



Supporting Activities for Investigation of Optimal Solution for Corium Localization at VVER-1000/320 (Temelin NPP)

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- **Background**

- **Project on Corium Localization**
 - IVR
 - ExVC

- **Conclusions**



- **UJV Rez provides complex services in SAM to Czech NPPs**

- *Dukovany* - 4x VVER-440/213
 - *Temelin* - 2x VVER-1000/320
- } CEZ utility

- **... in the fields of**

- SA progression
- Evaluation of ST
- Identification of SAM strategies & their optimization
- Validation of existing SAMGs
- Supporting analyses for MCR & ECR habitability
- Development of HMS

- **Fukushima Dai-ichi => enhance SAM strategies**

- Implementation of HMS (2015)
- Modifications of PC depressurization
- Corium localization strategy
 - VVER-440/213 (*Dukovany*) – IVR implemented
 - VVER-1000/320 (*Temelin*) – R&D program initiated in 2015 to choose between
 - IVR
 - ExVC

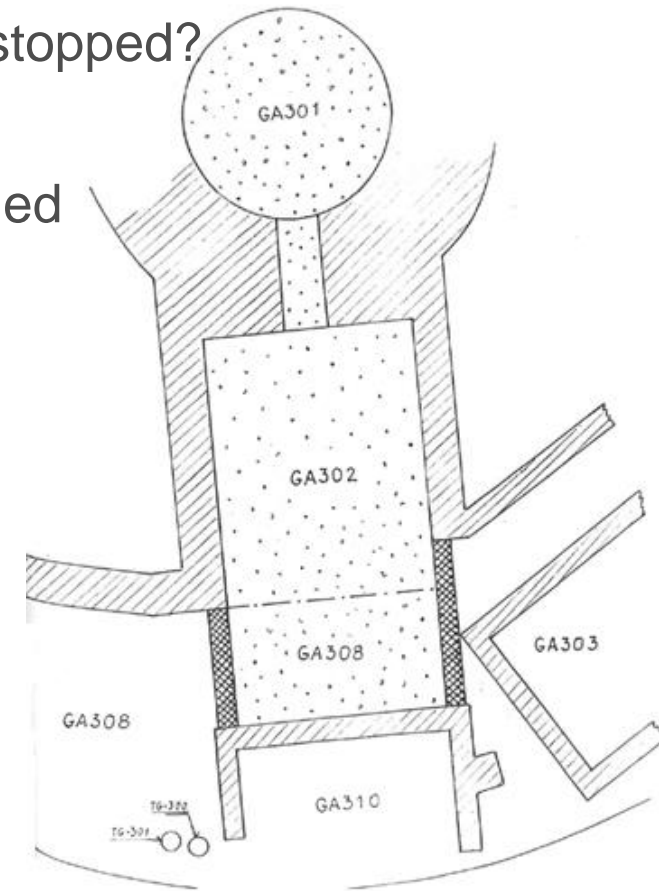


■ Preceding activities (IVR for VVER-1000)

