Romanian requirements and experience regarding SSC Environmental Qualification in a CANDU6 NPP

Elena Dinca – CNCAN (National Commission for Nuclear Activities Control)

Valentin Vasile – CITON (Center of Technology and Engineering for Nuclear Projects)

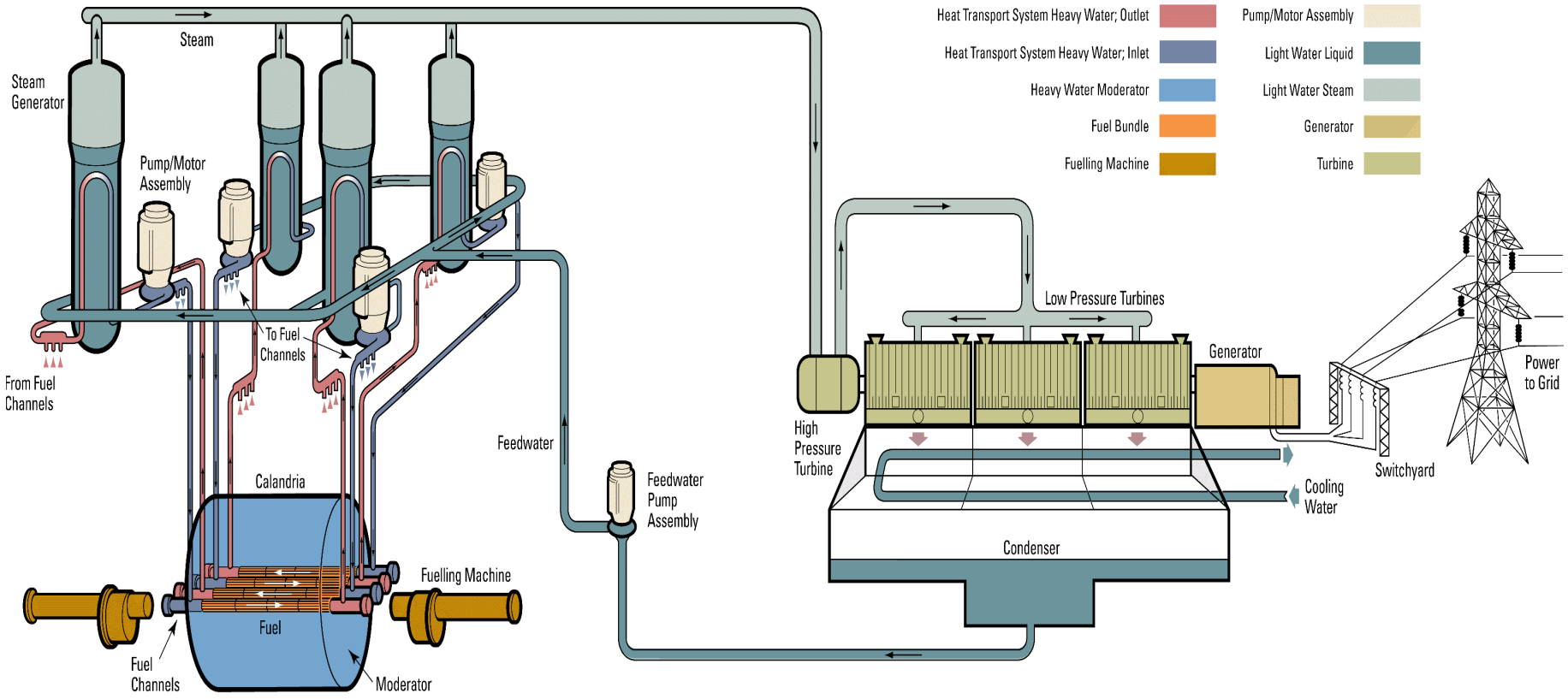
Regional Workshop on Environmental Qualification of Equipment for NPP in Harsh Environment, May 20-24, 2019, Husinec Rez, Czech Republic

Cernavoda NPP

Currently, Cernavoda NPP is the only one NPP in Romania

Reactor	Type	Gross Capacity MW(e)	Construction Start	First Criticality	Status
Cernavoda-1	CANDU-6	706.5	1980	16th of April 1996	In operation
Cernavoda-2	CANDU-6	706.5	1980	6th of May 2007	In Operation
Cernavoda-3	CANDU-6	720	1980	-	Under Preservation- plans to restart construction
Cernavoda-4	CANDU-6	720	1980	-	Under Preservation plans to restart construction
Cernavoda-5	CANDU-6	-	1980	-	Changed destination in Emergency response center

