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Stress test Follow-Up Actions

Issue Paper for Slovakia

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Prepared by the Order of the BMLUFW
(BMLFUW-ZI.UW.1.1.3/0020-V/6/2011)

Report, Final version
Vienna, 20-01-2014

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1. Introduction

The EU post Fukushima Stress tests provided important insights into the robustness but also the vulnerabilities of individual NPP sites and units. Even during the performance of the Stress tests, having identified safety weaknesses, many plants embarked on modifications and safety improvements, in particular by adding mobile equipment. Following the completion of the Stress tests, all EU countries operating nuclear power plants prepared National Action Plans defining safety improvement measures and their implementation schedule. The National Action Plans addressed specific vulnerabilities found during the stress tests but also other elements, like safety improvements identified by other analyses or peer reviews.

Achieving and maintaining a high level of safety of NPPs in the neighbouring countries is of high interest to Austria. An important part of this is the understanding of and information concerning the implementation of the safety improvements, which are designed to rectify the vulnerabilities identified during the Stress tests, as well as other safety improvements. In order to identify the issues and safety improvements that are of highest relevance to Austria, the Federal Ministry for Agriculture, Forestry, Environment and Water Management engaged a group of Consultants (Project Team) to undertake an in-depth analysis of the Stress Tests reports (including operators' and regulators' reports), the Extraordinary CNS reports, the National Action Plans, but also some other sources like bilateral meetings and other previous discussions. The results of the analysis for Slovakia are provided in the attached report.

Using the sources as described above, a set of safety issues and improvement measures of high interest for each of the neighbouring countries has been identified. Those issues and measures, following the same structure as used during the Stress Tests, are grouped into three categories:

- Topic #1: Initiating Events (earthquake, flooding and extreme weather)
- Topic #2: Loss of Safety Systems
- Topic #3: Severe Accident Management

In each category relevant safety issues are listed. For each issue, the safety relevance and background information are provided. The information is, in general, taken from available reports and sources, and extended by the analyses of the Project Team. The Project Team provided its own estimates of the safety importance, as well as the expected schedule for the implementation. The latter (generally) reflects the schedules as provided by each country in the National Action Plan, though in some cases modified on the basis of perceived safety importance. Finally, the analysis of each of the safety improvements contains an entry called "To be discussed". In this entry, the specific details are summarized which are relevant for each specific safety issue and are considered to be of particular interest by the Project Team, and that are proposed to be discussed during bilateral meetings.

With the selection of safety issues and improvement measures, it is intended to open the discussion during the regular annual bilateral meetings with each of the neighbouring countries. It is expected that each of the safety issues and improvement measures will be followed up upon to their final implementation or resolution.

In order to assure that the safety improvements are discussed commensurate to their actual safety relevance, a categorisation of the issues has been proposed. With the analysis as described above, all the issues are grouped in 3 categories. The categorisation reflects the perceived safety importance of each issue or measure, but also the amount (and clarity) of information currently available. The three categories, in the increasing level of complexity are:

- Check list
- Dedicated presentation
- Dedicated workshop

The **"check list"** is assigned to the safety issues/improvement measures that are in general understood and specifics of which are either known or obvious. Considering this, it is expected that a short presentation is made describing the status and announcing the schedule for the completion of the issue/improvement measure.

The **"dedicated presentation"** is the next higher category. For issues/safety improvements in that category, it is expected that the countries will provide a dedicated presentation, where the relevant specifics of the issue or improvement measure will be highlighted in more details. This is expected to include e.g. the design concept, the specifics of the construction/implementation/analysis, or the planned operation of a modification.

For the issues of greatest safety significance but also for those of high complexity, or for the issues where the design solution is not known or many alternatives exist, the Project Team recommends that a **"dedicated workshop"** is organized. In this, the country would present all related details on the issue to enable the Austrian side to ask clarifying questions, to assure full understanding of the concept, details of installation/operation or any other element that is relevant for the issue/improvement measure. To increase the efficiency, some of the workshops are meant to address several related subjects as one set.

For presentations and workshops, the list in the "to be discussed" entry indicates the main (though not necessarily all) the elements that are of interest.

It is generally expected that each safety issue or improvement measure will remain on the agenda of bilateral meetings until the final completion and clarification. This does not mean that for each of the issues/improvements, a specific action (e.g. a workshop) would have to be made in each of the bilateral meetings. Rather, it is expected that in the course of the next several meetings all the issues will be addressed in accordance with a mutually agreed work plan.

2. Glossary

AC	Alternate Current
AFW	Auxiliary Feedwater
AHRS	Additional Heat Removal System
AM	Accident Mitigation
AMP	Ageing Management Program
ANSYS	Analysis System (finite element software)
ASME	American Society of Mechanical Engineers
ASTEC	Accident Source Term Evaluation Code
BD	Czech for Control Room (Bloková Dozorna)
BDB	Beyond Design Basis
BDBA	Beyond Design Basis Accident
BHB	German acronym for Operating Manual
BSVP	Czech for Spent Fuel Storage Pool (Bazén Skladováni Vyhořelého Paliva)
BMU	German Federal Ministry for the Environment
BWR	Boiling Water Reactor
CCW	Component Cooling Water
CW	Cooling Water
CDF	Core Damage Frequency
CERES	Cooling Effectiveness on Reactor External Surface
CEZ (ČEZ)	České Energetické Závody, Czech Electrical Utility
CH	Switzerland
CISRK	Czech for Central Radiation Monitoring System (Centrální Informačni Systém Radiačni Kontroly)
CNS	Convention on Nuclear Safety
CNS EOM	CNS Extraordinary Meeting
CRP	Copper-rich Precipitates
CS	Containment Spray
ČSN	Česká Norma
CST	Condensate Storage Tank
CVCS	Chemical & Volume Control System
CZ	Czech Republic
ČEPS	Czech Transition Grid (Česká Elektrická Přenosová Oustava)
DACAAM	Data Collection and Analysis for Ageing Management
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DE	Germany
DEC	Design Extension Conditions
DC	Direct Current
DG	Diesel Generator

E.ON	German Electrical Utility
EBO	Bohunice Nuclear Power Plant, Slovakia
EC	European Commission
ECC	emergency control centre
ECCS	Emergency Core Cooling System
ECR	Emergency Control Room
EDA	Power Plant Dalešice, Czech Republic
EDG	Emergency Diesel Generator
EDU	Dukovany Nuclear Power Plant, Czech Republic
EFW	Emergency Feedwater
EFWS	Emergency Feed Water System
EMO	Mochovce Nuclear Power Plant, Slovakia
EMS	European Macroseismic Scale
EnBW	Energie Baden-Württemberg AG, German Electrical Utility
ENSI	Swiss Federal Nuclear Safety Inspectorate (Eidgenössisches Nuklearsicherheitsinspektorat)
ENSREG	European Nuclear Safety Regulators Group
EOP	Emergency Operating Instructions
EPG	Emergency Power Generators
ERMSAR	European Review Meeting on Severe Accident Research
ES	Engineered Safeguards
ESCW	Essential Services Chilled Water
ESR	Electron Spin Resonance Dating
ESW	Essential Service Water
ETE	Temelín Nuclear Power Plant, Czech Republic
FWT	Feedwater Tank
GKN I	Neckarwestheim I Nuclear Power Plant, Germany
GKN II	Neckarwestheim II Nuclear Power Plant, Germany
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit, Germany
GPP	Gas Power Plant
HA	Hydro Accumulator
HAEA	Hungarian Atomic Energy Authority
HCLPF	High Confidence of Low Probability of Failure
HP	High Pressure
HŘS	Czech for Emergency Control Centre (Havarijní Řídící Středisko)
HU	Hungary
HVAC	Heating, Ventilation and Air Conditioning
HZSp	Czech for Fire Brigade of the NPP (Hasičský Záchranný Sbor Podniku)
IAEA	International Atomic Energy Agency
ICTS	Information and Communication Technology Services
IRS	Incident Reporting System
ISI	In-service Inspection
IZS	Czech for Integrated Rescue System (Integrovaný Záchranný System)

I&C	Instrumentation & Control
KBR	Brokdorf Nuclear Power Plant, Germany
KKB	Beznau Nuclear Power Plant, Switzerland
KKC	Czech for Emergency Coordination Centre (Krizové Koordinační Centrum)
KKE	Emsland Nuclear Power Plant, Germany
KKG	Grafenrheinfeld Nuclear Power Plant, Germany
	Gösgen Nuclear Power Plant, Switzerland
KKI-1	Isar I Nuclear Power Plant, Germany
KKI-2	Isar II Nuclear Power Plant, Germany
KKK	Krümmel Nuclear Power Plant, Germany
KKL	Nuclear Power Plant Leibstadt, Switzerland
KKM	Mühleberg Nuclear Power Plant, Switzerland
KKP I	Philippsburg I Nuclear Power Plant, Germany
KKP II	Philippsburg II Nuclear Power Plant, Germany
KKU	Nuclear Power Plant Unterweser, Germany
KRB B	Gundremmingen Nuclear Power Plant Unit B, Germany
KRB C	Gundremmingen Nuclear Power Plant Unit C, Germany
kV	Kilovolt
kW	Kilowatt
KWB A	Biblis Nuclear Power Plant Unit A, Germany
KWB B	Biblis Nuclear Power Plant Unit B, Germany
KWG	Grohnde Nuclear Power Plant, Germany
LFRS	Lead-Cooled Fast Reactors
LOCA	Loss of Coolant Accident
LOOP	Loss of Off-site Power
LP ECCS	Low Pressure Safety Injection (within Emergency Core Cooling System)
LRF	Large Release Frequency
M	Magnitude
MCCI	Molten Corium Concrete Interaction
MCR	Main Control Room
MPa	Megapascal
MPLS WAN	Multiprotocol Label Switching Wide Area Network
MSK	Modified Mercalli Scale
NAcP	National Action Plan
ND	Czech for Emergency Control Room (Nouzová Dozorna)
NPP	Nuclear Power Plant
NRC	(US) Nuclear Regulatory Commission
OECD	Organisation for Economic Co-operation and Development
OECD/NEA	Nuclear Energy Agency of OECD
OSL	Optically Stimulated Luminescence Age dating
PAMS	Post-Accident Monitoring System
PAR	Passive Autocatalytic Recombiners

PC	Primary Circuit
PGA	Peak Ground Acceleration
PGAH	Peak Horizontal Ground Acceleration
PGAV	Peak Vertical Ground Acceleration
PSA	Probabilistic Safety Analysis
PSHA	Probabilistic Seismic Hazard Assessment
PSR	Periodic Safety Review
PTS	Pressurized Thermal Shock
PU	Power Uprate
PWR	Pressurized Water Reactor
RA	Radioactive
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RELAP	Reactor Excursion and Leak Analysis Program (simulation tool)
RHR	Residual Heat Removal
RPV	Reactor Pressure Vessel
RSK	Reactor Safety Commission (Advisory Body to German Federal Ministry for the Environment)
RWE	German Electrical Utility
RWST	Reactor Water Storage Tank
SA	Severe Accident
SAM	Severe Accident Management
SAMG	Severe Accident Management Guidelines
SBLOCA	Small Break LOCA
SBO	Station Blackout
SCW	Service Circulating Water
SDSA	Steam Dump Station to Atmosphere
SFP	Spent Fuel Pool/pit
SFSP	Spent Fuel Storage Pool
SG	Steam Generator
SHA	Seismic Hazard Assessment
SiAnf	German Safety Requirements for Nuclear Power Plants
SK	Slovakia
SLO	Slovenia
SPSS	Secure power supply systems
SSCs	Structures, Systems and Components
StMUG	(Bavarian) State Ministry for the Environment
SÚJB	State Office for Nuclear Safety, Czech Republic
SUP	Safety Upgrade Program
SUSAN	Special Emergency System (Spezielles unabhängiges System zur Abfuhr der Nachzerfallwärme)
SW	Service Water
SWR69	German type of BWR