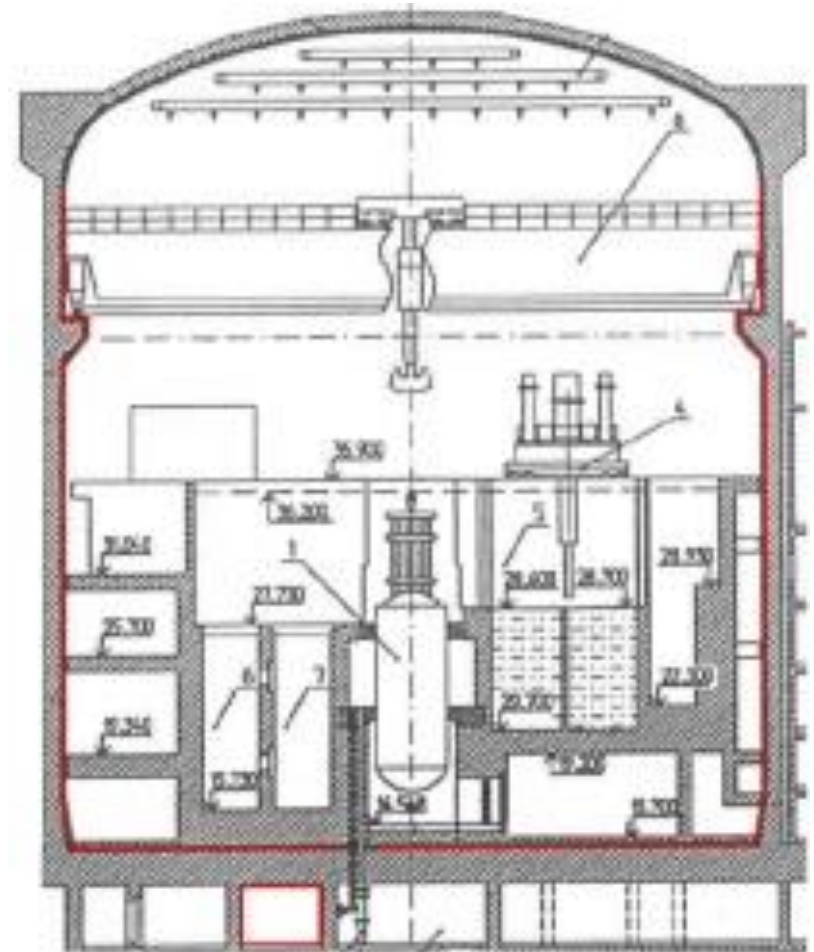
1. MELCOR 1.8.6 simulations
2. Collaboration with *Kurchatov Institute*
 - SOCRAT & ASTEC simulations of heat flux distribution (BC: external RPV cooling)
3. CEZ project: “Feasibility of IVR at Temelin NPP”
 - SOAR
 - Models development & analyses for
 - heat flux distribution
 - external RPV cooling
 - Preliminary investigation of technical solution on coolant supply
 - Preliminary testing of “cold spray” (High Velocity Particle Coating) applicability
4. JRC Benchmark: “IVR at VVER-1000”
 - 2013-2015
 - MELCOR, ASTEC, SOCRAT, MAAP, PROCOR, FLUENT, CFX simulations of heat flux distribution
5. Analytical investigation of RPV cooling
 - RELAP-3D simulations of small scale experiments (BESTH2 facility)
 - RELAP-3D simulations of external RPV cooling
 - Overview of existing CHF correlations

■ Preceding activities (ExVC for VVER-1000)

1. Strategy: corium spreading + top flooding (90's)
 - Analyses confirmed positive effect, but can MCCI be stopped?
2. *OECD* MCCI and MCCI2 projects + CCI7 test
 - Potential of MCCI termination with top cooling confirmed
 - common sand/limestone concrete - more effective
 - siliceous concrete - less effective
 - Extensive validation on CCI tests of
 - CORQUENCH, ASTEC/MEDICIS & MELCOR/CORCON
3. *Temelin* NPP applications (siliceous concrete)
 - Analyses => general conclusion:
 - MCCI impossible to terminate if already initiated
 - Recent approach – refractory material
 - to prevent MCCI + cool down corium after spreading
 - further research: choice of refractory material, conditions of corium spreading (dry vs. submersed)

