as would require to perform the provisions thereof.

7.1.2 Agreements and Cooperation with Countries

Further to Art. 9 of the Convention on early notification of a nuclear accident, the Slovak Republic succeeded or concluded bilateral agreements in the field of early notification of a nuclear accident, exchange of information and co-operation with all neighbouring countries. The agreements lay down the form, the method and the scope of information to be provided to contracting parties in the case of an accident relating to nuclear installations or nuclear activities, and establish the co-ordinators of contact points. The purpose of the said agreements is to make a contribution toward minimizing the risk and consequences of nuclear accidents and creating a framework for bilateral co-operation and exchange of information in areas of common interest in regard of peaceful uses of nuclear energy and protection against radiation.

Formal (on the basis of international treaties) and informal cooperation exists with all neighbouring countries (Czech Republic, Poland, Ukraine, Hungary and Austria), as well as with other countries (such as: Armenia, Bulgaria, Germany, France, Finland, Slovenia, the US). The cooperation focuses on exchange of experience in the field of peaceful use of nuclear energy, developing the system of emergency preparedness, accident analyses, etc.

Forum of state nuclear safety authorities of countries operating NPPs of WWER type

Forum of state nuclear safety authorities of countries operating NPPs with WWER type was established with the aim of mutual exchange of experiences in construction and operation of nuclear power plants of WWER type. These activities are also supported by the IAEA and other developed countries having a nuclear program. Ad hoc working groups have been set up dealing with the current issues of nuclear safety and state regulation.

Network of Nuclear Regulatory Bodies of countries with small nuclear program

Network of Regulators of Countries with Small Nuclear Program (NERS) was established in 1998 from the initiative of the Swiss Regulator (HSK) with the aim to enhance cooperation and exchange of experiences among countries with similar nuclear program. UJD SR has been taking an active part in the activities of NERS on a regular basis.

7.2 Cooperation with the International Organizations

Cooperation with the International Atomic Energy Agency (IAEA)

Cooperation between the SR and the IAEA in the field of nuclear safety has been extraordinarily successful. Within of this cooperation expert missions are focusing on nuclear safety review. During the last decade dozens of expert mission were invite e. g.:

External Review Missions NPP Bohunice V-2

- IAEA Safety Review Mission – September 5 – 12, 1994. The aim of the Mission was to compare the NPP design with the current safety-related approach.
- IAEA PSA Peer Review (Probabilistic Safety Assessment Level 1) of V-2 Units – January 17 – 28, 1995.
- IAEA Operation Safety Review Mission (OSART) – September 9 – 26, 1996.
- Follow-up IAEA Operation Safety Review Mission (OSART – Follow-up visit) – March 2 – 6, 1998.
- Repeated IAEA Mission – Assessment of seismic data (SIDAM) for the Nuclear Power Plants Bohunice and Mochovce, on 16 – 20 November, 1998.
- Visit of an IAEA expert group to review the preparedness for the Project Y2K (the year 2000), on 26 – 28 April, 1999.
- Apart from the missions mentioned to assess seismicity of the Bohunice site and Y2K issues an International IAEA Review Mission IPERS Review Mission for Bohunice V-2 NPP Low Power and Shut-down PSA – SPSA has taken place on 27 September – 6 October, 1999.
- In October 2007 an international WANO review was performed at NPP Bohunice V-2.

External Review Missions NPP Mochovce – Unit1,2

- IAEA Mission - for OSART, conducted on January 9 - 29, 1993, was focusing on the review of the preparedness of the operator to commissioning and to operate the plant.
- IAEA Mission - Safety Improvements Review for NPP Mochovce. The Mission was focusing on the check of safety improvements at NPP Mochovce.
- IAEA Seismic Safety for Nuclear Power Plants Bohunice and Mochovce Mission. The aim of the Mission was to verify the evaluation method of seismic input data and to assess effects of external earthquake risk for NPP safety.
- RISKAUDIT Mission (consortium of technical support organizations IPSN and GRS working for national nuclear authorities of France and Germany) focused on the review of safety improvements of NPP Mochovce and the assessment of design safety was concluded on December 20, 1994.
- In November 2001, IAEA - IPSART mission for evaluation of Project PSA for low power conditions and reactor shutdown, whose recommendations were taken into account in the final report of the study, was conducted.
- WANO Peer Review was held in EMO between 7 – 25 of October 2002. Results of the Review were summed up in the final report of WANO.
- Following N-PRW WANO Peer Review took place between 21 - 25 of June 2004, 19 months after realization of PRW in 2002. Review activity was aimed at inspection of fulfillment of measures drafted under the WANO mission in 2002.
- Between 4. - 20. 9. 2006, OSART mission - was conducted in NPP Mochovce. The reviewed areas were: management and organization, training and qualification of the personnel, operation, maintenance, technical support, feedback program, radiation protection, chemistry, and emergency planning and preparedness.
- The second WANO review was held from May 8 to 19, 2009. Results are included in WANO Final Report.

