Safety upgrading program in NPP Mochovce

Pavol Baumeister
Mochovce Nuclear Power Plant
Slovakia

ABSTRACT

EMO interest is to operate only nuclear power plants with high standards of nuclear safety. This aim EMO declare on preparation completion and commissioning of Mochovce Nuclear Power Plant. Wide co-operation of our company with International Atomic Energy Agency and west European institutions and companies has been started with aim to fulfil the nuclear safety requirements for Mochovce NPP. Set of 87 safety measures was implemented at Mochovce Unit 1 and is under construction at Unit 2. Mochovce NPP approach to safety upgrading implementation is showed on chosen measures. This presentation is focused on the issues category III.

1. Introduction

The Safety improvement is a permanent part of the work for the NPP operator. In 1995 a Safety Improvement Programme for Mochovce NPP was elaborated in the framework of Units 1 and 2 completion works.

For the realisation of the Mochovce NPP Safety Improvement Programme, the Technical Specifications of the Safety Measures defining the requirements for the solution of the safety issues have been prepared in July 1995 with the collaboration of the Nuclear Power Plants Institute Trnava (VUJE) which have been used as data for the contracts with the contractors in charge of the issues. They have been broken down into 87 Safety Measures and take into consideration SE EMO project specificities.

The basic document for the preparation of the Technical Specifications of the Safety Measures was “Safety issues and their ranking for WWER-440/213 Nuclear Power Plants draft “ elaborated in March 1995 by IAEA expert group. This document has been reviewed several times and printed in April 1996 as IAEA-EBP-WWER-03 when the contract have been signed. The mentioned safety issues are ranked into 4 categories according to their safety significance. It is important to highlight that none of the issues related to WWER 440/213 is ranked in the IV category, it means the category with the highest significance.

The process of the safety measures implementation is issued from the federal decree 105/81 and managed by the QA procedure. The Change Procedure is the initiation of the inclusion of the safety measure design results into the general supply.

The Safety Measures implementation was contractually agreed between SE a.s. - EMO and the General Supplier Skoda Praha and between SE a.s. - EMO and Hydrostav Bratislava for the civil engineering.
The “Mochovce NPP Safety Improvement programme” contains the solutions of the issues according to the proposals of foreign experts who have participated in the past to the safety assessment and gives the guaranty to the Slovak and the international population that the operation of the plant will be safe. The aim of the operator is to solve, before the start up of Units 1 and 2, all safety issues ranked in the III and the II categories or to implement temporary solutions in order to reduce the safety significance issues.

The issues of high safety concern are the following category III issues:

- Insufficient qualification of equipment for anticipated ambient and seismic conditions for DBAs (G02-Qualification of equipment see Chapter 1).
- Bubbler condenser behavior at maximum difference (double-ended guillotine break of primary piping) is also of high safety concern. The regulations pertaining to strength calculations in force at the time of bubbler condenser design did not correspond to western practice and has been changed in Russia itself. (CONT01- Bubbler condenser strength behavior under LOCA conditions see Chapter 2).
- Non-destructive testing for reactor coolant system in framework of in service inspection (ISI) present deficiencies and deviations from current standards. The ISI approach used so far is not adequate for a timely detection of degradation. As reliable ISI is a key element required to preserve the integrity of the third barrier (primary system boundary), this issue is also considered of high safety concern (C102-Non-destructive control see Chapter 3).
- The risk of ECCS sump screen blocking appeared higher than expected after an incident which happened in 1992 at a Swedish nuclear power plant. This could result in a common cause failure of whole ECCS following a large break LOCA (S05-ECCS sump screen blocking risk see Chapter 4).
- The layout of EFWS, which is located in turbine hall, is such that it might be exposed to common cause failure by fire, flooding, high energy pipe break or earthquake when, is needed to cool the core (S13-Feedwater system vulnerability see Chapter 5).
- Fire protection, which is all the more important as redundant safety related equipment, is insufficiently separated in some areas such as the EFWS in the turbine hall, and power cables (or control cables) of redundant safety related components follows the same route are located in same compartments (IH02-Fire prevention see Chapter 6).
- High energy pipe breaks in the intermediate building at 14.7 m could result in multiple failures of safety related systems and, in some cases, to loss of EFWS when is needed (IH07-Internal hazards due to high energy pipe breaks see Chapter 7).
- Seismic safety is also considered of high safety concern since the original seismic design is generally not in accordance with current international practice (EH01-Seismic design see Chapter 8).