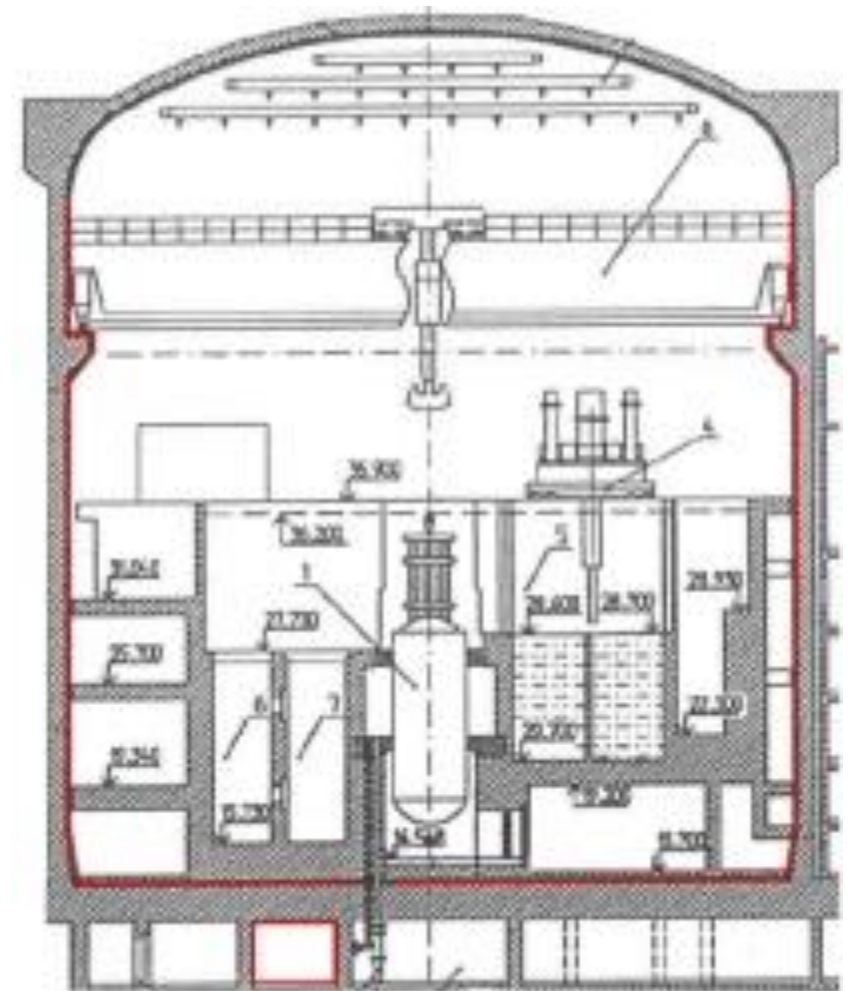


- **Since 2015, 5 years duration**
- **Six main topics**
 1. PC depressurization in SA conditions
 2. Core cooling by water injection into RPV
 3. **Strategy IVR**
 - Water supply to cavity
 - Steam release from cavity
 - Deflector
 - IVR malfunction consequences
 - IVR efficiency for VVER-1000
 4. Strategy ExVC
 5. CTMT response to SA and long term issues
 6. SA initiated in SFP

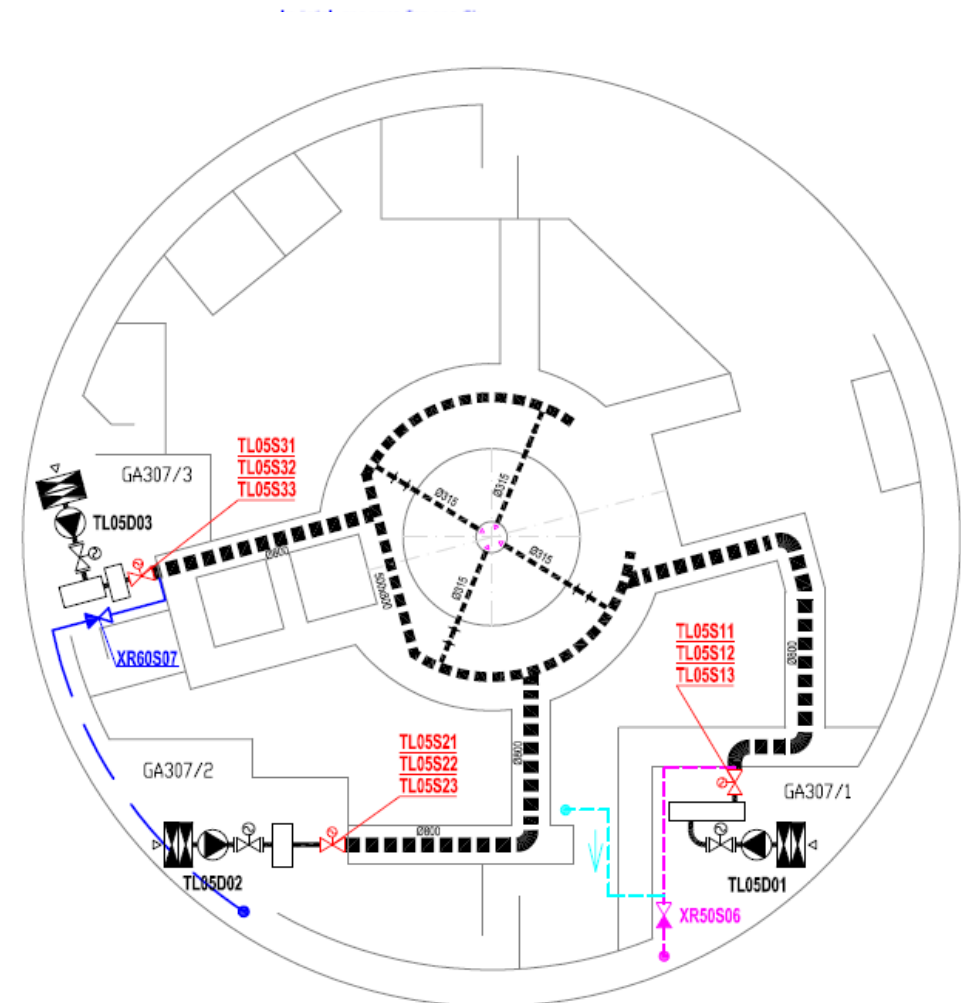


■ VVER-1000 CTMT

- Does not allow for closed cycle of cooling water
 - drainage of water to recirculation sump below CTMT basemat ⇒
⇒ **External water source**
- Solution:
 - “Passive” initial flooding
 - necessity of activation
 - Active long term water supply
- Unresolved issues:
 - Removal and storage of RA water accumulated in CTMT