SWR72	German type of BWR
SZN	Czech for Safety Ensuring System (Systém Zajištění Bezpečnosti)
T_k	Ductile to Brittle Transition Temperature
TSC	Technical Support Centre
TVD	Czech for Essential Service Water (Technická Voda Důležitá)
UHS	Ultimate Heat Sink
UPS	Czech for Uninterruptible Power Supply (Nepřerušitelný Zdroj Elektrického Napájení)
V	Volt
VE	Czech for Hydroelectric Power Station (Vodní Elektrárna)
VVER	Water-Water-Energy-Reactor (reactor type of Soviet provenience)
WANO	World Association of Nuclear Operators
ZUNA	German acronym for AHRS

3. Summary of the Findings

SUMMARY TABLE Stresstest Follow-Up Action: Issues for Monitoring, Slovakia				
Issue	Title	Safety importance	Follow-up	
			Action	Schedule
TOPIC 1: Initiating Events				
SK 1.1	EBO: Status of seismic site evaluation and integration of new paleo-seismological data from the Vienna Basin Fault Zone	High	Dedicated workshop	4Q/2016
SK 1.2	EBO: Seismic margin assessment	High	Dedicated presentation	2Q/2015
SK 1.3	EMO: Seismic hazard assessment	High	Dedicated workshop	4Q/2014
SK 1.4	EMO: Seismic reinforcement to 0.15 g	High	Dedicated presentation	2Q/2015
SK 1.5	EMO: Resilience of fire brigade equipment and impact of non-classified SSCs on safety functions	Medium	Check list	2Q/2014
SK 1.6	EBO: Assessment of flooding hazard due to extreme precipitation	Medium	Dedicated presentation together with SK 1.7	2Q/2016
SK 1.7	EBO: Assessment of hazards related to extreme weather	Medium	Dedicated presentation together with SK 1.6	2Q/2016
TOPIC 2: Loss of Safety Systems				
SK 2.1	EBO and EMO: Increase resistance and reliability of EPS for beyond design basis events	High	Dedicated presentation	2Q/2016
SK 2.2	EBO and EMO: Exceptional AC power supply from mobile or dedicated off-site source	High	Dedicated presentation	2Q/2014
SK 2.3	EBO : Enhance the availability of the accumulator batteries	High	Check list	2Q/2014
SK 2.4	EBO and EMO: Increase of long term RCS cooling capability through SG	High	Dedicated presentation	2Q/2015
SK 2.5	EBO and EMO: Increase of plants robustness for the case of loss of ultimate heat sink	High	Dedicated presentation	2Q/2016
TOPIC 3: Severe Accident Management				
CZ/HU/SK 3.1	Stabilization of molten core of reactors of type VVER 440/213 (Bohunice, Dukovany, Mochovce, Paks)	High	Dedicated workshop[1]	1Q/2016
SK 3.2	Containment hydrogen management by passive autocatalytic recombiners	High	Dedicated presentation	2Q/2014
SK 3.3	Alternative coolant system(s) for primary circuit, containment and spent fuel pool	High	Dedicated presentation	2Q/2016
SK 3.4	Containment long-term heat removal	High	Dedicated presentation	2Q/2016
SK 3.5	Provisions for multi-unit accidents	High	Dedicated presentation	2Q/2017
SK 3.6	Severe accidents in the spent fuel pool – hydrogen generation and MCR accessibility	Medium	Dedicated presentation	2Q/2017
SK 3.7	Measures to support containment integrity in case of a severe accident	High	Check list	2Q/2015
SK 3.8	Extension of post-accident monitoring system (PAMS), including control of components for SAM	Medium	Check list	2Q/2016

[1] For this Issue, a quadri-lateral workshop (between Czech Republic, Hungary, Slovakia and Austria) would be preferable. In case the Issue will be discussed in a bilateral framework, the questions will be revised to refer more specifically to what is relevant for each particular country.

3.1 Topic 1: Initiating Events (Earthquake, flooding and extreme weather)

SLOVAKIA	
Topic 1: Initiating events	
Issue No	**SK 1.1**
Title	EBO : Status of seismic site evaluation and integration of new geological and paleoseismological data from the Vienna Basin Fault Zone
Content	During the Stress Tests information was obtained that in the development of PSHA of the EBO site (1997), seismic source zones covering the Eastern Alps and the Vienna Basin were introduced with maximum magnitudes of 5.8 - 6.4 and 6.2 - 6.8, respectively. It was further explained that the seismic monitoring systems around the Bohunice and Mochovce sites recorded micro-earthquakes in the area of the Vienna Basin Fault. New seismological, paleoseismological and geological data from the Vienna Basin Fault System, which is the most important seismic source in the near-region of EBO provide new constraints on fault slip velocities, MCE estimates, and proofs that the system is capable to generate earthquakes with maximum magnitudes up to M≈7. This data requires a revision of the hazard assessment for the Vienna Basin Fault System and should be incorporated into an updated seismic hazard evaluation.
Safety relevance	The assessment of safety margins for EBO 3+4 revealed that loss of containment integrity is assumed not to occur below PGA=0.35. This number indicates a very small safety margin beyond the design basis as the DBE for the plant has assessed with PGA_H=0.344g. The reliability of the ground motion parameters of the design basis event, and the accuracy of the seismic hazard assessment to derive these values is therefore highly important.
Background	The EBO site is located at a distance of less than 20km from the seismotectonically active Vienna Basin Fault System. The seismic source zone, which represents seismicity associated with this fault system, provides a dominant contribution to the site-specific hazard. Recent geological, geophysical, and paleoseismological investigations resulted in a wealth of novel data that characterize active faulting of the Vienna Basin Fault System with much more accuracy than the data previously available for the PSHA 1997. Data include the following: ➢ Geological data that resolve the complex kinematics of the fault system, which consists of a strike-slip fault extending into the EBO near-region and numerous splay faults (Decker et al., 2008; Hinsch et al., 2005) ➢ Novel data on the exact location, dimension (fault length, fault area) and segmentation of both, the strike-slip fault and the splay faults (Beidinger & Decker, 2011; Hinsch & Decker, 2010). ➢ Data on fault kinematics derived from focal mechanisms and fault locations in the Dobrá Voda seismotectonic area (Fojtíková et al., 2010;

	Fojtíková et al., submitted). Data derive from the seismic monitoring of the EBO site. ➢ Data on the geologically, geodetically and seimologically derived slip velocities of the strike-slip fault system (Decker et al., 2005; Hinsch & Decker, 2003; Hinsch & Decker, 2010). ➢ Estimates of the maximum credible earthquake magnitudes (Decker et al., 2010). ➢ Paleoseismological data from capable splay faults of the strike-slip fault system that characterize magnitudes and recurrence intervals of surface-breaking earthquakes with M>6 (Decker & Hintersberger, 2011; Hintersberger et al., 2011). ➢ Paleoseismological data from capable segments of the strike-fault system (Lassee segment) that characterize surface-breaking earthquakes with M>6 (Hintersberger & Decker, 2011). ➢ The assessment of the intensity of the 1906 Dobra Vodá earthquakes based on the Environmental Seismicity Intensity Scale (Mühlmann et al., 2012). The novel data improved the understanding of the fault system and the related seismicity significantly. It is expected that the data will require major changes of the assumptions and input parameters for seismic hazard assessment when compared to the PSHA 1998. The most important expected changes concern the update of maximum magnitudes (M≈7 has been proved by paleoseismological data; PSHA 1998 assumed values between 5.8 and 6.8), the evidence that severe earthquakes (M=6-7) occurred on faults, which have not produced any historical seismicity and therefore are not considered in previous hazard assessments, and the possibility to constrain seismicity models by paleoseismological data and fault slip velocities. This data can be used for advanced hazard modeling by the integration of fault sources. ENSREG documents inform that the EBO site is currently re-evaluated to define the feasibility for the construction of a new nuclear installation. It is expected that site characterization will include an update of the seismic hazard assessment. This revaluation should include all available geological and paleoseismological data. References: Decker, K., Beidinger, A. & Hintersberger, E., 2010. A fault kinematic based assessment of Maximum Credible Earthquake magnitudes for the slow Vienna Basin Fault. Gephysical Research Abstracts, 12, EGU2010-8312. Decker, K. &.Hintersberger, E. 2011. How useful are geological data derived from seismogenic faults for SHA in intraplate Central Europe? Abstract #S13-B02, American Geophysical Union, Fall Meeting 2011, AGU, San Francisco, Calif., 5-9 Dec. http://adsabs.harvard.edu/abs/2011AGUFM.S13B..02D Decker, K., Peresson, H. & Hinsch, R., 2005. Active tectonics and Quaternary basin formation along the Vienna Basin transform fault. Quat. Sci. Rev., 24: 305–320.

	Fojtíková, L., Vavrycuk, V., Cipciar, A. & Madarás, J., 2010. Focal mechanisms of micro-earthquakes in teh Dobrá Voda seismoactive area in the Malé Karpaty Mts. (Little Carpathians), Slovakia. Tectonophysics, 492: 231-229. Fojtíková, L., Málek, J. & Sekereš, J., submitted. Seismic identification of a fault activated during earthquake sequence 1 of 2006 in the Little Carpathian region. Submitted to: Geologica Carpatica Fojtíková, L., Vavryčuk, V., Cipciar, A. & Madarás, J., 2010. Focal mechanisms of micro-earthquakes in teh Dobrá Voda seismoactive area in the Malé Karpaty Mts. (Little Carpathians), Slovakia. Tectonophysics, 492: 231-229. Hinsch, R. & Decker, K., 2003. Do seismic slip deficits indicate an underestimated earthquake potential along the Vienna Basin Transform Fault system? Terra Nova 15: 343–349. Hinsch, R. & Decker, K., 2010. Seismic slip rates, potential subsurface rupture areas and seismic potential of the Vienna Basin Transfer Fault. Int. J. Earth. Sci., DOI 10.1007/s00531-010-0613-3 Hinsch R, Decker K, Wagreich M (2005a) 3-D mapping of segmented active faults in the southernViennaBasin.QuatSci Rev 24: 321–336. Hintersberger, E., Decker, K. & Lomax, J., 2011. The extended (paleo)seismological story of the Vienna Basin, including the largest earthquake north of the Alps. Seislmological Research Letters, 82:301-302. Hintersberger, E. & Decker, K., 2012. Geologische Evidenz für das Carnuntum-Erdbeben im Wiener Becken gefunden? PANGEO Austria 2012, Abstracts, p.65, Universität Salzburg, 15-20 September 2012, Salzburg. Mühlmann, E., Decker, K. & Hintersberger, E. 2012. Neubewertung des Dobra Voda Erdbebens an der Wiener Becken-Störung nach der Environmental Seismicity Intensity Scale (ESI) 2007. PANGEO Austria 2012, Abstracts, p.101, Universität Salzburg, 15-20 September 2012, Salzburg.
To be discussed	The Project team asks for information on the status of the current site evaluation for EBO and offers to inform the Slovak Experts about the latest results obtained from the Vienna Basin Fault System. It is proposed to compare the data and assumptions of the PSHA 1998 with the novel data from the Vienna Basin Fault System in a dedicated technical workshop. The workshop format should provide an opportunity to summarize the data from the Austrian part of the fault zone and request the following information from the Slovak expert community: ➢ What are the major differences between the data and assumptions used in the PSHA 1998 and the current state of knowledge? ➢ What are the latest results and evidences obtained from the microseismic observation network around the EBO site? ➢ What is the status of seismic hazard evaluation of the EBO site? ➢ From the Regulator’s perspective: does the novel data/evidence require an update of the seismic hazards assessment?