During the safety assessment process of Mochovce Unit 1 taking place before the start up, a “Synthesis sheet” document was elaborated for each safety measure resolved on the basis of “Technical Specifications of the Safety Measures for Mochovce Unit 1 Safety Improvement Programme rev. 1, July 1995”, describing the safety issue, the scope of the measure and the contents of the studies to be done and the results already available. We had also modifications to be implemented in order to show the state before the start up of Unit 1. The assessment was done to the 31.8.98. The “Synthesis Sheets” of the Safety Measures was presented under the same order as the “Technical Specifications” and each one had the correspondent
comparison with IAEA document concerning the safety issues related to WWER-440/213 NPPs (IAEA-EBP-WWER-03, April 1996).
The Safety Measures implementation was contractually agreed between SE a. s. - EMO and the General Supplier Skoda Praha a. s. and between SE a. s. - EMO and Hydrostav Bratislava a. s. for the civil engineering.
On the basis of the preliminary PSA for the risk of unit 1 core melting, the input frequency of the core melting was reduce from $1.03 \times 10^{-3}/\text{year}$ before the implementation of the Safety measures to $6.54 \times 10^{-5}/\text{year}$ at the start up after the implementation of the contractually approved Safety Measures (this value does not include implementation of EOP- s).

1. G01 - Qualification of equipment

1.2 Safety Measure scope
1. A comparison between the national - decree 436/90- and the international standards:
   - OPB-88
   - INSAG-3, IAEA I/88-Safety Series-75
   - 50-SG-D1, Safety functions and component classification for BWR, PWR and PTR
   - 94C1841, Report 9.7, Criteria for seismic evaluation and potential design fixes for WWER
2. Modification of the existing list of classified equipment.
3. Elaboration of the corrected list of classified equipment.

1.2 Results and conclusions of performed studies
A comparison between the Decree 436/90 and the IAEA Safety Series 50-SG-D1 “Safety Function and component classification for BWR, PWR and PTR” and 75-INSAG-3 “Basic Safety Principles” taking into account OPB-88, was performed. The list of classified equipment, rev.1 contains already the design amendments from 05.97 to 31.1.1998. This list of classified equipment was edited at EMO’s as a quality assurance procedure approved by NRA.

The comparison concluded that the Decree 436/90 is in full accordance with NUSS 50-C. The existing list is completed with the required data (function, redundancy, location) and is approved by UJD. The list will be completed with the safety equipment which will be installed in the future as a result of safety improvements.

1.3 Measures taken at MOCHOYCE NPP
These modifications include:
   - qualification to the environment of mechanical, electrical and I&C equipment on the basis of documentation analysis,
   - qualification evaluation of buildings,
   - test reports of classified electrical equipment and drives.
These preliminary activities resulted in a set of qualification certificates. Due to the lack of some documents for the corresponding components, the conclusions in some cases were “non satisfactory” or “satisfactory under conditions”. In these cases, additional tests according to valid qualification procedures will be performed.
The implementation will improve the reliability and ensure the qualification of pressure differential sensors in emergency condition at 158 °C.
No further hardware modifications are foreseen.
In the second stage the real life time of the equipment will be studied and the recommendations elaborated how to maintain and follow-up the qualification during the life time, including the ageing process. Recommendations for qualified equipment maintenance will be prepared before December 1999.

Hardware modifications resulted in the replacement of the classified pressure and pressure differential sensors SAPHIR 22DD by ROSEMOUNT 1151, 1152 and 1153 type. Sensors linked to reactor trip HO and ESFAS have been installed in the first stage.

2. CONT 01 - Bubbler condenser strength behavior under LOCA conditions

2.1. Safety Measure scope

The final loads on the bubbler condenser structures will be defined in the scope of the SMs CONT02 - CONT04. On the basis of these results, or on conservative loads for the most severe design basis accident (large LOCAs, main steam line breaks, feedwater line breaks), strength analyses of the bubble condenser structures will be performed and the associated strength capability per comparison with design data assessed. If necessary the upgrading design will be elaborated and reinforcement implemented.

2.2. Results and conclusions of performed studies

To check the as-built situation, the following studies were performed:

✓ assessment of the strength analysis of the bubbler condenser structure, based on design drawings, as-built drawings,

✓ acceptance criteria for the structures, structural analyses, experimental strength verification, theory of elasticity and allowable stress for the main steel structures, non-linear theory of elasticity and plasticity for the steel sheet structures, analyses using finite shell elements for membrane and bending stresses, conservative material properties, verification by partial models and experiments,

✓ basic and detailed design of necessary modifications.

2.3. Synthetic description of the proposed modification

These modifications include:

1) the stabilisation of the outer beams against the impact of horizontal overpressure forces on the side walls (ending stress, buckling, torsion) by mean of:

✓ stay-bolts ribs bracing of the 1st. to 10th. floor ceiling with the bottom of the 2nd. to 11th. floor chambers on the side walls,

✓ modification: upgrading of the beams anchoring of the platforms to the concrete of bubble condenser side walls,

2) strutting between 1st. and 2nd. floor main beams outside of the baffle to protect the 1st. and 2nd. floor against lifting.