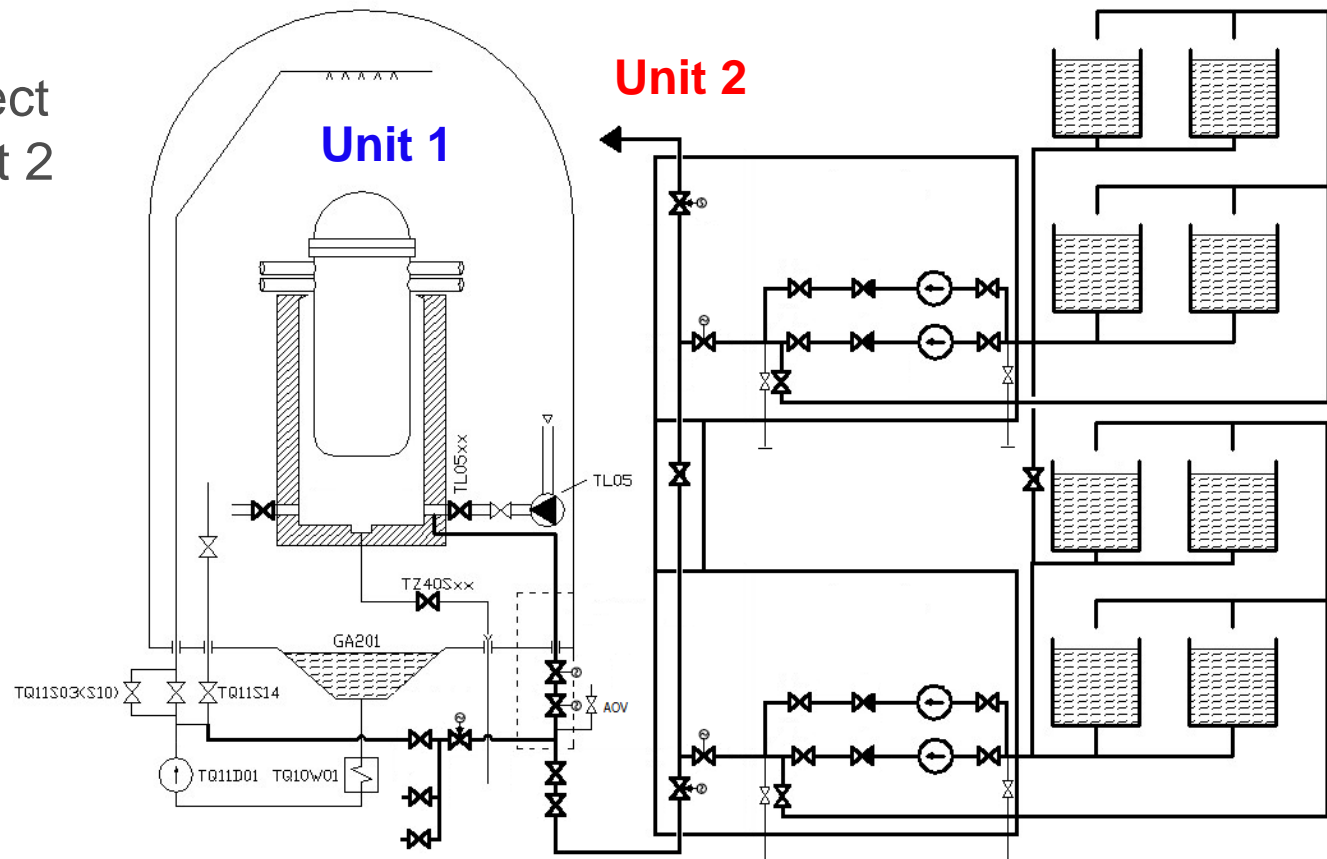


- “Passive” initial flooding
 - Two phases:
 - initial flooding
 - 2 tanks, N2 pressurized
 - short term passive water supply
 - 2 tanks, water level regulation
 - Water temperature control to avoid
 - freezing in winter
 - RPV temperature shock
 - Water injection to cavity via venting system TL05
 - new valves to be installed



■ Active long term water supply

- Activated after depletion of water from 4 “passive” tanks
- Independent system in new building
 - auxiliary systems for electricity supply incl. mobile DGs
- 1 system per unit
 - but possibility to re-direct between unit 1 and unit 2