CANDU-6 NPP schematic diagram



Introduction

- **CITON** (**C**enter of **T**echnology and **E**ngineering for **N**uclear **P**rojects) is a subsidiary of **RATEN** (**T**echnologies for **N**uclear **E**nergy **S**tate **O**wned **C**ompany) together with **Institute for Nuclear Research** from Pitesti (having TRIGA Research Reactor)

- **CITON** – location and history
  - ✓ located in Magurele town, close to Bucharest
  - ✓ CITON was established in 1970 as a design division of nuclear power plants and nuclear installations.
  - ✓ In 1979, acting as the General Design Authority, commenced the design and engineering work for the Cernavoda NPP 5x700MWe units, CANDU-6 type, in collaboration with AECL (Canada), Ansaldo (Italy) and General Electric (USA).

- **CITON** performs design and engineering work and assures technical assistance and engineering support for construction – installation, commissioning, operation and maintenance of nuclear power plants and other nuclear facilities.
- The main activities are:
  - ✓ Design and Engineering Services,
  - ✓ Basic Design Documentation,
  - ✓ License and Safety Documentation,
  - ✓ Technical Assistance,
  - ✓ Consulting Services,
  - ✓ Research and Development Services.

Introduction (1)

- General licensing conditions for a nuclear installation in Romania are provided in **Law No. 111/1996, on safe deployment , regulation, licensing and control of nuclear activities in Romania**, with subsequent modifications and completions.
- **National Commission for Nuclear Activities Control (CNCAN)** is the national authority competent in exercising regulation, licensing and control in the nuclear field in **Romania**, for all the activities and installations in nuclear field;
- Regulation, licensing and control is performed for both nuclear and radiological installations and activities in Romania

Regulatory Requirements for SSC Environmental Qualification

- EQ is required for the SSC that have to respond to accident conditions and to fulfill their fundamental safety functions
- EQ objective is to prevent common cause failures that would conduct to simultaneous failure of redundant systems which fulfil safety functions.
- Specific requirements are in place in Romania in CNCAN regulations (norms) for SSC EQ, starting with the design of NPP, calculations performed to assess harsh conditions, testing, re-assessment of conditions, ageing behaviour of qualified SSC to EQ, etc.
- Standards are recommended by CNCAN for qualification of specific components (as cables, instrumentation, etc.) in the regulatory guide GSN-01 "Nuclear safety guide regarding codes and industrial standards for nuclear power plants" (issued in 2015).
- For CANDU NPPs, GSN-01 recommends CSAs (Canadian standards), as:
  - CSA N290.13-05 (R2010) - Environmental Qualification of Equipment for CANDU Nuclear Power Plants;

Regulatory Requirements for SSC Environmental Qualification (1)

- **Regulatory requirements related to Envoronmental Qualification of SSCE in a NPP, established by CNCAN** can be found in the following regulations:
  - **Norms regarding Deterministic Safety Analyses for nuclear instalations, 2019 (to be issued)**
  - **Nuclear Safety Requirements regarding recording, reporting, analysis of the events and use of the operating experience for nuclear installations (NSN-18), 2017;**
  - **Nuclear Safety Requirements regarding the Ageing Management for Nuclear Installations (NSN-17) 2016;**
  - **Nuclear Safety Requirements regarding the Preparedness of the Response to Transients, Accidents and Emergency Situations at Nuclear Power Plants (NSN-07), 2014;**
  - **Nuclear Safety Requirements for Siting for Nuclear Power Plants (NSN-01), 2010;**
  - **Nuclear Safety Requirements for Design and Construction of Nuclear Power Plants (NSN-02), 2010;**

Regulatory Requirements for SSC Environmental Qualification (2)

- **Other regulatory requirements related to nuclear safety of NPPs, containing requirements related to EQ are:**
  - **Nuclear Safety Requirements on Periodic Safety Review for Nuclear Power Plants (NSN-10), 2006;**
  - **Nuclear Safety Requirements on Containment Systems for CANDU NPPs (NSN-12), 2005; (*)**
  - **Nuclear Safety Requirements on Shutdown Systems for CANDU NPPs 9NSN-13), 2005; (*)**
  - **Nuclear Safety Requirements on Emergency Core Cooling Systems for CANDU NPPs (NSN-11), 2006; (*)**