✓ the sheet structures of the tray chambers in the regular floors (1st to 11th floors) resist to this overpressure without reinforcement, and the functional capability remains preserved,

✓ even if a similar strength capacity of the tray chamber on the 12th floor has not been demonstrated either by analysis or by experiment, a sufficient functionality of the bubbler condenser is preserved (and the global stability of the floor is preserved when this tray level would fail); therefore, no reinforcement is necessary,
the main floor beams located under the side walls need and 12th. floor to be upgraded, and beams in the bottom floor need to be protected from uplift.

3. C102 - Non destructive control

3.1 Safety Measure scope
✓ to develop, have approved by NRA and maintain a pre-operational and operational inspection programme, taking into account the experience gained from research programmes and other NPPs operation,
✓ to introduce a qualification system for NDT personnel and for equipment testing,
✓ to analyse in detail all questions relative to the main primary components NDT.

3.2 Results and conclusions of performed studies
The following analyses and studies were performed:
1. Methodologies of primary circuit NDT
2. RPV in-service inspections
3. In-service inspections of primary piping
4. ISI and PSI project for base metal, welds and welding material for SG 213
5. ISI and PSI project for base metal, welds and welding material for pressurizer
6. Qualification requirements of pressure vessels ultrasonic ISI.

PSI and ISI programmes have been prepared for the main primary components reflecting the present level of technical means, PSI, ISI QA procedures and fulfilling the requirements for quality solution as per ISO 9000.

Reports a. m. in points 2, 3, 4, 5 in paragraph “Results and conclusions of performed studies” have been the subject of a Change Procedure. Requirements for inspections resulting from IB1 methodology have been enforced.

NDT methodologies and programmes have been prepared according to PSI which was performed before the start up of unit 1 and further ISI.

4. S05 - ECCS sump screen blocking risk

4.1 Safety Measure scope
The objective of this SM is to ensure the operability of the ECCS and confinement spray system in case of a LOCA, preventing the insulation material of the primary circuit released by the accident and flowing to the sump screens to block them, and to monitor the filter clogging degree.

4.2 Results and conclusions of performed studies
Skoda performed the following studies and developed the SM basic design:
✓ determination of the effective surface of the filters,
✓ verification of the physical and mechanical properties of the insulation material,
✓ evaluation of the insulation material behaviour in dynamic conditions,
✓ verification of the operating modes of the ECCS pumps,
✓ verification of the sump structures mechanical reinforcements,
✓ basic design of the new anchorage of the filters,
✓ basic design of sump operability monitoring system.
Analyses stated that it is not necessary to change the heat insulation of equipment and pipes in the containment but it is necessary to increase the filter surface around the sumps and to protect them against the effects of water flow. Furthermore, it is necessary to monitor the filter clogging process in the SG compartment floor in LOCA mode.

The data of the monitoring system will be used in the strategy of symptom oriented EOPs.

4.3 Synthetic description of the proposed modification
The hardware modifications consist of:
 ✓ installation of a new anchorage of the filters,
 ✓ installation of two independent water level measurement systems for each ECCS system, one before and the second one into the screen:
   * one level measurement by mean of conductivity sensors before and after the screens,
   * the second level measurement will use submersible pressure measurement.

Each of the 3 lines is individually evaluated.

5. S13 - Feedwater system vulnerability

5.1 Safety Measure scope
Upgrading of EFWS in such a way to fulfil all criteria required by NRA for the design, construction and operation of safety systems:
 ✓ re-routing of EFWS piping to avoid hazard areas at level +14.7 m,
 ✓ it is necessary in the design to take into consideration the non impact of all 3 EFWS that might come from flooding and the confirmation of seismic resistance of all EFWS components and their resistance to the impact of other non seismic components,
 ✓ verification of present pumps characteristics in regards to the new routing (piping configuration),
 ✓ implementation of physical and electrical separation of system components, in particular the power supply of valves layout according to the new design,
 ✓ setting of criteria of EFW supply to SGs,
 ✓ determination of the acceptance risk of the consequences of 1 MPa cold water supply to SG through FW tanks,
 ✓ verification of the continuous measurement efficiency of make up water quality from EFWS tanks to SG.