Safety importance	High
Safety priority	Medium term
Follow-up	Dedicated workshop

SLOVAKIA	
Topic 1: Initiating events	
Issue No	**SK 1.2**
Title	EBO : Seismic margin assessment
Content	Assessments of safety margins for EBO 3+4 during the European Stress Tests revealed very small safety margins beyond the design basis. Documents inform that a loss of containment integrity is assumed not to occur below PGA=0.35g (ÚJD SR, 2011). This value is practically identical with the design basis. It is claimed, however, that about 80% of SSCs have additional design margins estimated to be 30% above the original design basis as a minimum (ENSREG, 2012).
Safety relevance	Reliable assessments of the safety margins are highly important at the background of the apparently very small safety margins beyond the design basis (currently PGA=0.344g for EBO 3+4).
Background	Assessments of safety margins for EBO 3+4 during the European Stress Tests partly revealed very small safety margins beyond the design basis. Documents inform that a loss of containment integrity is assumed not to occur below PGA=0.35g. This value is practically identical with the design basis (ÚJD SR, 2011). ÚJD SR (2011) does not provide quantitative data on the safety margins for the safety classified SSCs of the EBO 3+4 units. During the Stress Test Country Visit it was claimed that within the project for seismic re-evaluation and reinforcement of SSCs of EBO 3+4 seismic margins were evaluated using the SMA method and determining the robustness of SSCs by a HCLPF approach (ENSREG, 2012). It is further stated that an enveloping floor response spectrum has been applied to all of the SSCs. Results are said to show that about 80% of SSCs have additional design margins estimated to be “30% above original as a minimum” (ENSREG, 2012). The National Action Plan scheduled the completion of seismic margin analyses for 2013 (NAcP ID 5; ÚJD SR, 2012). The details on the methodology used to quantify margins and some results of the safety margin assessment were presented at the Country Visit during the Stress Tests. This information, however, is not available to the Austrian side. References: ENSREG (2012). Slovakia. Peer review country report. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 ÚJD SR (Nuclear Regulatory Authority of the Sovak Republic) (2011). The Stress Tests for Nuclear Power Plants in Sovakia. http://www.ensreg.eu/node/366

To be discussed	The Project team asks for the following information: ➢ The methodology used for seismic margin assessment ➢ The results of the seismic margin assessment in terms of margins above the DBE ➢ Information should particularly identify those about 20% of SSCs, which appear to have no significant safety margin, and envisaged measures to increase safety margins.
Safety importance	High
Safety priority	Medium term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 1: Initiating events	
Issue No	**SK 1.3**
Title	EMO : Seismic hazard assessment
Content	Seismic hazard assessment of the EMO site has been extensively discussed in the Slovakian-Austrian Expert Workshop on site seismicity and seismic design (Safety Dialogue EMO 3+4, Bratislava, July 2010). The Austrian perspective of this discussion is summarized in the report by the Austrian Expert Team (2010). It identified several points that require further clarification: (1) Hazard assessment: Open points concern the earthquake catalogue (in particular, the estimation of the magnitude of historic earthquakes), seismic zoning, and the determination of maximum and minimum (lower-bound) magnitudes. (2) Investigation of faults: Open points concern the study of faults in the near-region, and the results of geological investigations there. The re-evaluation of the capability of near-regional faults is particularly suggested by the new seismologic data obtained from the seismic monitoring system. These data were acquired after the completion of seismic hazard assessment and are therefore not included in the assessment. (3) Peak ground acceleration: The open point concerns the discrepancy between the results of seismic analyses for the EMO site and the SESAME and GSHAP hazard maps. (4) Seismic monitoring system: The open point concerns the use of newly acquired microseismic data for identifying active faults and for defining seismic source zones. (5) Seismic design and the LBM concept: The open point concerns the possible effects of low magnitude/high acceleration earthquakes, focusing on systems and components, but also including civil structures.
Safety relevance	The assessment of safety margins performed during the ENSREG Stress Tests indicate that a loss of containment integrity in EMO 1+2 units is assumed not to occur below PGA=0.2g. This number indicates a rather small safety margin for EMO as the DBE for the plant is currently assessed with PGA=0.143. Reinforcement of the plant from 0.1g to 0.15g is pending (see SK 1.4). The reliability of the seismic hazard assessment is therefore highly important.
Background	The topics summarized in this issue arose from the workshop "EMO 3+4 Completion: Expert Workshop on Site Seismicity/Seismic Design, Bratislava, 2010-07-14". Five open points remained from that workshop, which should be clarified in an additional workshop: (1) Hazard assessment ➢ The earthquake catalogue used for the PSHA 2003 is dominated by historical seismicity with only few significant 20th century events. This calls into question how the conversion from intensity to magnitude was assessed for historical earthquakes. It further seems that the version of magnitude used for historical earthquakes was surface-wave magnitude

	(Ms). Ms, however, cannot be used for the smaller earthquakes recorded in recent years (assuming that these are in local magnitude, ML), so some homogenization is needed. ➢ Seismic source zones. In the PSHA (2003) no "active" source zone was drawn encompassing the site. Instead, a background zone was drawn encompassing the whole of western Slovakia. A certain amount of seismicity was allotted to this zone, which could potentially occur close to Mochovce – or anywhere else, including inside the other source zones. Although this approach is sanctioned by past practice, it is regarded outdated and the Austrian Expert Group preferred to use a complete tessellation of source zones over the whole area of interest, such that the Mochovce site would lie in its own low-seismicity source zone. ➢ Seismic source zones. The zone exerting most influence over site hazard is Zone 5 in the model, which represents seismicity associated with the Certovica Shear Zone. This zone was defined with an abrupt N-S termination on its western edge, despite the fact that maps of the Certovica Shear Zone show it extending towards Mochovce. The delimitation of this peculiar zone should be justified. ➢ Maximum magnitudes. The Austrian expert team disagrees with setting the maximum magnitude (Mmax) for the background source zone which includes the site as low as 5.5 Ms. Mmax for other source zones appear underestimated as well (e.g., Mmax for source zone 6, Vienna Basin, should be increased to M=7.0). ➢ Lower-bound magnitude (LBM) is an arbitrary cut-off value for hazard analysis to filter out small-magnitude earthquakes that can generate high PGA but do not have the capacity to cause damage. It should be clarified what level of the LBM has been adopted in the PSHA (2003), and whether or not the concept of the LBM and the level of the LBM can be applied to all safety-relevant components of the NPP (compare (5) below). (2) Investigation of faults ➢ Faults in the near-region of the NPP (radius of 25 km from the site) such as the Mojmirovce, Šurani, Kozárovce, Stary Tekov, Tlmače Fault were studied by reflection seismic and geological cross sections. Data show that the Kozárovce and Mojmirovce Fault cut up to the surface displacing sediments as young as Pliocene (5.4 – 2.6 Ma). Post-Pliocene faulting results in maximum vertical offsets of 25 – 40 m (Kovać et al., 2002), which corresponds to vertical displacement rates less than 0.02 mm/year. ➢ A thorough re-assessment of the near-regional faults appeared reasonable in the light of data obtained after the completion of the geological survey by Kovać et al. (2002). New data includes the results of the EMO microseismic monitoring program which are indicative for active faulting (see (4) below). (3) Peak ground acceleration ➢ Comparison of the SL2 level for EMO (PGA=0.143g for the non-exceedence probability of 10^{-4} per year) with published hazard maps

	reveal significant discrepancies as several hazard maps show higher hazard levels for Slovakia than the analysis performed for EMO. These hazard maps show PGA values of about 0.1-0.15g for return period of 475 years (GSHAP, 1999; SESAME, 2003) and 0.15-0.2g for a return period of 3.000 years (Musson, 2000) indicating that PGA of SL2 (for a 10.000 years return period) should be even higher. It is evidently important to understand the differences between these hazard determinations. It is speculated that the differences may be due to the use of different values for the lower bound magnitude (LBM; see above). (4) Seismic monitoring system ➢ A seismic network for monitoring seismic activity in the region around the NPP has been established in 1996. This network of currently 13 seismic stations can reliably detect active faults in the near region of the NPP. From comparing the reports on geology (Kovać et al., 2002) and microseismic monitoring (Sekereš, 2009) it appears that, there are seismically active faults between 5 and 20 km from the NPP. In particular, the Levice fault, east of the NPP, showed significant seismic activity, including an M=3.8 event in 1991 and an M=3.4 event in 2004. ➢ Most of the microseismic data was not yet available for the geological assessment by Kovać et al. (2002) and the PSHA (2003). Kovać et al. (2002) therefore classified the Levice fault as “alpine” rather than “neotectonic”. It is now clear from the microseismicity data that the Levice fault is active and therefore “neotectonic”. ➢ The fault has a surface trace located less than 20 km east of the NPP, and the base of the seismogenic portion of this fault is likely located right below the town of Levice, meaning that epicenters of larger events on this fault would likely occur about 15 km east of the NPP. It would be important to determine the geometry of this fault and its maximum possible rupture area, which control the maximum earthquake magnitude used in seismic hazard assessment. (5) Seismic design and the LBM concept ➢ The PSHA (2003) uses a lower bound magnitude to cut-off small-magnitude earthquakes that generate high PGA values in impulsive spikes, which, however, do not have the capacity to cause damage due to their insufficient energy or duration. The LBM value adopted in the hazard assessment is unknown. It was speculated during the Bratislava Workshop (2010) that it is probably M=5, which could correspond to intensities as high as I≈VIII. ➢ The application of a LBM is sanctioned by current practice. It should, however, be proven that none of the safety classified SSCs (including civil structures) is challenged by the ground motion of a LBM event. References: Austrian Expert Team, 2010. EMO 3+4 Completion. Report of the Slovakian-Austrian Expert Workshop on Site Seismicity and Seismic Design, Bratislava, 2010-07-14 (unpublished draft report to BMLFUW)