(*) for CANDU NPPs

- **Regulatory requirements alligned to the newest reccomandations of the IAEA standards (as SSR 2/1 rev. 1 reffering to design of NPPs) and WENRA Reference levels**

Regulatory Requirements for SSC Environmental Qualification (2)

Examples of regulatory requirements related to SSC EQ:

NSN-02:Norms on Design of NPPs:

- Art. 17. - (1) An environment condition qualification procedure shall be adopted in order to confirm that the SSCE important for nuclear safety are able to meet the performance requirements associated to their functions throughout their entire lifetime in the installation, considering the environmental conditions they can be exposed to during the normal operation of the NPP and as a result of the anticipated events during the operation and of the design-based accidents. The considered environmental conditions shall include, for example, vibrations, temperatures, pressures, electromagnetic interferences, irradiation, humidity, and combinations thereof.
- (2) The qualification shall be demonstrated by tests "…to indicate that, in the extent practically possible, the respective type of equipment can operate under conditions similar to those that may occur throughout or as a result of accidents. Should it be impossible to carry out such tests, analyses shall be run to demonstrate that the environment qualification requirements are met."

Regulatory Requirements for SSC Environmental Qualification (3)

Examples of regulatory requirements related to SSC EQ:

NSN-024: Norms on Deterministic Safety Analysis (to be issued- now in external consultation)

- ✓ "DBA shall include the nuclear installation behaviour following common cause failures, such as internal and external initiating events which can lead to the failure of two or more SSC.
- ✓ …Shall be demonstrated that SSCE credited to ensure nuclear safety functions in case of a common cause failure are properly qualified"

…..

- ✓ "(1) "Shall be demonstrated that SSCE credited to operate for prevention of the nuclear fuel melting or for mitigation of a DEC consequences, including mobile equipment and facilities for their connection, have adequate capacity and qualification to fulfil relevant functions for the necessary period of time."
- ✓ "Analyses of DEC have to demonstrate that:

…. g) I&C qualified to specific accident conditions are ensured, to be credited for implementation of the accident management procedures …"

Cernavoda SSCs Environmental Qualification

Cernavoda SSCs Environmental conditions

- Structures, Systems and Components (SSC) have to fulfil their safety functions in environmental conditions classified in two categories: "Harsh" or "Mild".
- After Fukushima Daiichi nuclear accident and taking into account the best practice, the EQ conditions were re-assessed for Cernavoda NPP units for Design Basis Accidents
- New Severe Accident Analyses were performed in order to determine the environmental conditions for these accident sequences, for:
  - ✓ SSCE that are credited to respond to SA and mitigate the consequences
  - ✓ Instrumentation and control to monitor the plant state

