Implementation of the Severe Accident Management in Slovenské elektrárne

Vladivoj REZNIK, Engineering Director

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Presence in 40 countries
Installed capacity 97,839 MW
Annual production 295.7 TWh
EBITDA 16.7 bln. €
Capex 2012-16 27.2 bln. €
Customers 60.5 million
Employees 73,702

Stock exchange
Enel is listed on the Milan stock exchange (~1.36 mln shareholders). 14 companies of the Group are listed on Milano, Madrid, Mosca, New York stock exchanges and in other Latin American countries.
Data as of 31.12.2012
Slovak NPPs EBO and EMO

EBO Unit 3 = 107% = 505 MWe
EBO Unit 4 = 107% = 505 MWe

EMO Unit 1 = 107% = 470 MWe
EMO Unit 2 = 107% = 470 MWe
SEVERE ACCIDENT MANAGEMENT
EBO 2009-2013 and in EMO 2011-2015

SAM HW Measures

SAM Implementation Project

SAM Support Tools & Training

SAMGs

SAM Team in TSC
SEVERE ACCIDENT MANAGEMENT HW MEASURES
EBO 2009-2013 and in EMO 2011-2015

The SAM project is divided into following subprojects:

- „SIPHON“ AND REACTOR CAVITY FLOODING
- DEPRESSIONORIZATION OF PRIMARY CIRCUIT
- MANAGEMENT OF HYDROGEN IN CONTAINMENT
- BREAKER OF VACUUM IN CONTAINMENT
- ALTERNATIVE COOLANT SYSTEM
- ALTERNATIVE ELECTRIC POWER SUPPLY SYSTEM
- INFORMATION SOURCES I&C FOR SAM - PAMS AND CONTROL
- LONG-TERM HEAT REMOVAL FROM CONTAINMENT
Localization and stabilization of corium under SA conditions

- Essential in support of management of SA consequences
- IVR (in-vessel retention) strategy for corium localization and stabilization adopted in VVER-440 design due to small reactor size
- Corium cooling is maintained by cooling of RPV from the outside
- Measures implemented to provide for an intentional flooding of reactor cavity under SA conditions
DEPRESSURIZATION OF PRIMARY CIRCUIT

Prevention of High Pressure Core Melt Scenario

- Primary circuit is required to be depressurized prior to the core melt relocation in RPV
- Depressurization is required for the execution of IVR strategy
- Prevention of HPME (high pressure melt ejection) is essential to maintain high degree of containment survivability under SA conditions
Management of Underpressure in Containment under SA Conditions

- Due to specific design of VVER-440/V213 containment, excessive underpressure may occur as a result of hydrogen management.
- Management of underpressure in the containment, needed to prevent high containment loads, is executed by manual connection of bubbler tower airtraps with SG compartment.
ALTERNATIVE COOLANT SYSTEM

Diverse Core Make-up and Containment Spray System for SA Conditions

- Possibility to inject boron water into the RPV, spent fuel pool and into the containment (via spraying)
- Diverse system allowing to execute SAMG strategies (inject into RPV, inject in the containment,…) with high degree if confidence
ALTERNATIVE ELECTRIC POWER SUPPLY SYSTEM

Diverse Electric Power Supply System for SA Conditions

- Alternative and diverse power supply for SA management
- Consumers considered essential for SA management are supplied from dedicated SAM DG
I&C FOR SAM - PAMS & CONTROL

I&C System for SA Conditions

- Instrumentation for SA conditions (PAMS + dedicated SA measurements)
- Control of equipment considered essential for SA management
- Dedicated SAM control panel in the unit control room and Emergency response center
LONG-TERM HEAT REMOVAL FROM THE CONTAINMENT

Long-term Heat Removal under SA Conditions

- Recovery strategy of existing systems for long-term heat removal during SA conditions adopted
- Existing systems for containment spray and essential feedwater system modified for SA conditions
- New pipelines are designed to ensure the ultimate coolant delivery to the reactor cavity, spent fuel pool and alternative coolant system tanks (make up)
# MOBILE DG EQUIPMENT – ONE PER UNIT

<table>
<thead>
<tr>
<th>Power [kVA/kW]</th>
<th>350 / 280</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage [V]</td>
<td>230 / 400</td>
</tr>
<tr>
<td>Current [A]</td>
<td>507</td>
</tr>
<tr>
<td>Frequency [Hz]</td>
<td>50</td>
</tr>
<tr>
<td>Fuel tank [L]</td>
<td>900</td>
</tr>
</tbody>
</table>
MOBILE FEEDWATER EQUIPMENT – ONE PER UNIT

Volume flow \([\text{m}^3/\text{hr}]\) 32
Discharge pressure \([\text{bar}]\) 70
Power \([\text{kW}]\) 70
Emergency Response Center

ERC Bunker

ERC SAM - operators

ERC Radiation - group

ERC TSC - group
**GENERAL IDEA – CONFIGURATION MATRIX TOOL**

**DiD Level 3 – DB/BDB Accidents**

**DiD Level 4 – Severe Accidents**

**Safety Functions:**
1. Subcriticality
2. Reactor core and Spent fuel pool heat removal
3. Containment integrity

**Cliff-Edge Effect #1**

**Cliff-Edge Effect #2**

**Cliff-Edge Effect #3**

**Cliff-Edge Effect #4**

- Database of valuable SSC data with respect to AM (seismic, flooding and environment robustness, electrical supply,...)
- Database of pre-developed configurations of plant systems capable to provide for specific safety function

**Set of computational aids to predict:**
- Mission times of configurations
- Time needed to set up particular configurations
- Pumps flooded in room A, BUT tanks are operable and can be used
- It is possible to use pumps located in room B or room C
MAIN ADVANTAGES OF CONFIGURATION MATRIX

EOPs and SAMGs provide only strategies not particular SSC configurations directly linked with safety functions, what CMT does:

- All information about SSCs and system dependencies (cooling, electrical supply,…) stored at one place
- Direct solutions of setting up particular system and all of its dependent subsystems
- Computational aids help to prioritize individual steps in AM strategy

Quick assessment of the existence of necessary measures for the provision of safety functions:

- Possibility to systematically check for the plant robustness of safety functions provision under user defined IEs
- Gradual increase in the severity of IE allows one to search for potential cliff-edge effects
CONCLUSIONS

✓ SAM implementation has started before Fukushima accident as management decision.

✓ Complementary measures have been implemented in light of Fukushima experience mainly for SBO with mobile devices.

✓ Action plan resulted from performed stress tests in Slovakia is realized and majority of adopted measures will be finished by 2015.
THERMAL-HYDRAULIC CALCULATIONS IN SE, a.s.

Development of In-house TH modelling Capabilities
- Project started in 2009
- Bohunice plant and containment models developed
- Further developments ongoing

Plant life-cycle wide utilisation of APROS

Engineering
- Process and control engineering
- Safety design
- Optimal design

Operation and Maintenance
- Changes in process
- Optimal operation of the plant
- Operator training

Research and Development
- Process analysis and troubleshooting
- Operator support simulator
- Experiment design and test-bench
- Studies on basic process phenomena
- Pilot applications

Research and Development

SLOVENSKÉ ELEKTRÁRNE
### Future Model Developments

- Bohunice plant specific SA model
- Mochovce specific plant, containment and SA model

### Planned Usage of APROS

- Sensitivity studies in support of Design Basis development (comprehensive analysis of plant transients)
- Independent review of safety analyses performed by contractors
- In-house analysis for EOPs and SAMGs development and maintenance – support of TSC teams
- Controller modifications and setup
- Support for plant operation
- Staff training (TSC - SAMG, Engineering, Operations)