	GSHAP, 1999. http://www.seismo.ethz.ch/static/GSHAP/ SEASME, 2003. http://www.ija.csic.es/gt/earthquakes/ Kovać, M., Hók, J. & Šujan, M. (Equis Ltd.) 2002. Geological evaluation of the EMO NPP locality, Summary Report, Bratislava, 2002. Musson, R., 2000. Generalised seismic hazard maps for the Pannonian Basin using probabilistic methods. Pure appl geophys, 157: 147-169. PSHA, 2003. Probabilistic Seismic Hazard Assessment for the Mochovce Nuclear Power Plant (Slovakia) Site. PDF file of a presentation to IAEA in 2003, 82 slides. Sekereš, J. (Progseis s.r.o.), 2009. JE-Mochovce Seizmické Meranie. Priebežna správa zo spracovania záznamov za obdobie 1.10.2008-31.12.2008, Trnava, 2009.
To be discussed	The workshop should clarify the questions that remained from the Slovakian-Austrian Expert Workshop on site seismicity and seismic design in Bratislava, 2010. The open points mentioned above should be discussed, particularly the following issues: ➢ The estimation of the magnitude of historic earthquakes, seismic zoning, the determination and justification of maximum and minimum (lower-bound) magnitudes used for the PSHA (2003). ➢ The noted discrepancy between published hazard maps and the results obtained from PSHA performed for the EMO site. Understanding the discrepancies between these different hazard assessments is regarded highly important. ➢ It should be clarified whether additional specific studies on the youngest tectonic history of faults in the EMO near-region (<25km) have been conducted or scheduled upon the evidence of possible active faulting in the near-region (Kozárovce-, Mojmirovce-, Levice fault). ➢ The integration of novel seismological data obtained from the microseismic monitoring network into the hazard model. In particular, the apparent evidence for microseismic activity of the Levice fault, and its possible impact on the assessment of site seismicity. ➢ The assumption should be justified by engineering evidence that none of the safety classified SSCs (including masonry buildings) is challenged by the ground motion of an event corresponding to the lower bound magnitude (LBM).
Safety importance	High
Safety priority	Short term
Follow-up	Dedicated workshop

SLOVAKIA	
Topic 1 Initiating events	
Issue No	**SK 1.4**
Title	EMO: Seismic reinforcement to 0.15g
Content	Seismic hazard of the Mochovce site has been revised in 2007. In accordance with this revision the Slovak regulator issued a new operational license in 2011 where the new target value of 0.15g for seismic reinforcement has been put as one of the license conditions for EMO 1+2. The Project team asks for information on the schedule for the implementation of the seismic upgrade to this new target value.
Safety relevance	Compliance of all safety classified SSCs with the design basis is a stringent safety issue.
Background	For the Mochovce site, the original seismic hazard assessment in 1978 defined the DBE with I=6 MSK-64, PGA=0.06g (occurrence probability 10^{-4}/year). Subsequently, in the late 1990ties, the DBE was upgraded to PGA=0.1g to comply with IAEA's suggested minimum level. Updates of the hazard assessment in 2007 revealed PGA=0.143g. In 2011 the regulatory body decided to increase the design basis with a certain margin to the value PGA=0.15g (ÚJD SR, 2011). This value serves as the design basis for both, the construction of EMO 3+4 and for safety upgrading of the EMO 1+2 units. Information on the time schedule for the seismic upgrade of safety relevant SSCs derives from NAcP (NAcP ID No. 5 and 6; ÚJD SR, 2012). NAcP ID No. 6 follows the recommendation "Seismicity - minimum peak ground acceleration 0.1g" and sets priorities for implementing seismic reinforcements of certain SSCs of EMO 1&2. Reinforcements of structures with the highest priority should be implemented by 2015. The formulation of NAcP ID No. 6 is unclear and may suggest that some upgrades to PGA=0.1g have not yet been completed. Taking into account the fact that the final target value of PGA=0.15g is by 50% higher than the previous one (PGA=0.1g) and that reinforcement will require significant interventions in many components and civil construction structures, the deadline for implementation of this measure was set for 2018 (ENSREG, 2012; NAcP ID No. 5; ÚJD SR, 2012). References: ENSREG (2012). Slovakia. Peer review country report. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 ÚJD SR (Nuclear Regulatory Authority of the Sovak Republic) (2011). The Stress Tests for Nuclear Power Plants in Sovakia. http://www.ensreg.eu/node/366 ÚJD SR (Nuclear Regulatory Authority of the Sovak Republic) (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on

	Nuclear Power Plants. http://www.ensreg.eu/node/692
To be discussed	A dedicated presentation should clarify the following: ➢ What is the current status of seismic upgrading of EMO 1&2? ➢ Explain the content of NAcP ID No. 6 and confirm that all safety classified SSCs meet the requirement to sustain seismic loads of PGA=0.1g ➢ The priorities which have been set for the continuing upgrade process ➢ Will the new target value of PGA=0.15g be exceeded after the completion of the upgrade, i.e., will there be some significant margin beyond the hazard level, which was established by the latest seismic hazard assessment (PGA=0.143g)?
Safety importance	High
Safety priority	Medium term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 1 Initiating events	
Issue No	**SK 1.5**
Title	EMO: Resilience of fire brigade equipment and impact of non-classified SSCs on safety functions
Content	Seismic qualification of the fire brigade building and possible impact of the failure of non-safety classified SSCs on safety functions
Safety relevance	The equipment of the fire brigade shall ensure the functionality of the fire brigades after a seismic event. Failure of non-classified equipment shall not impact safety-relevant SSCs.
Background	Walk-down in the EMO plant during the Stress Tests plant visit revealed that the fire brigade building and some equipment of the fire brigade seem to have no proper seismic reinforcement (safety relevant computer systems, the UPS for the fire brigade control centre, components in the garage; ENSREG, 2012). The site visit further identified some cases where components of no primary safety feature potentially may have indirect influence on some safety functions. It was recommended that all such cases shall be re-evaluated by the licensee and the regulator (ENSREG, 2012). Both issues are apparently not considered in the NAcP (ÚJD SR, 2012). References: ENSREG (2012). Slovakia. Peer review country report. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 ÚJD SR (Nuclear Regulatory Authority of the Sovak Republic) (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants. http://www.ensreg.eu/node/692
To be discussed	Information resulting from the walk-down in the EMO plant during the Stress Tests plant visit is not available to the Austrian side. The Project team therefore asks to inform about: ➢ The weaknesses identified in the case of the fire brigade building and equipment ➢ Measures envisaged to increase the robustness of the fire brigade building and equipment ➢ The identified non-safety classified SSCs, which may impact safety functions upon their failure ➢ Measures envisaged to strengthen these non-safety classified SSCs or protect the endangered safety systems
Safety importance	Medium
Safety priority	Short term
Follow-up	Check list

SLOVAKIA	
Topic 1 Initiating events	
Issue No	**SK 1.6**
Title	EBO: Assessment of flooding hazard due to extreme precipitation
Content	The design basis flood for EBO was previously defined by extreme rainfall with a return period of 100 years. An update of the design basis flood was expected for 2013.
Safety relevance	Due to the topographic conditions at the EBO site flooding hazard and the definition of the design base flood are governed by extreme meteorological conditions.
Background	The EBO site is located some 20 m above and more than 2 km from the closest creeks. Due to this site topography a design basis flood has not been specified in the design documentation and extreme precipitation is assumed to be the only credible source for flooding (ÚJD SR, 2011). The design basis rainfall for EBO was assessed with 65l/s/ha, 15 minutes duration, and a return period of 100 years (ÚJD SR, 2011). This occurrence probability is not in agreement with ENSREG's suggestion to use a return frequency of 10^{-4} per annum for plant reviews/back-fitting with respect to external hazard safety cases (ENSREG, 2012). At the time of the Stress Tests a novel assessment of extreme precipitation values for the EBO site has been under preparation (ÚJD SR, 2011). The assessment should use an extrapolation of historical time series of rainfall intensities using Depth Duration Frequency curves. The results of the study should be used to update the original design values of the EBO plant. According to the NAcP (ID No. 8) The study should have been finalized by 2013 (ÚJD SR, 2012). NAcP ID No. 8 further schedules the planning of implementation of additional measures for 2013. References: ENSREG (2012). Compilation of recommendations and suggestions. Peer review of stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/513 ÚJD SR (Nuclear Regulatory Authority of the Sovak Republic) (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants. http://www.ensreg.eu/node/692

To be discussed	The Project team asks for clarification of the following questions: ➢ What is the status and result of the study on extreme precipitation? ➢ Does the new design basis flood also account for other meteorological phenomena than extreme rain (e.g., combinations of rain and snow melt)? ➢ Is the updated design basis flood enveloped by the design or existing margins? ➢ If not: what kind of measures are planned to protect against the updated design basis flood?
Safety importance	Medium
Safety priority	Medium term
Follow-up	Dedicated presentation together with SK 1.7

SLOVAKIA	
Topic 1 Initiating events	
Issue No	**SK 1.7**
Title	EBO: Assessment of hazards related to extreme weather
Content	Establishment of design bases for extreme meteorological conditions for return frequencies of 10^{-4} per year for plant reviews/back-fitting and quantification of safety margins of SSCs and civil structures
Safety relevance	Hazards due to extreme meteorological conditions (including extreme temperatures and humidity, drought, snow and icing, direct and rotating wind, and their combinations) were previously not fully explored for the EBO site.
Background	Previous evaluations of the effects of extreme meteorological conditions for EBO 3+4 were mostly qualitative, based on operating experience and on engineering judgment (ENSREG, 2012a). It appears that design bases for extreme meteorological conditions were not rigorously defined in the design documentation and safety reports (ÚJD SR, 2011). With respect to safety margins ENSREG (2012a) concludes that during the Stress Tests evidence has been provided to the existence of safety margins but their quantification has been pending. Due to the lack of information in the plant documentation on resistance of SSCs to the beyond design weather conditions, engineering judgment has been applied to estimate the plant response and assess the safety margins. The assessment of extreme weather conditions for the EBO site has been under development in 2012 (ÚJD SR, 2011). The analysis should be performed on the basis of the latest IAEA guidelines and should consider combinations of Postulated Initiating Events with internal and external hazards. Both issues, the assessment of the severity of extreme meteorological phenomena for occurrence probabilities of 10^{-4} per year in accordance with ENSREG (2012b), and the evaluation of the resistance of selected SSCs against extreme external events are addressed in the Slovak NAcP (ID No. 8; ÚJD SR, 2012). References: ENSREG (2012a). Slovakia. Peer review country report. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 ENSREG (2012b). Compilation of recommendations and suggestions. Peer review of stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/513 ÚJD SR (Nuclear Regulatory Authority of the Sovak Republic) (2011). The Stress Tests for Nuclear Power Plants in Sovakia. http://www.ensreg.eu/node/366 ÚJD SR (Nuclear Regulatory Authority of the Sovak Republic) (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants. http://www.ensreg.eu/node/692

To be discussed	The requested dedicated presentation should provide information on the following issues: ➢ What is the status and result of the study on extreme meteorological phenomena? ➢ What is the status and result of the evaluation of the robustness of safety-relevant SSCs, functions, and civil structures with respect to extreme meteorological phenomena? ➢ Are the updated design basis values enveloped by the original design or existing margins? ➢ If not: what kind of measures are planned to protect against the updated design basis hazards?
Safety importance	Medium
Safety priority	Medium term
Follow-up	Dedicated presentation together with SK 1.6