Cernavoda SSCs Environmental Qualification at DBA

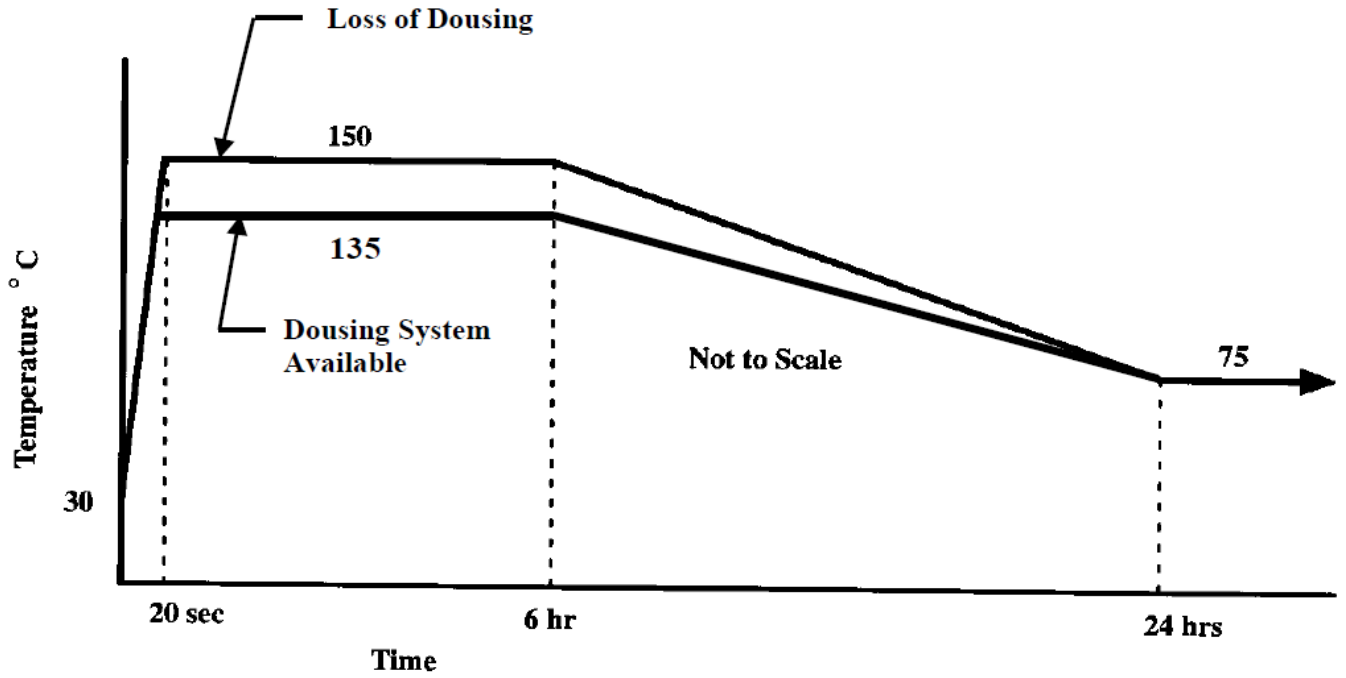
- According to the newest DBA analyses, pressure and temperature in the Reactor Building (RB) have different values for LOCA and MSLB accidents, and these values are enveloped by the pressure and temperature evolutions
- The bounding accident conditions for Cernavoda NPP for Design Bases Accidents were found for LOCA and MSLB sequences
- Current computer codes used for DBAs analysis for determining the environmental conditions for EQ of safety related SSC for a CANDU6 NPP are CATHENA and GOTHIC
- The mandatory period of time required for SSC qualified of environmental conditions to DBA is:
  - ✓ 3 months for SSC qualified EQ for LOCA
  - ✓ 1 week for SSC qualified for MSLB accident

Cernavoda SSCs Environmental Qualification at DBA

- In the Turbine Building (TB), the limiting environmental conditions are produced by the following accident scenarios:
  - Main Steam Line Break (MSLBO)
  - The area of ECCS equipment (pumps and heat exchangers the limiting conditions for radiation are applied from the LOCA accident
- For the SSCE located in the Service Building (SB), the environmental conditions considered are of “Mild” type,
- Examples of “Harsh” Environmental conditions for Cernavoda NPP U2 with CANDU-6 reactor in the Reactor Building are presented in the following Figures.