External review mission of Regulators

- At the request of the Slovak Nuclear Authority, the Commission of the European Communities has invited WENRA (Western Regulatory Authorities) to provide assistance on regulatory and safety related issues, July 19 – 23, 1993;
- IRRT mission (Integrated Regulatory Review Plan) to verify the regulatory activity of the regulator, 1998;
- Follow-up IRRT mission, 2002
- IRRS mission planned for the year 2012
- During the pre-accession period the European Union (namely the Working Group on Atomic Question and its ad hoc formation, the Working Group for Nuclear Safety) elaborated and adopted the “Report on nuclear safety in the context of enlargement” (May 2001) and “Report on its subsequent evaluation” (June 2002), which defined what is expected from the candidate countries to achieve high level of nuclear safety. The report contained general information and specific recommendations for each country. The candidate countries, including Slovakia, were called upon to verify these recommendations and subsequently to take a position. Slovakia fulfilled all the indicated recommendations.

Significant part of regional projects related to issues of nuclear safety. Internships of foreign experts, seminars, workshops and trainings with broad international participation are being organized under regional projects in the SR.

Cooperation with the Organization for Economic Cooperation and Development/ the Nuclear Energy Agency (OECD/NEA)

Representatives of SR attended the government experts meeting on nuclear liability, the meetings of government experts in the Committee for Safety of Nuclear Installations (CSNI) and the committee for nuclear regulatory activities, the committee on radioactive waste, as well as other committees and working groups.

Cooperation with the European Commission and the countries of the European Union

Representatives of UJD SR are attending on a regular basis meetings of expert groups of the EU Council and the European Commission with the aim to exchange knowledge on reviews of the level of nuclear safety of nuclear installations in Europe and they participate in developing the EU legislation in selected areas.

7.3 Providing feedback including occurrences at nuclear installations of other nuclear power plants abroads

Feedback

The purpose of feedback is to take such measures so as to eliminate repetition of failure on the technological equipment. Due to this, it is essential to investigate the failure in detail and find its root cause.

The operator uses international informative systems on operational experience from nuclear energy (WANO, IAEA, INPRO) to apply measures from analyses of events of other NI for its own unit and also to pass his own experience to other operators. The aim of this activity is to eliminate repetition of the same events by implementation of preventive measures.

The procedure of processing and using information about events at other NI is described in detail in the relevant documents of the operator.
For numbers of assessed outside occurrences and numbers of corrective actions taken thereon, see the figures below (see

Figure 23, Figure 24, Figure 25, Figure 26).