3.2 Topic 2: Loss of Safety Systems

SLOVAKIA	
Topic 2: Loss of safety systems	
Issue No	**SK 2.1**
Title	EBO and EMO: Increase resistance and reliability of EPS for beyond design basis events
Content	Procurement and installation of new air cooled, 6 kV, 1200 kW, 3 days autonomy emergency DG for severe accidents is envisaged, to increase reliability of AC emergency power supply. The SAM diesel generator will have automatic start-up capability and will also be equipped to allow its manual start from the main control rooms or from the emergency response centre in case of a SA. After start-up, voltage will be supplied to the relevant 6 kV and 0.4 kV substations of both units. The remaining operations will be managed manually, some by remote control, other ones by local operation. A dedicated distribution bus will be installed.
Safety relevance	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. A serious consequence of a SBO event could be the 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 the loss of RCP seal water flow and the loss of water flow through the coolers of the RCP. On the long-term, this may lead to RCS coolant leakage through the drain line from the RCP seal. The long-term loss of heat removal from the primary circuit will lead to loss of the core cooling with the potential risk of fuel damage.
Background	The **National Report** on the Stress Tests for Nuclear Power Plants in Slovakia describes that on both EBO and EMO sites there are 8 different options (with different vulnerability to external hazards) for providing power supply to plant consumers; 5 of these options are independent of 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 an unlimited period of time. The same possibility is offered by connecting the NPPs to the preselected hydro plants. Internal power sources in the plant include 3 x 100% redundancy emergency DG with fuel reserves for 9 - 10 days. These facilities are independent from the external grid. The Slovak NPPs have no stationary diverse AC power source, and therefore a SBO with loss of the ordinary back-up AC power sources leads to a full SBO. The existing diesel generators are cooled by essential service water, and will be lost in case of a loss of the UHS. The installation of a new 6kV emergency air cooled diesel generator for SAM has been identified as a measure to increase resistance and reliability of emergency power supply for BDB events as a result of the conducted PSRs already before the Fukushima accident and implementation is currently in progress. After Fukushima, the deadline for completion at Bohunice was maintained to 2013 (but includes some new improvements) and was accelerated from 2018 to 2015 at Mochovce NPP (ENSREG **Peer Review**

	Country Report, **NAcP** Action 38). In the utility safety concept, all dedicated SA modifications are physically and electrically independent from other original safety systems, and are seismically qualified. They are also qualified for the conditions in which they should be used. They are supposed to be used only during severe accident conditions (they can nevertheless also be used in the core damage preventive phase, under specified conditions). In addition, each modification has to be approved by the regulator before implementation. References: ENSREG (2012). Peer Review Country Report: Slovakia. http://www.ensreg.eu/node/404 Nuclear Regulatory Authority of the Slovak Republic (2011). National Report on the Stress Tests for Nuclear Power Plants in Slovakia, 30 December 2011. http://www.ensreg.eu/node/366 Žiaková, M. (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants, December 2012, http://www.ensreg.eu/node/692
To be discussed	The presentation should describe in more detail the safety concept and design of the proposed measure and answer the following questions: ➢ What is the implementation schedule and progress to date, including regulatory approval? ➢ Are the DGs going to be located in dedicated locations qualified against external hazards (other than seismic)? ➢ Where would they connect? ➢ Which consumers would they supply a) prior to core damage and b) in case of SA? ➢ What is the time required for their start?
Safety importance	High
Expected schedule	Medium term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 2: Loss of safety systems	
Issue No	**SK 2.2**
Title	EBO and EMO: Exceptional AC power supply from mobile or dedicated off-site source
Content	DGs of 0.4 kV with 300 kW power will be procured (one per unit) for recharging of accumulator batteries and supplying selected unit consumers in the case of a long-term SBO and failure of all home consumption power sources.
Safety relevance	In case of station black-out, only the top priority consumers remain operating to ensure a limited set of functions aimed primarily at monitoring of the unit conditions and the safe shutdown equipment. These consumers are supplied from three vital power supply sources (accumulator batteries). Accumulators have limited time of service in the case of failure of all home consumption power sources. With the loss of accumulators it is impossible to ensure the control of vital unit parameters. In addition, in the case of SBO, 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 0.4 kV DG).
Background	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 switchyard 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 from all above mentioned other sources fails, the most important consumers will be supplied from a mobile 0.4 kV DG (emergency power supply consumers of vital power supply and selected important consumers for provision of the main safety functions) at each unit. Mobile rectifiers are available for back up charging of EBO 3 & 4 and EMO 1 & 2 accumulators (**National Report** on the Stress Tests for Nuclear Power Plants in Slovakia). Recharging of the plant batteries and supplying selected unit consumers in the case of long-term SBO is planned to be performed by mobile 0.4 kV DGs (one per each unit) which are under procurement (**NAcP**, Actions 20, 23, 26, 28, 29, and 30; Žiaková, 2012). Modifications of the power supply (also from 0.4 kV diesel generators) of the high-pressure boron system pumps enabling their use during SBO. References: ENSREG (2012). Peer Review Country Report: Slovakia. http://www.ensreg.eu/node/404 Nuclear Regulatory Authority of the Slovak Republic (2011). National Report on the Stress Tests for Nuclear Power Plants in Slovakia, 30 December 2011. http://www.ensreg.eu/node/366 Žiaková, M. (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants, December 2012.

	http://www.ensreg.eu/node/692
To be discussed	The presentation should describe in more detail the safety concept and design of the proposed measure and answer the following questions: ➢ Where will the DGs be stored and how will they be transported? ➢ Where would they connect, and are the connections already installed? ➢ Which consumers would they supply a) prior to core damage and b) in case of SA? ➢ How soon after SBO will their start be possible? ➢ What will be their autonomy (with fuel supply stored together with the DGs or other arrangements)?
Safety importance	High
Expected schedule	Short term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 2: Loss of safety systems	
Issue No	**SK 2.3**
Title	EBO: Enhance the availability of the accumulator batteries
Content	A system for monitoring of the accumulator batteries charge will be installed at EBO. Presently 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.
Safety relevance	In a case of a SBO, the last line of defence are the battery backed systems. In case of a full loss of the AC power supply (SBO) and if all the following levels of defence-in-depth fail, the only sources supplying safety systems and safety related systems are the emergency sources of uninterrupted DC power supply (accumulator batteries). Until the batteries are consumed, they provide the power for key valves, I&C for key parameters, control circuits, emergency lighting, etc. When accumulator batteries are connected to the consumers and are discharging, there is a risk of complete discharging if their capacity is not monitored. Therefore battery availability is a limiting factor for safety of the unit in a SBO sequence, and the discharge of batteries is one of the cliff edges for the SBO sequences. An extended battery discharge time would allow for a longer time for recovery and /or alternative remedial actions. The consequence of uncontrolled discharging is irreversible damage to the batteries and loss of monitoring of the vital plant parameters during SBO.
Background	The limited set of equipment dedicated to monitoring of plant conditions and equipment essential to maintain safe shutdown is available in case of SBO. These consumers are supplied from the three first category (uninterruptable source) emergency power supply systems (3x100%), and from two additional battery systems, which also ensure safe turbines trip and power supply to plant information and communication systems. The original design of Bohunice NPP 3&4 required at least 2 hours operation availability for batteries in case of SBO. For Mochovce NPP 1&2 the 220 V batteries were also required to be designed for 2 hours operation, and additional 24 V batteries in each vital power supply system for I&C equipment were installed as well. These batteries have been designed for 4 hours of operation. Design assumptions used for determination of this time were too conservative. Operational tests of vital power supply systems were performed in Bohunice 3&4 and Mochovce 1&2. The tests have demonstrated that in reality the plant batteries can supply power to each vital power supply system for at least 8-10 hours. Discharge time of the plant batteries can be further increased by power saving actions (for example, disconnection of non-essential lighting) specified in the corresponding emergency operating procedure. The tests of the plant batteries capacity considered such power saving actions. Nevertheless the above mentioned times of operation of the batteries are conservative. The National Report states that a system monitoring the status (including time to discharge) of the batteries during normal operation and emergency conditions is already implemented in Mochovce NPP 1&2 and procurement of such system is going on in Bohunice NPP 3&4. The **NAcP** states that “replacement of accumulator batteries and completion of

<table>
<tr><td></td><td>battery state monitoring system” at EBO was part of the MOD V-2 program of modernization of NPP Bohunice 3&4, which was completed in 2008. At the same time, the NAcP lists (in its Part III - Specific Activities Relating to Areas 1 – 3 Resulting from the Document “Slovakia: Peer Review Country Report“) providing a systems for monitoring of batteries capacities for NPP Bohunice 3&4 as an improvement still being considered, but this action is not readily identifiable in the NAcP Part IV – Implementing measures.

References:
Nuclear Regulatory Authority of the Slovak Republic (2011). National Report on the Stress Tests for Nuclear Power Plants in Slovakia, 30 December 2011. http://www.ensreg.eu/node/366
Žiaková, M. (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants, December 2012. http://www.ensreg.eu/node/692</td></tr>
<tr><td>To be discussed</td><td>The issues of interest include:
➢ What improvement is expected by the battery monitoring and the interventions it will permit – in terms of hours gained?
➢ What is the status of implementation?
➢ Will the system function continuously or only when the batteries are in use?
➢ Will the system be included in the periodic testing?
➢ Will the system start automatically or manually, locally or remotely?
➢ Will its indications be available in all control rooms and emergency response centre or only locally?
➢ How/where is this measure included in the NAcP?</td></tr>
<tr><td>Safety importance</td><td>High</td></tr>
<tr><td>Expected schedule</td><td>Short term</td></tr>
<tr><td>Follow-up</td><td>Check list</td></tr>
</table>

SLOVAKIA	
Topic 2: Loss of safety systems	
Issue No	**SK 2.4**
Title	EBO and EMO: Increase of long term RCS cooling capability through SG
Content	Mobile high-pressure feed water pumps with 6 MPa pressure heads and minimal flow rates of 20-25 m^3/hr will be provided for each unit (at EBO and EMO) to inject into SGs in case of SBO. In addition the logistics of supplies for the mobile equipment with possible use at both EBO 1&2 and EMO 1-4 (the same nozzles) will be ensured. Relevant nozzles dedicated for feeding of steam generators using mobile means will be reinstalled to convenient positions to facilitate their connection.
Safety relevance	The main severe consequence of SBO is endangering of heat removal from the RCS, which will occur due to loss of SG feed water that cannot be supplied without power supply. Due to interruption of SG feed water supply, the residual heat removal from the core leads to gradual reduction of the secondary coolant. If the mobile emergency feed water source is not available, the level in the SG will drop. When the pressurizer relief valve or the pressurizer safety valve opening pressure is reached, loss of the RCS coolant begins, with further deterioration of core cooling. The long-term loss of heat removal from the primary circuit will gradually lead to overheating of the core. If power supply of the unit is not recovered on time and water supply to the SG or RCS is not recovered, a blackout-type initiating event leads to fuel damage.
Background	In case of SBO, feedwater supply to the steam generators would be lost. The time until the loss of heat removal from the RCS to SG, if using only water in steam generators (about 300m^3) is at least 5 hours. If a mobile high-pressure feedwater supply to the SG is not available, other heat removal means available (e.g. passive gravity SG feeding from FWT - 20 hours; , coolant contained in HAs - 5 hours; coolant volume in the RPV - 2 hours) will ensure at least 32 hours until fuel damage. 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). The operator actions dedicated for the establishment of alternative heat removal can extend the time to core damage by up to 10 days following the SBO event if it occurs during full power operation and 12 days following the SBO event if it occurs during shutdown (primary circuit depressurized and possibly open), without any off-site assistance. All equipment required for residual heat removal to the alternative UHS is manually operable and easy accessible. Enhancement of the plant resistance in the case of loss of UHS by providing additional mobile high-pressure source of SG feedwater for each site, and ensuring the logistics of supplies for the mobile source, with possible use for both EBO and EMO (the same nozzles), are the improvement measures planned according to the **NAcP** (NAcP Actions 18, 28, 29, and 30; Žiaková, 2012).