Cernavoda SSCs Environmental Qualification at DBA

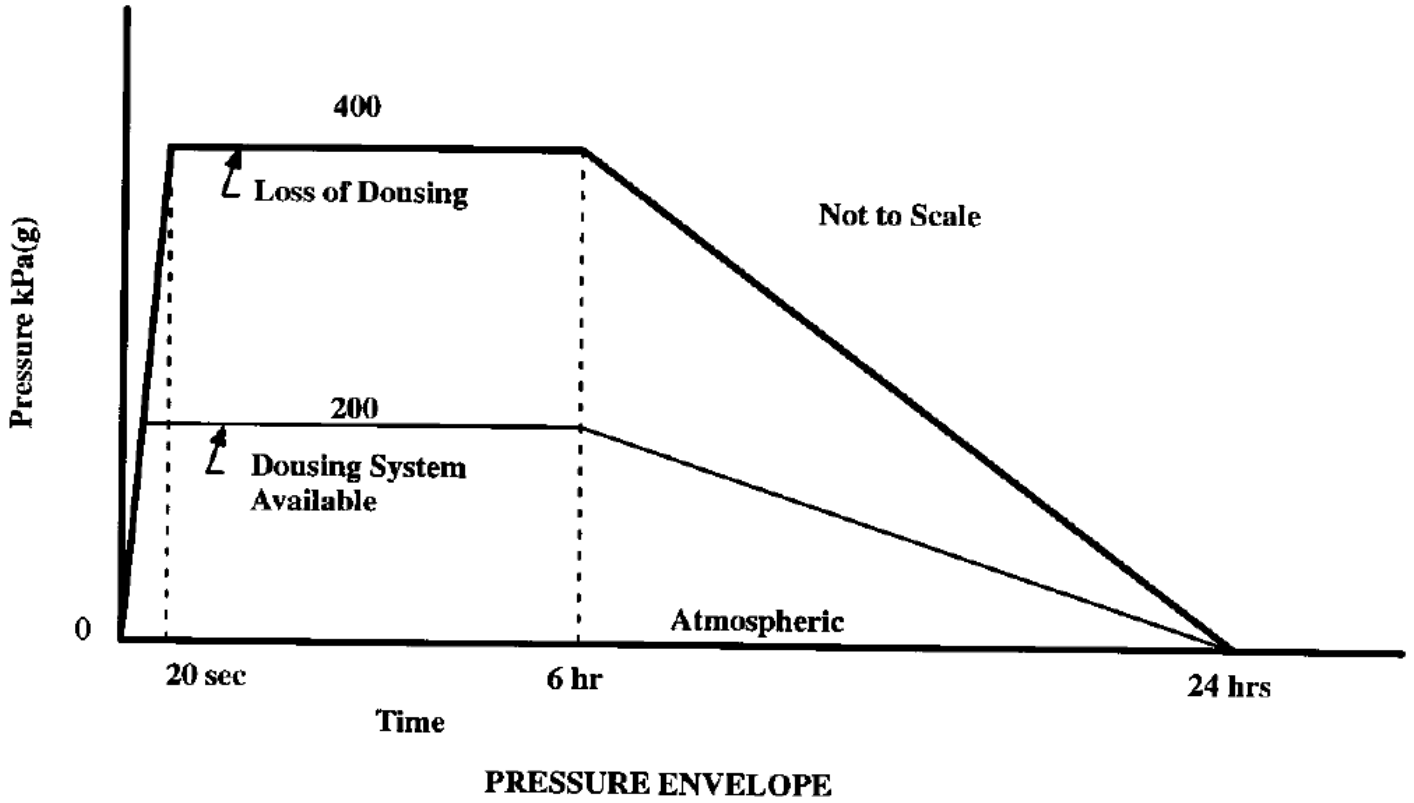
"Harsh" Environmental conditions for Cernavoda NPP: Temperature envelope in RB in case of a Main Steam Line Break accident



TEMPERATURE ENVELOPE

Cernavoda SSCs Environmental Qualification at DBA

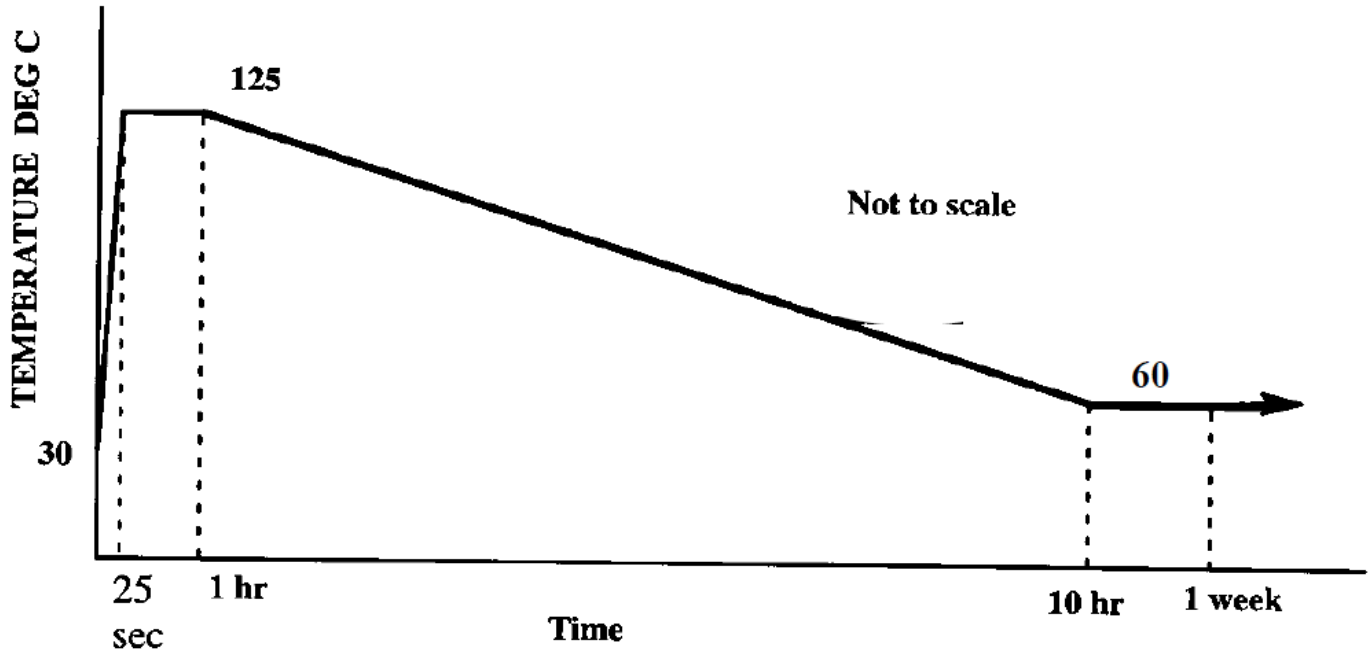
"Harsh" Environmental conditions for Cernavoda NPP: Pressure envelope in RB in case of a Main Steam Line Break accident