5.2 Results and conclusions of performed studies
 ✓ basic design of the new installation of the EFWS,
 ✓ analysis of the risk of 10 ata. water supply to FW tanks,
 ✓ settlement of criteria for water supply to SG,
 ✓ draft of new EFWS routing outside turbine hall a intermediate building using the new mechanical penetrations,
 ✓ draft for the reduction of actuating components (valves) number for each EFW subsystem,
 ✓ the risk analysis for 10 ata. water supply to FW tanks proves the accuracy of the design solution.

5.3 Measures taken at MOCHOVCE NPP
The modifications have been partly performed before Unit 1 start-up; in particular, part of the lines has been installed inside the reactor building and the confinement penetrations have been made.

The existing design solution remain temporarily without modifications. The work outside containment will continue during plant operation. The rest of the modifications will be implemented during the plant outage.

6. 1H02 - Fire prevention

6.1. Safety Measure scope
Based on the results of the compartmentalisation, the required fire resistance and qualification of the fire barriers at the boundaries of the fire areas have to be checked, e.g. fire doors and dampers, penetration seals, protection of the steel structure, heat insulation of the ventilation ducts. In case of common modes, the efficiency of the coating and the covering will be checked.

The separation of the MCR and ECR will be checked from the fire protection point of view.

6.2. Results and conclusions of performed studies
After checking of the design, test protocols, walkdowns on site, the conclusions are as follows (summary report):
- fire doors are qualified for 90 min protection and their smoke tightness will be improved
- fire dampers will be improved in the power block (motorised with remote control) or changed,
- the penetrations sealing is generally satisfactory,
- there is a need for some additional protection coating of cable trays steel structures,
- the heat insulation of the ventilation ducts is satisfactory.

6.3. Measures taken at MOCHOVICE NPP
The fire dampers are qualified for 90 min fire they will be changed if it is not possible to improve them by addition of a remote control modification. Defined ventilation ducts will be insulated.

The coating of cables and steel structures, the separation of cable common modes and the doors smoke tightness have been implemented before unit 1 start-up.

Replacement of the fire dampers and the thermal insulation of some ventilation ducts will be done during the first planned shutdown.

7. 1H07 - Internal hazards due to energy pipe breaks

7.1. Safety Measure scope
The analysis of the high energy pipe break effects will cover the following steps:
- identification of weak and possible break points and analysis of the impact on the safety,
- identification of safety components to be protected against mechanical and hydraulic effects resulting from a
- pipe break (mechanical and electrical components, ESFAS instrumentation),
- protective measures wherever needed.

7.2. Results and conclusions of performed studies
The analyses demonstrate the satisfactory level of the strength of the piping and existing restraints of the MSL and MFWL. However, in accordance with the rules, a rupture shall be postulated to occur at the terminal ends. For this reason, protective measures are defined to achieve full protection (protection of building structures, restriction of pipe whip effects and protection of jet forces, axial and radial guide of the failed line). Such measures are foreseen for these lines at the containment penetrations in axis “B” (including modification of LBA 62 and 65 penetrations from the reactor hall to the intermediate building), LAB 5,3,5 FW lines and LBA 1,2,31,32 steam lines at the boundary between the intermediate building and the turbine hall.

8. EH01 - Seismic project

8.1. Safety Measure scope
The seismic reassessment of Mochovce NPP will go through the following steps:
✓ principles for the cooldown of the unit after an earthquake,
✓ definition of the seismic input data,
✓ establishment of the list of the civil structures and equipment to be verified,
✓ seismic calculations and evaluation,
✓ design and implementation of reinforcement measures,
✓ revaluation of the seismic monitoring system.

8.2. Results and conclusions of performed studies
The seismic revaluation contents:
✓ principles for the cooldown of the unit after an earthquake,
✓ the identification of the safety related structures and safe shutdown equipment,
✓ the evaluation of the seismic limit resistance using different methodologies and walkdowns or calculation of critical group of components,
✓ the comparison of the seismic load with response spectra of the location,
✓ the evaluation of the anchoring,
✓ the identification of possible interaction.
✓ elaboration and approval of document “Main principles for the unit cooldown after an earthquake”.

8.3. Synthetic description of the proposed modification
The improvements of the civil structures consist of modifications of the support of beams embedded into the existing walls between reactor hall and turbine hall, reinforcement of the light walls by steel profiles and wire mesh, new columns for the reinforcement of the floor slabs.
The improvement of the seismic behaviour of the equipment consist mainly of the improvement of their anchoring and the reinforcement of the tanks (braces).
Completion of components and equipment in order to have the possibility of a seismic cooldown through ECCS (JNB) on the basis of the document “Main principles for the unit cooldown after an earthquake”.
Seismic monitoring system:
The result is the operation of the external seismic monitoring network in the surrounding of the NPP and directly in the NPP site for 1997. Sensors have been changed in the frame of anti seismic protection system.