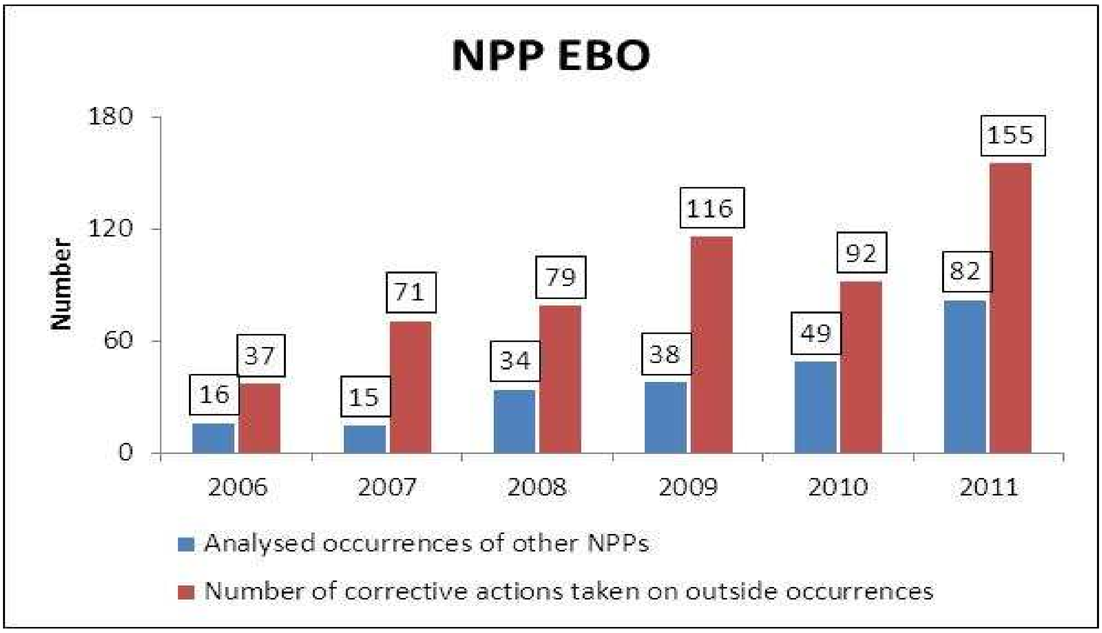


Figure 23: Numbers of analysed outside occurrences - NPP Bohunice

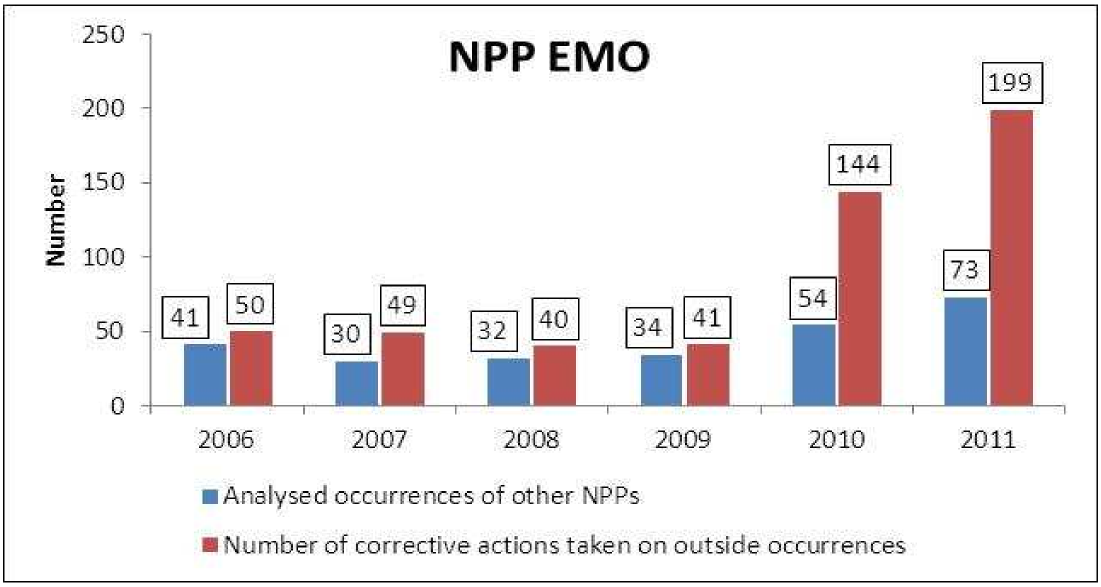


Figure 24: Numbers of analysed outside occurrences - NPP Mochovce

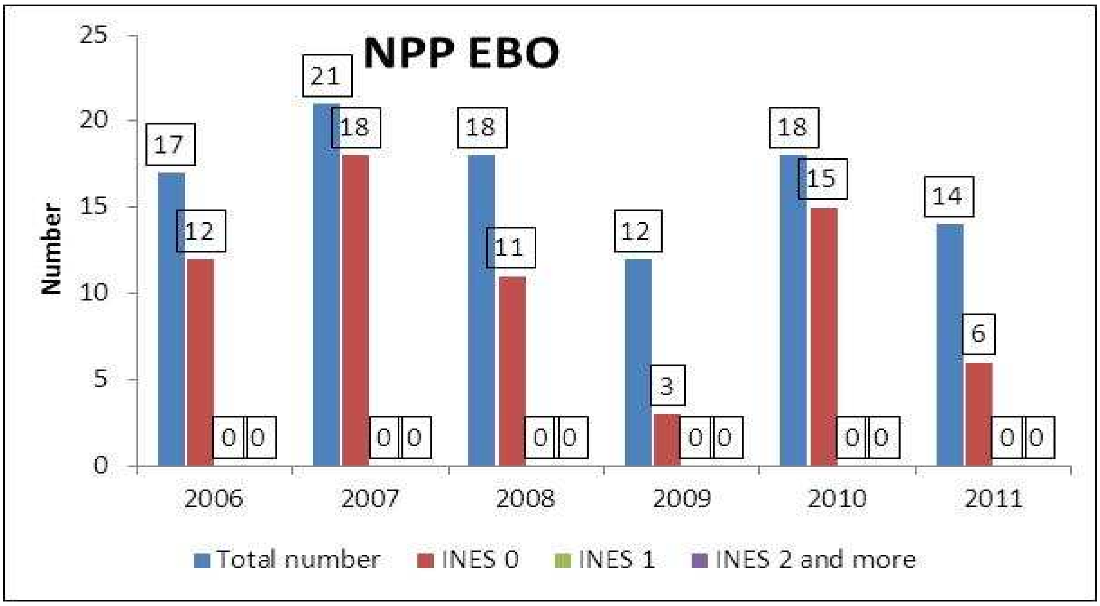


Figure 25: Numbers of reported occurrences and their assessment according to INES - NPP Bohunice V-2