PRESSURE ENVELOPE

Cernavoda SSCs Environmental Qualification at DBA

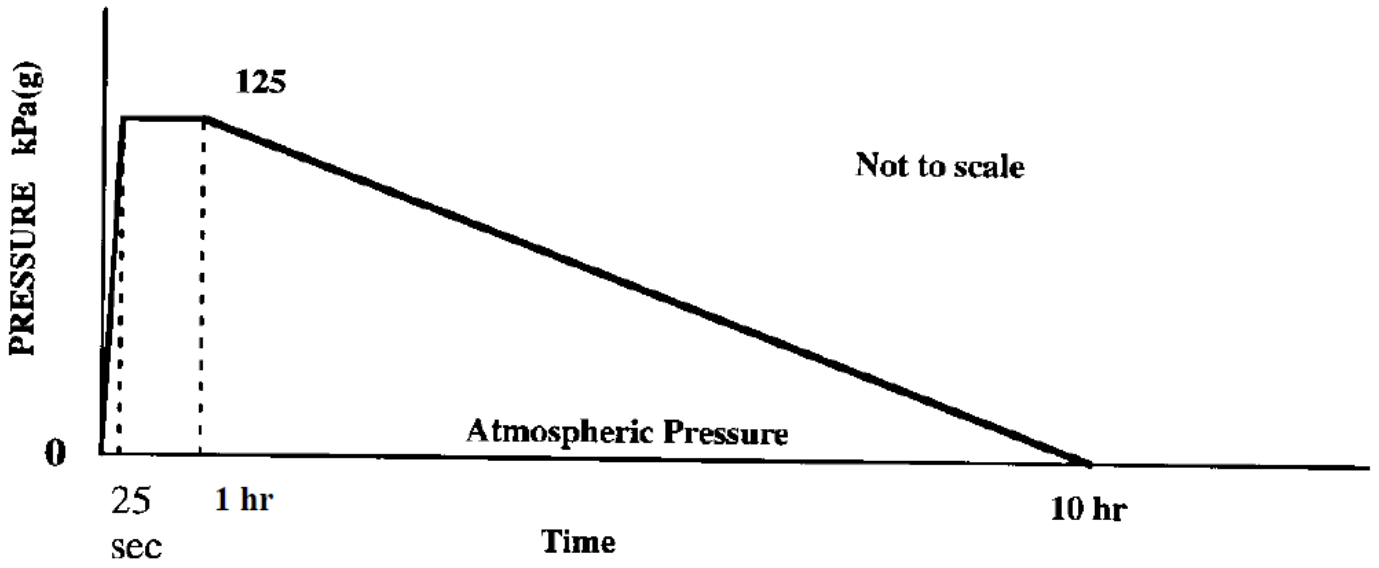
"Harsh" Environmental conditions for Cernavoda NPP: Temperature envelope in RB in case of a Large Loss of Coolant Accident



TEMPERATURE ENVELOPE

Cernavoda SSCs Environmental Qualification at DBA

"Harsh" Environmental conditions for Cernavoda NPP: Pressure envelope in RB in case of a Large Loss of Coolant Accident