	References: Nuclear Regulatory Authority of the Slovak Republic (2011). National Report on the Stress Tests for Nuclear Power Plants in Slovakia, 30 December 2011. http://www.ensreg.eu/node/366 Žiaková, M. (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants, December 2012. http://www.ensreg.eu/node/692
To be discussed	The presentation should describe in more detail the safety concept and design of the proposed measure and answer the following questions: ➢ Which are the water sources available on site and how much is the time to core damage extended by each of them? ➢ How will the mobile pumps be transported to the place where they are needed? ➢ What are the planned logistics of supplies for the mobile equipment? Are there permanent modifications planned to the feedwater sources onsite to allow transfer into the SG?
Safety importance	High
Expected schedule	Medium term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 2: Loss of safety systems	
Issue No	**SK 2.5**
Title	EBO and EMO: Increase of plants robustness for the case of loss of ultimate heat sink
Content	Several modifications will be implemented for compensation of ESCW circuit water losses from internal or external sources. They include the use of mobile pumps for make-up of the ESCW basins from the existing internal water sources (CW cooling tower basin and supply channels) and the pumps of SCW system. As far the SCW system is a normal operational system without reinforcement against beyond-design-basis external events and without seismic classification, the necessary modifications will be implemented to increase its resistance to external events. Additional modifications will be implemented to make the connection of emergency mobile source to EFWS suction and discharge accessible from level 0 m, beyond the anti-freezing barrier (in EMO) in order to ensure emergency mobile supply in cases of internal and external floods and fires.
Safety relevance	ESCW system ensures residual heat removal from 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. Total loss of 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 also affect containment integrity. Failure of all ESCW systems would lead to loss of cooling of DG, emergency core cooling systems, spray systems, SFP coolers, and HVAC in respective rooms. Moreover, cooling of all 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.
Background	The ESCW system is the supporting system for core cooling safety systems. ESCW fulfils the safety function of heat removal from safety systems to the primary UHS (atmosphere). ESCW should provide not only the ultimate heat removal, but also cool all consumers requiring uninterrupted cooling water supply. Loss of the main UHS can occur (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. The ESCW system is designed with 3x100% redundancy. Each train contains 2 pumps per unit (2x100%) and 2 forced draught cooling towers (2x100%). The ESCW system is resistant against a single failure and a number of common cause failures (fire, flooding, design basis seismic events, interactions with high-energy pipes, missiles, heavy load drop, environmental conditions and extreme meteorological conditions). ESCW trains are independent and physically separated. Each ESCW train is supplied from a different train of emergency power supply. Complete loss of operability of all three ESCW trains can be considered an envelope case of UHS loss that is conservatively covered by the SBO event.

	For evaluation of other scenarios leading to loss of ultimate heat sink, the interruption of raw make-up water supply to NPP site was considered. The ESCW system is dependent on equipment out of the NPP area supporting its operability, the most important of which is the raw make-up water supply system. Equipment ensuring water supply is protected against inlet clogging and freezing of sensitive system parts. However, in general the raw 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. The provision of mobile pumps for essential service cooling water make-up from circulating water is listed in the ENSREG **Peer Review Country Report** as a measure already decided or implemented by operators and/or required for follow-up by regulators. The improvement measures are included in several actions listed in **NAcP** (NAcP Actions 18, 28, 29, 30, and 31; Žiaková, 2012). References: ENSREG (2012). Peer Review Country Report: Slovakia. http://www.ensreg.eu/node/404 Nuclear Regulatory Authority of the Slovak Republic (2011). National Report on the Stress Tests for Nuclear Power Plants in Slovakia, 30 December 2011. http://www.ensreg.eu/node/366 Žiaková, M. (2012). National Action Plan of the Slovak Republic Regarding Actions to Comply with the Conclusions from the Stress Tests Performed on Nuclear Power Plants, December 2012. http://www.ensreg.eu/node/692
To be discussed	The presentation should describe in more detail the safety concept and design of the proposed measures.
Safety importance	High
Expected schedule	Medium term
Follow-up	Dedicated presentation

3.3 Topic 3: Severe Accident Management

CZECH REPUBLIC / HUNGARY / SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**CZ/HU/SK 3.1**
Title	Stabilization of molten core for reactors of the type VVER-440/213 (Bohunice, Dukovany, Mochovce, Paks)
Content	Implementation of this measure – stabilization of the molten core by cooling the reactor pressure vessel from outside – was already planned before the Fukushima accident, and indeed was already completed at some units at the time of the accident. The measure requires a number of technical modifications. Since the cooling of the RPV from the outside is a complex procedure, extensive analyses and experiments have been performed to demonstrate the feasibility. Of particular importance is the CERES test facility which permits to simulate the gap between RPV and biological shield 1:1 regarding elevation, with a 1:40 slide of the cylindrical structure. Furthermore, considerations for the case of failure of this measure have been performed in the three countries concerned. The assessment of and the approach to this problem appears to differ between the countries.
Safety relevance	There are two options to attempt to stabilize a molten core: Inside the reactor pressure vessel, by external vessel cooling; or, after melt-through of the RPV, by cooling in the reactor cavity. For smaller reactors, in particular VVER-440s, the former option (in-vessel retention) could, in principle, be practicable. (For larger reactors – roughly above 1.000 MWe – in-vessel retention does not appear feasible due to a less favourable ratio between decay heat and RPV surface.) Successful in-vessel retention leads to rather limited pressure increase in the containment (for VVER-440s, this is supported by the relatively large volume of the containment), and to limited release of radionuclides into the containment atmosphere. Comparatively low releases into the environment are the result. Insofar, the implementation of filtered venting can be seen with less urgency for VVER-440/213 than for VVER-1000. Without cooling and stabilization of the molten core inside the reactor vessel, containment failure appears likely. There appear to be differences in the assessments regarding the possible accident sequences in this case, and the severity of resulting releases, in the countries discussed here; the basis for these differences is not clear, and this point should be pursued further.
Background	<u>Implementation of external reactor pressure vessel (RPV) cooling</u> A number of technical modifications have to be performed to implement external cooling of the RPV: Modification of the drainage system of the bubble condenser, modifications in the reactor shaft to permit coolant flow along the RPV, modification of the ventilation piping to avoid losses of cooling water, strengthening of the hermetic door of the reactor cavity and others. According to the **Peer Review Country Reports** (ENSREG 2012a, 2012b, 2012c) and other sources, the schedule for implementation is as follows: EDU – until 2015

	Paks – between 2011 (unit 1) and 2014 (unit 4) EBO – 2010 EMO 1+2 – 2011/12 (EMO 3+4 – part of the original design) Thus, the implementation is already quite far advanced and it can be expected to continue according to the planned schedule. <u>Demonstration of feasibility of external RPV cooling</u> It is generally assumed (by the licensees as well as, subject to further review, the regulatory authorities) that the risk of vessel failure can be significantly reduced by implementing the strategy of cooling the reactor pressure vessel from outside. Analyses have been performed to investigate whether stable cooling can be assured through natural circulation of the coolant, maintaining the intactness of the RPV. In support of the calculations, experiments have been performed in the CERES test facility in Hungary. Information on analyses and experiments have been provided by the Hungarian side at the regular bilateral meeting Hungary-Austria 2012: 1. Research Results in Support of In-vessel Corium Retention Program in the Paks Nuclear Power Plant (lecture at European Review Meeting on Severe Accident Research (ERMSAR) 2012) 2. CERES experiments calculation with the ASTEC code (lecture at ERMSAR 2012) 3. CERES test facility and test results (presentation at regular bilateral meeting Hungary-Austria 2012) The first paper describes the CERES test facility which simulates the gap between RPV and biological shield (1:1 regarding elevation, with a 1:40 slide of the cylindrical structure). Results of experiments for different gap configurations are presented, as well as results of calculations for one case. It is concluded that removal of the decay heat could be demonstrated in all cases. The second paper provides results of analyses for another gap configuration. It concluded that there is good agreement between experiment and calculations, and that the coolability of the RPV has been demonstrated. The third document mostly summarizes the other two. The CERES experiments were mostly completed in late 2012. There was one remaining issue at that time: A test with boric acid, which was planned for 2013. No information on other comparable investigations has come to the attention of the Austrian experts. It can be assumed that the CERES experiments and the calculations carried out in this context constitute the mainstay of the demonstration of feasibility of external RPV cooling. <u>Considerations for the case of RPV failure</u> Different considerations regarding RPV failure have been performed in the three countries concerned. In the **Czech Republic**, the emphasis lies on cooling the steel door of the reactor shaft by flooding the shaft. No analysis has been performed; but according to "professional estimate", failure of the door can be prevented. This would be

	followed by melt-through of the wall of the shaft after about 4 days after failure of the RPV bottom. It is pointed out that this *represents high and late damage to the containment. The concentration of fission products in the atmosphere of the containment would be low at this time* (National Stresstest Report (SÚJB 2011) section II.6.2.3, repeated in the Czech Report to the 2nd CNS EOM (CR 2012)). No information is available whether further analyses and preparation of measures is planned in this respect. In **Hungary**, two cases are distinguished: RPV failure before flooding of the reactor cavity, and after it. In the first case, it has to be decided whether flooding of the cavity should be still be performed, taking into account the possibility of a steam explosion. In the second case, *a relatively small amount of molten fuel will escape and then the solidifying debris will block the route* (National Stresstest Report section (HAEA 2011a) 6.2.3). This seems to imply that RPV failure does not lead to major problems as long as flooding occurs sufficiently early. The basis for this statement is not clear; no information is provided whether there are analyses supporting it, or whether further analyses are planned. In **Slovakia**, it is assumed that failure of the cavity door is unlikely to be prevented in case of RPV failure. The failed door is expected to lead to releases outside the containment and a serious worsening of the accident progression. *Stabilization of the melt composition, termination of concrete degradation and long-term preservation of the cavity integrity cannot be guaranteed* by coolant feeding into the reactor cavity. Therefore, RPV failure prevention is given high importance and *no special additional measures were assumed for hypothetical corium cooling on the cavity bottom* (National Stresstest Report (UJDSR 2011) 6.3.5.2). The Slovak Report to the 2nd CNS Extraordinary Meeting (SR 2012) contains similar statements. In the Slovak National Action Plan (NAcP) (UJDSR 2012), this point is again emphasized: *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 (part III, section 'severe accident management')*. It is noteworthy that in the Peer Review Country Report (ENSREG 2012b), it is stated that RPV failure is considered very unlikely after the modifications for in-vessel retention. *Nevertheless, investigation to limit the consequences in case of RPV failure could be considered in further steps* (section 4.3). References: CR (2012). Czech Republic – Extraordinary National Report under the Convention of Nuclear Safety, February 2012. http://www.sujb.cz/fileadmin/sujb/docs/zpravy/narodni_zpravy/CZ_NR_2012.pdf ENSREG (2012a). Peer review country report – Czech Republic. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/393 ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 ENSREG (2012c). Peer review country report – Hungary. Stress tests