- **Feasibility study on deflector application has just finished**
- **The following issues were successfully resolved:**
 - conflict during unit operation
 - possibility to remove and restore during outages
 - technical solution of installation and removal procedure
 - manipulators
 - duration (impact on outage duration)
 - storage of deflector parts removed from cavity
 - material of deflector (activation)
- **Conclusion – it is feasible!**



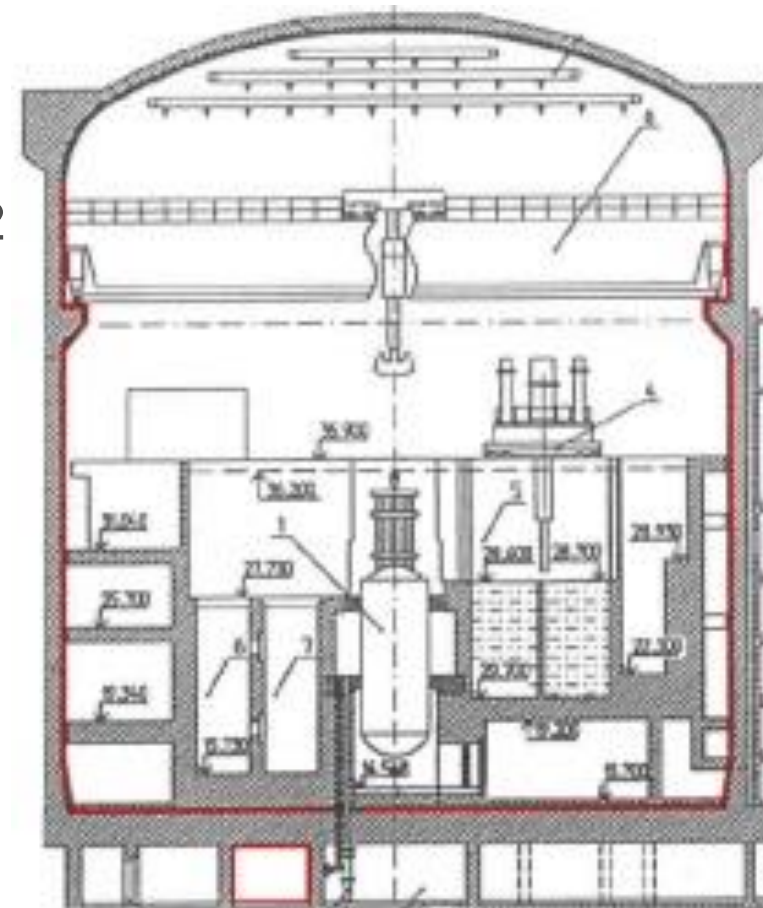


■ Analytical activities

- Analyses of VVER-1000/320 unit behaviour with applied IVR strategy
 - MELCOR whole-plant simulations
 - JRC organized benchmark
 - H2020 *IVMR* project (WP2: reactor applications)
 - FLUENT simulation of heat flux distribution
 - RELAP-3D & FLUENT simulation of external RPV cooling
 - FLUENT + RELAP-3D coupling
- Analytical support to the *THS-15* facility design
 - Sensitivity studies
 - heat flux profile
 - size of cooling channel delimited by the deflector
 - pressure in cavity



- Project initiated in 2015 with duration up to 5 years
- Six main topics
 - Primary circuit depressurization under SA conditions
 - Corium cooling with water injection into RPV
 - Strategy IVR
 - **Strategy ExVC**
 - Corium spreading and stabilization in GA301/302
 - Modifications necessary to cavity/spreading area
 - Coolant supply solutions
 - Containment response to SA and long term issues
 - SA initiated in SFP



- **Corium localization is a key measure in SAM**
- **Application of the IVR or ExVC strategy to existing reactors requires extensive efforts on**
 - Evaluation of the efficiency of a proposed strategy
 - Evaluation of its feasibility within the bounds of existing design
- **UJV Rez performs extensive R&D activities to investigate the applicability of IVR and ExVC strategy to the *Temelin NPP* (VVER-1000/320)**
 - Analytical program
 - Experimental program
 - Design of new SSCs
- **Decision on the strategy of corium localization**
 - by the end of 2017



- **To ČEZ a. s. for support of the project on Corium Localization**
- **To colleagues from *ÚJV Řež, a. s.***
 - Division 23000 on Material Integrity and Engineering
 - Division 25000 ENERGOPROJEKT PRAHA
 - Dept. 22020 on Safety Analysis**their outputs were included in this contribution**



Thank You for Your Attention