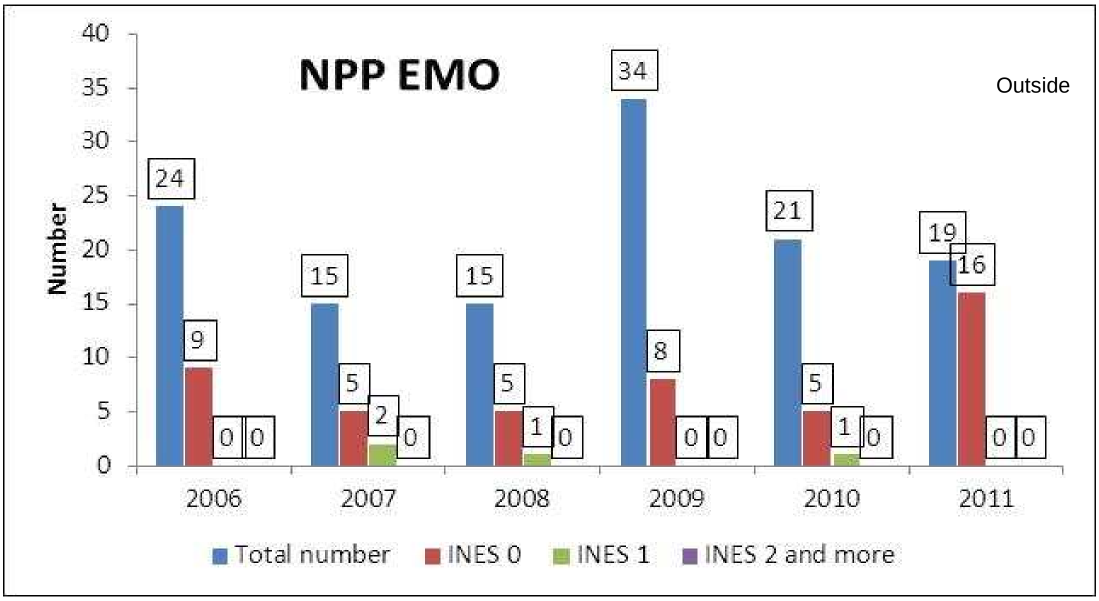


Figure 26: Numbers of reported occurrences and their assessment according to INES - NPP Mochovce

The most frequent cause of operational events over the assessed period were equipment failures and personnel errors. Based on identified causes, corrective action is taken to eliminate and prevent events from recurring.