	performed on European nuclear power plants. http://www.ensreg.eu/node/398 HAEA (Hungarian Atomic Energy Authority) (2011a). National Report of Hungary on the Targeted Safety Re-assessment of Paks Nuclear Power Plant, December 29, 2011. http://www.ensreg.eu/node/362 SR (2012). Special National Report of the Slovak Republic, compiled under the Convention of Nuclear Safety, April 2012. http://www.ujd.gov.sk/files/SNR_NS_April2012.pdf SÚJB (2011). National Report on “Stress Tests” NPP Dukovany and NPP Temelin Czech Republic. Evaluation of Safety and Safety Margins in the Light of the Accident of the NPP Fukushima. http://www.ensreg.eu/node/369 UJDSR (Nuclear Regulatory Authority of the Slovak Republic) (2011). The Stress Tests for Nuclear Power Plants in Slovakia. 30. December 2011. http://www.ensreg.eu/node/366 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692
To be discussed	This measure - stabilization of the molten core by cooling the reactor pressure vessel from outside - has already been decided, the corresponding modifications have been planned in detail, and the implementation is already far advanced (by the end of 2013, it will be completed in more than half of the units concerned), although it follows different schedules in the different countries. The discussion should therefore focus primarily on the demonstration of the feasibility, and also on the considerations for the case of failure of the measure. <u>Demonstration of feasibility</u> The information provided by the Hungarian side (see above) gives an overview of the programme performed in Hungary to demonstrate the feasibility of in-vessel retention. The CERES test facility follows the geometry at Paks NPP. There may be some small differences in geometry between the VVER-440/213s under consideration here, but it can be assumed that the CERES results are also important for the other plants. After evaluation of the information provided, a number of questions remain open: ➢ Has the test with boric acid, planned for 2013, already been performed? If so, what are the results? ➢ The experiments are modelling a part of the whole system only (the cooling of the external vessel wall). The overall concept (e.g. containment spray system, piping from sump to reactor cavity) should be described in more detail. ➢ Two load cases have been calculated with ASTEC/ANSYS. It is not clear to which extent they are representative for the whole spectrum of accidents. ➢ Different widths of the gap between RPV and cavity wall have been studied in experiments and calculations. However, the case of complete local gap closure was not considered, as far as can be seen. Can this case be excluded? If not, what would be the effect of a local closure? ➢ In the tests, stepwise increase of the thermal power has been

	implemented. It is not clear that all relevant cases are covered. ➢ The experiments show, that boiling crisis, drying-out of the wall and local temperature increases to up to 200° above boiling temperature can occur for brief periods of time. Subsequently, the wall is cooled again to boiling point when water flows up again. Have structure-mechanical analyses been performed to study possible consequences of this heating-cooling cycle of the RPV wall? ➢ The codes used for calculations (RELAP5 and ASTEC) predict the mass flow well; however, both codes appear to have difficulties in correctly predicting the boiling crisis at the wall. ➢ How reliable is the transfer of the results from a 1:40 slide to the full RPV circumference? Reliable codes are needed for such a transfer. Are RELAP5 and ASTEC adequate for this task, considering their limitations in predicting experimental results? ➢ Are there differences in geometry and/or other differences regarding the whole concept of IVR, between Paks and the other VVER-440/213s considered here? If so, what are the differences and how can the results of CERES be transferred to other plants in spite of these differences? <u>Considerations for the case of RPV failure</u> Different considerations have been performed in different countries. All in all, there is a number of questions which appear relevant: • When the cavity is flooded after RPV failure, there is the hazard of a steam explosion. Should flooding be avoided completely in this case, or could there be circumstances in which it might be advantageous nevertheless? Are further analyses and investigations planned in this respect? • What is the basis for the assumption that only a relatively small amount of molten fuel will escape and then the route will be blocked by solidifying debris (as assumed in Hungary)? Are further analyses and investigations planned in this respect? • What is the basis for assuming that the integrity of the cavity door can be preserved by flooding (Czech Republic)? Further analyses and investigations planned? • What is the basis for assuming that melt-through of the shaft will occur after about 4 days (Czech Republic)? To which extent will releases from the containment be reduced in this case, compared to early containment failure through failure of the cavity door? Which further analyses and investigations are planned? The CERES experiments were expected to be completed by the end of 2013, and it can be assumed that the considerations for the case of RPV failure are on-going. The appropriate time for a workshop could be early 2016.
Safety importance	High
Expected schedule	Medium term
Follow-up	Dedicated workshop

SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**SK 3.2**
Title	Containment hydrogen management by passive autocatalytic recombiners
Content	Hydrogen management during a severe accident is being implemented at the Slovak NPPs with high priority. Equipment for hydrogen monitoring had already been installed some years ago. Now, a large number of passive autocatalytic recombiners (PARs), as they are used in most PWRs in Europe, have been or are being installed. Furthermore, implementation of a SAMG procedure for containment spray activation and support of ventilation systems by severe accident DGs is under way.
Safety relevance	Hydrogen deflagration or detonation can lead to early containment failure, and to large, early releases (i.e. to a severe accident with very high consequences, compared to accidents with late containment failure or intact containment).
Background	According to the **National Stresstest Report** (UJDSR 2011), the original design at EBO 3+4 and EMO 1+2 does not provide means for reliable hydrogen removal in case of severe accidents. Installation of passive autocatalytic recombiners (PARs) has been planned in various containment areas. Furthermore, the hydrogen is to be managed during severe accidents by prevention of the transition to the ex-vessel phase. According to the stresstest **Peer Review Country Report** for Slovakia (ENSREG 2012b), equipment for hydrogen and oxygen concentration measurements has already been installed since 2008. Regarding counter-measures, installation of 32 PARs is foreseen, as well as the implementation of a SAMG procedure based on measurements for containment spray activation and support of the ventilation systems in the auxiliary building by severe accident diesel generators (section 4.2.3.2). The measures are to be implemented at EBO 3+4 by the end of 2012, at EMO 1+2 by the end of 2013 (section 4.2.3.2). In the **National Action Plan** (UJDSR 2012), it is confirmed that the plant changes for hydrogen management have been/are being performed (Part III, p. 26). References: ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 UJDSR (2011). The Stress Tests for Nuclear Power Plants in Slovakia. 30. December 2011. http://www.ensreg.eu/node/366 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692

To be discussed	Questions which should be addressed in a presentation are: ➢ Have the measures for hydrogen management been implemented as planned according to the Slovak NAcP? ➢ Description of hydrogen management system – in particular, where are the new PARs located and how were the locations determined? ➢ Hydrogen management in case of severe accidents has several elements – PARs, procedure for spray activation, and ventilation system. How do the individual elements interact, what is the role of each element? ➢ General overview: How will safety be improved by this measure? How does the state of the NPPs before implementation compare with the state after implementation of the measure? Since the measures are to be fully implemented by the end of 2013 at the latest, an early date for discussion would be appropriate.
Safety importance	High
Expected schedule	Short term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**SK 3.3**
Title	Alternative coolant system(s) for primary circuit, containment and spent fuel pool
Content	The coolant supply for the primary circuit, the containment spray and the spent fuel pools is to be made more robust by adding new systems to supply borated water from existing tanks. Furthermore, provisions will be made to permit feeding of coolant by mobile means into these tanks, as well as direct feeding of coolant into the spent fuel pool and the reactor cavity.
Safety relevance	Without these measures, coolant supply for reactor and SFP is limited, and dependent on pumps which are not available in case of SBO. Thus, the measures significantly increase the robustness of the plant, particularly in case of extreme external event.
Background	According to the stresstest **Peer Review Country Report** for Slovakia (ENSREG 2012b), to increase coolant source redundancy, three existing and seismically qualified coolant tanks (500 m^3 each) will be devoted to provide borated coolant make-up for the primary circuit, containment spray and the SFP. Two new pumps will be added and supplied by SA DG. One system per two units will be available for EMO 1+2 and one for EBO 3+4. It is also mentioned in this report that these three 500 m^3 tanks should get connections to make filling from mobile sources possible (section 4.2.3.2). This is to be implemented at EBO 3+4 by the end of 2013, at EMO 1+2 by the end of 2015. Furthermore, it was planned, as part of the existing SAM implementation program, to install two additional lines to permit feeding of coolant from mobile pumps/fire trucks, from the exterior, not only in the three tanks mentioned above, but also directly into the SFP and the reactor cavity (section 4.2.4.1). The schedule for the additional measure (provisions for mobile feeding) is not explicitly given but since it belongs to the SAM program, the overall schedule of this program (completion at EDU by 2013, at EMO by 2015) can be assumed to apply. In the **National Action Plan** (UJDSR 2012), it is confirmed that these measures will be performed (Part III, p. 26). References: ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692

To be discussed	Questions which should be addressed in a presentation are: ➢ Detailed description of the systems to increase coolant source redundancy – in particular, how is it assured that the water filled in by mobile sources is also borated, and how is it assured that the I&C which is necessary for the systems remains operational in case of SBO? ➢ Which accident scenarios, which analyses were the basis for planning these systems? ➢ What will be the criteria for activations of the new systems? ➢ There is one system per two units. In case of a multi-unit accident, can the systems be used for both units simultaneously (or intermittingly)? ➢ General overview: How will safety be improved by this measure? How does the state of the NPPs before implementation compare with the state after implementation of the measure? An appropriate time for discussion would be after completion of the implementation.
Safety importance	High
Expected schedule	Medium term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**SK 3.4**
Title	Containment long-term heat removal
Content	The containment spray system which is at the moment only means for long-term heat removal from the containment, and hence for preserving long-term containment integrity, is to be improved for operation in severe accident conditions. Emergency power supply will be improved and other modifications are under consideration. The option of filtered venting for long-term containment heat removal is also being analysed.
Safety relevance	If in-vessel retention of the molten core is successful, pressure increase in the containment is limited. Therefore, in the long-term, heat removal from the containment and with it, pressure control, depend on the functioning of the spray system. Safety will be improved by modifying this system to operate in severe accident conditions (and/or by implementing a system for filtered containment venting). Should late containment failure due to over-pressure occur, there will be radioactive releases which, although significantly smaller than releases in case of early containment failure, are still radiologically significant.
Background	Heat is supposed to be removed by the existing containment spray system in recirculation mode. According to the Stresstest **Peer Review Country Report** (ENSREG 2012b, section 4.2.3.2), the system is to be modified to be able to operate in severe accident conditions. Spray system and essential service cooling water system are to be supplied by SA DG. Sump clogging is supposed to have been solved in previous plant upgrades; nevertheless, a solution to bypass possible clogged inlet from the containment sump cavity using alternative piping is part of these measures. It is under consideration to remove internal containment isolation valves of the spray system to avoid inoperability of the system in severe accident condition. The possibilities of recovery of spray system are to be reinforced and resistance of spray pumps against radiation is addressed. This is to be implemented at EBO 3+4 by the end of 2013, at EMO 1+2 by the end of 2015. In the **National Action Plan** (UJDSR 2012), it is stated that *[t]he 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* (Part III, p. 26). Furthermore, the NAcP lists the following measure: *To analyse a necessity of filtered venting of the containment and other potential technical measures for long-term heat removal from the containment and reduction of radiation load of the environment taking into account activities in this area at other operators of WWER-440/V213 NPP types and considering measures implemented within the SAM project*. 2015 is given as deadline for all Slovak NPPs, including EMO 3+4 (Part IV, ID 2).

	According to the National Action Plan, there appears to be a clear tendency towards relying on the improved containment spray system for long-term heat removal from the containment, rather than on filtered venting. References: ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692
To be discussed	Questions which should be addressed in a presentation are: ➢ Detailed description of the modification of the containment spray system as well as other measures taken in this context (concerning the sump and containment isolation valves). If internal isolation valves are removed – how is containment integrity guaranteed? ➢ What are the results of the analyses of filtered venting? Is the option of filtered containment venting still under consideration? ➢ Which accident scenarios, which analyses were the basis for planning these modifications and measures? ➢ General overview: How will safety be improved by this measure? How does the state of the NPPs before implementation compare with the state after implementation of the measure? An appropriate time for discussion would be after completion of the implementation.
Safety importance	High
Expected schedule	Medium term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**SK 3.5**
Title	Provisions for multi-unit accidents
Content	The planning and provisions for severe accidents so far have focussed on single-unit accidents. After the presently on-going SAM project is completed, an evaluation of a possible extension of this project to the management of a severe accident in two units at the same time is planned.
Safety relevance	The need to devote more attention to multi-unit accidents is a clear lesson learned from the Fukushima accident. In particular in case of extreme external events, there is a real possibility of accidents being initiated in more than one unit. In this case, qualified personnel will be required for each unit affected. Furthermore, material resources (cooling water, emergency power etc., including mobile equipment) have to be available for each unit. Therefore, is it important that planning for severe accidents also specifically considers multi-unit accidents.
Background	In the **Peer Review Country Report** (ENSREG 2012b, section 4.2.4.2), a number of studies to be considered for further analysis are listed. It is stated that decisions on performing these studies will only be made in conjunction with the adoption of the results of the stresstest peer review. The first item listed concerns the verification of available provisions for multi-unit accidents. According to the **National Action Plan** (UJDSR 2012), the SAM project (installation of hardware necessary for management of severe accidents, and implementation of SAMG) was initiated before the Fukushima event, in 2009. The deadlines for completion are 2013 for EBO and 2015 for EMO 1+2. The original philosophy was to consider a severe accident in one unit only. After completion, an evaluation of a possible extension of the SAM project to the management of a severe accident on two units at the same time is to take place (Part III, p. 26/27). It is not discussed further to which extent parts of such an evaluation have already started earlier, in parallel to the SAM project. Details regarding the further steps are not clear today; neither is the schedule. They cannot be expected to be available before the SAM projects are completed. References: ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692

To be discussed	Questions which should be addressed in a presentation are: ➢ Details regarding the further steps to improve the capability to deal with multi-unit severe accidents (scope and schedule). ➢ Which accident scenarios, which analyses were the basis for planning these additional measures? ➢ General overview: How will safety be improved by these measures? How does the state of the NPPs before implementation compare with the state after implementation of the measures? An appropriate time for discussion would be after completion of the SAM projects, with some buffer time allowing for delays.
Safety importance	High
Expected schedule	Long term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**SK 3.6**
Title	Severe accidents in the spent fuel pool – hydrogen generation and MCR accessibility
Content	In case of a severe accident in a spent fuel pool, large quantities of hydrogen can be generated. Also, accessibility and habitability of the main control room could be impaired. Detailed analyses of hydrogen distribution in the reactor hall during a severe spent fuel pool accident are on-going, to clarify whether there is a need for counter-measures (installation of PARs). Regarding measures to increase the habitability of the MCR in case of such an accident, it is not clear which analyses are planned for the operating Slovak NPPs.
Safety relevance	A severe accident in the spent fuel pool, with overheating and subsequent melting of the spent fuel, will lead to a complex situation. From certain temperature levels on, heating is accelerated by zirconium-steam-interaction producing heat and hydrogen. The pool can contain considerably more spent fuel than a reactor core; accordingly, the amounts of hydrogen generated can be very large. Therefore, analysis of the hydrogen generation and distribution is of importance, as well as implementing counter-measures if the results of the analysis indicate their necessity. Furthermore, the loss of shielding of the spent fuel due to evaporation of the water coolant, and the release of radionuclides from the pool, will lead to an increase of dose rates in the vicinity of the pool, as well as to contamination of the air. This can result, inter alia, in restrictions of MCR accessibility and habitability. Analysis of the possible hazards in this case is a necessary precaution.
Background	According to the Stress Test **Peer Review Country Report** (ENSREG 2012b), it has been considered that there is no need to install passive autocatalytic recombiners (PAR) for the case of an accident in the spent fuel pool because the hydrogen generated during spent fuel degradation and released to the 160,000 m^3 free volume of the reactor hall would not reach the minimum concentration for PAR operation. However, detailed analyses of the possibility of local high concentrations (e.g. on top of the spent fuel pool) are still on-going (section 4.2.1.4). Furthermore, it is stated in the Peer Review Country Report that no data were available at that time for an assessment of main control room accessibility and habitability in case of a severe accident in the spent fuel pool. It is also stated that such an assessment will be subject to further investigation for the development of SAMGs for SFP accidents (section 4.2.4.2). In the **National Action Plan** (UJDSR 2012, Part IV, ID 46), a measure referring to the ENSREG recommendation 3.3.10 (Presence of hydrogen in unexpected places, which concerns migration of hydrogen as well as hydrogen production in SFPs) is listed: “To analyse the SAM project from the viewpoint of potential

	migration of hydrogen to other places." (SFPs were not explicitly mentioned in this context.) This is to be performed until the end of 2015 for EBO 3+4 and EMO 1+2. In Part I of the NAcP, measures to increase the habitability of the EMO 3+4 MCR in case of a severe accident are mentioned – but not for the other units. These measures do not specifically refer to the spent fuel pool. Thus, it is not clear whether measures have been taken in this respect for EBO 3+4 and EMO 1+2, or whether measures are being implemented or planned. References: ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692
To be discussed	Questions which should be addressed in a presentation are: ➢ Details regarding the analyses of severe accidents in spent fuel pools (scope, methods, results). Are there also analyses regarding severe accidents with open reactor? Which analyses were performed regarding radiological conditions in the MCR? ➢ What are the provisions for MCR habitability according to the state pre-Fukushima, in particular regarding ventilation? ➢ Did the results of the analyses show the need for further measures regarding hydrogen control, and/or improvement of radiological conditions in MCRs? If so, which measures, schedule for their implementation? ➢ General overview: How will safety be improved by these measures? How does the state of the NPPs before implementation compare with the state after implementation of the measures? An appropriate time for discussion would be after completion of the analyses, even though the schedule is not entirely clear (it appears that the analyses mentioned in the NAcP with deadline 2015 cover only a part of the analyses planned in the context of this Issue).
Safety importance	Medium
Expected schedule	Long term
Follow-up	Dedicated presentation

SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**SK 3.7**
Title	Measures to support containment integrity in case of a severe accident
Content	A number of further measures are planned in Slovakia to support containment integrity in case of a severe accident: • Installation of an additional line for depressurization of the primary circuit, to prevent RPV failure at high pressure which can lead to containment failure • Examination of the tightness of containment penetrations, with additional measures as required • Installation of vacuum breakers to avoid excessive under-pressure
Safety relevance	The improvement measures are reducing the likelihood of radioactive releases from the containment, for different scenarios: • Reactor pressure vessel failure at high pressure can lead to containment failure. Since this would occur at an early stage during a core melt accident sequence, the consequence would be large, early releases. • If there are deficiencies regarding penetration tightness, there will be higher releases in case of a severe accident due to over-pressure in the containment, although the releases can be expected to be significantly lower than in case of containment failure. • Containment failure due to under-pressure can also lead to uncontrolled radioactive releases (which are, however, expected to be significantly lower than releases in case of early containment failure due to other mechanisms).
Background	<u>Depressurization of primary circuit:</u> To prevent vessel failure at high pressure, very reliable depressurization of the primary circuit is required. According to the stresstest **Peer Review Country Report** for Slovakia (ENSREG 2012b), installation of an additional line for depressurization with motor-valves qualified for use at the entry point into SAMG (qualified for LOCA conditions) is to be implemented at EBO 3+4 by the end of 2012, at EMO 1+2 by the end of 2014 (section 4.2.3.2). In the **National Action Plan** (UJDSR 2012), it is confirmed that the plant changes concerning PC depressurization have been/are being performed (Part III, p. 26). <u>Tightness of containment penetrations:</u> Containment integrity relies on the tightness of all penetrations. According to the **Peer Review Country Report** (ENSREG 2012b), the tightness of the reactor cavity door (which is part of the containment boundary (UJDSR 2011, fig. 6) was examined in detail, but not the tightness of the other penetrations (section 4.2.2.2). It was pointed out in the Peer Review Report that the verification of leak-tightness of all containment penetrations in severe accident conditions should

	be further examined (in particular, resistance of seals). In the **National Action Plan** (UJDSR 2012, Part IV, ID 54), this point is dealt with. It is stated that an analysis of the SAM project from the viewpoint of resistance of seals and penetrations of the containment under SA conditions will be performed. The analysis and a plan for implementation of additional measures are to be completed by the end of 2014 for EBO 3+4 and EMO 1+2. <u>Avoidance of containment under-pressure:</u> The VVER-440/213 containment has special characteristics: Pressure reduction by steam condensation in the bubble condenser, and air traps for non-condensible gases. This can lead to a situation over-pressure in the air-traps and sub-atmospheric pressure in the other parts of the containment. To avoid containment failure due to excessive under-pressure (implosion), the installation of vacuum breakers which establish a connection between the air traps and the other containment spaces is planned, according to the **Peer Review Country Repor**t (ENSREG 2012b). The vacuum breakers are valves requiring power and will be provided with a double power supply. They are to be implemented at EBO 3+4 by the end of 2012, at EMO 1+2 by the end of 2015 (section 4.2.3.2). In the **National Action Plan** (UJDSR 2012), it is confirmed that the installation of vacuum breakers has been/is being performed (Part III, p. 26). References: ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 UJDSR (2011). The Stress Tests for Nuclear Power Plants in Slovakia. 30. December 2011. http://www.ensreg.eu/node/366 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692
To be discussed	Confirmation of implementation of measures. No further information required.
Safety importance	High
Expected schedule	Medium term
Follow-up	Check list

SLOVAKIA	
Topic 3: Severe Accident Management	
Issue No	**SK 3.8**
Title	Extension of post-accident monitoring system (PAMS), including control of components for SAM
Content	The existing post-accident monitoring system is to be extended by equipment needed for the implementation of SAMGs and will be connected to the emergency control center. Control of components needed for SAM will be included.
Safety relevance	Extension of the post-accident monitoring system, including the control system, will improve the reliability of obtaining vital information in case of a severe accident. Furthermore, it will permit control of the main SAM related equipment remotely from the emergency control centre. This should increase the chances for successful accident management in case the control rooms are not available.
Background	According to the stresstest **Peer Review Country Report** for Slovakia (ENSREG 2012b), a post-accident monitoring system was installed in 2008 (measuring sensors, signal processing and display). This system is to be extended by measuring equipment needed for the implementation of SAMGs and will be connected to the emergency control centre. Control of components needed for SAM will be included. After complete implementation of SAM, it will be possible to control the main SAM related equipment remotely from the emergency control center. This is to be implemented at EBO 3+4 by the end of 2013, at EMO 1+2 by the end of 2015 (section 4.2.3.2). In the **National Action Plan** (UJDSR 2012), various measures to improve I&C are mentioned for EMO 3+4 (under construction), among them the qualification of the set of PAMS signals for severe accident conditions and inclusion of new, dedicated signals, and the increase of control and monitoring capacity of the NPP. No information on EBO 3+4 and EMO 1+2 is provided in this context (Part I, p. 14). However, it can be expected that implementation of the corresponding measures is on-going at these plants. References: ENSREG (2012b). Peer review country report - Slovakia. Stress tests performed on European nuclear power plants. http://www.ensreg.eu/node/404 UJDSR (2012). Post Fukushima National Action Plan (NAcP) of the Slovak Republic. http://www.ensreg.eu/node/692
To be discussed	Confirmation of implementation of measure. No further information required.

Safety importance	Medium
Expected schedule	Medium term
Follow-up	Check list