PRESSURE ENVELOPE

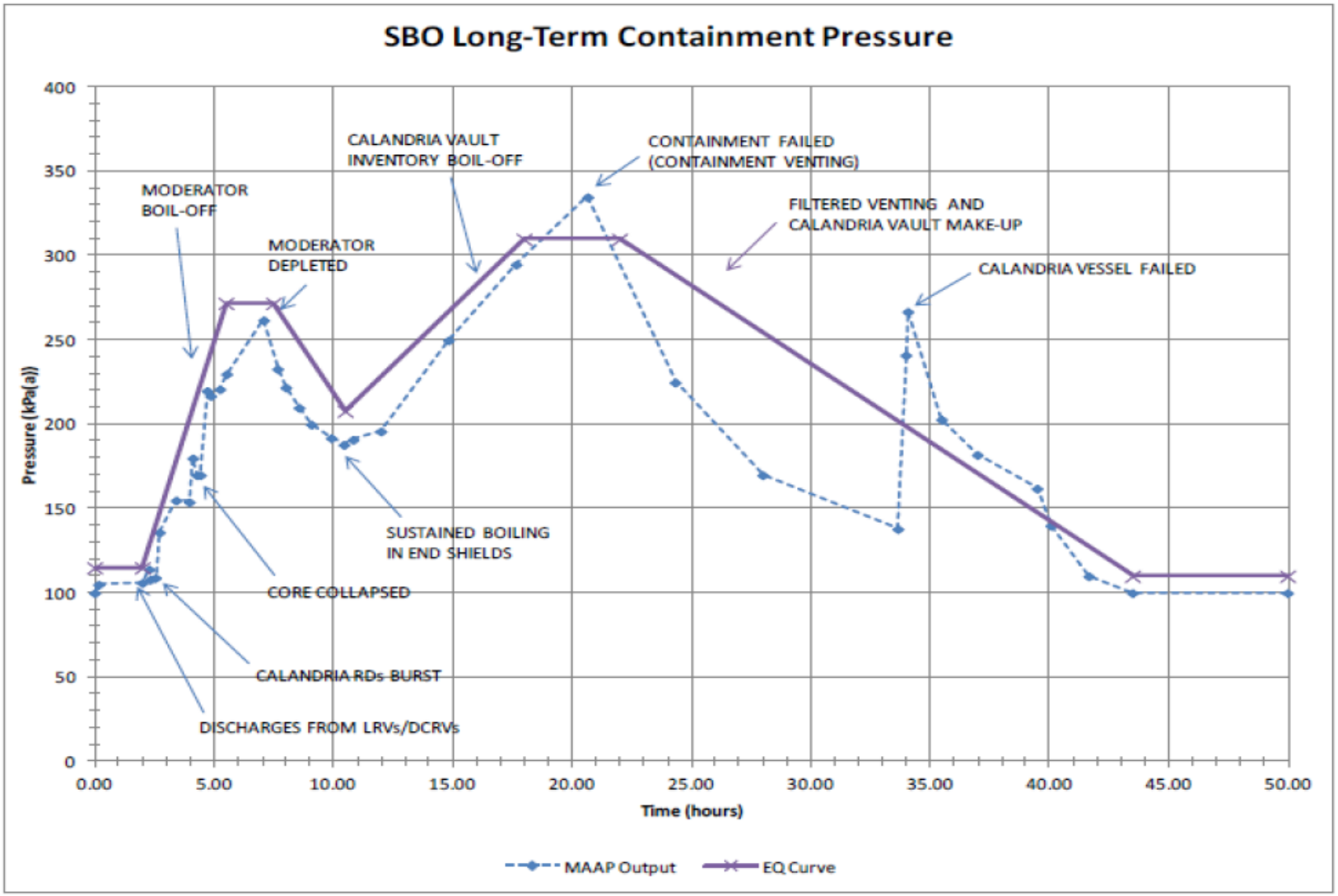
Environmental conditions for SSC Environmental Qualification – Severe Accidents

- After Fukushima NPP nuclear accident in 2011, for Environmental Qualification in case of a severe accident, parameters relevant (pressure, temperature and total integrated radiation doze) were calculated,
- These parameters were used for the EQ of the instrumentation in the Reactor Building, in order to both monitor the plant conditions and the effectiveness of the accident management measures taken.
  - The measurement rages of instrumentation were increased to cover severe accident conditions (as containment pressure) and new instrumentation, qualified to severe accident conditions, was added for these conditions monitoring (temperature, level in calandria vessel and calandria vault)
- Analyses of SA were performed borh in the frame of Stress Tests organized by EC after Fukushima Daiichi nuclear accident but also for ensuring support for Level 2 PSA for Cernavoda NPP units and
  - results were used to determine specific conditions in different areas to be considered for qualification or judgement of survival ability of component during and post severe accidents

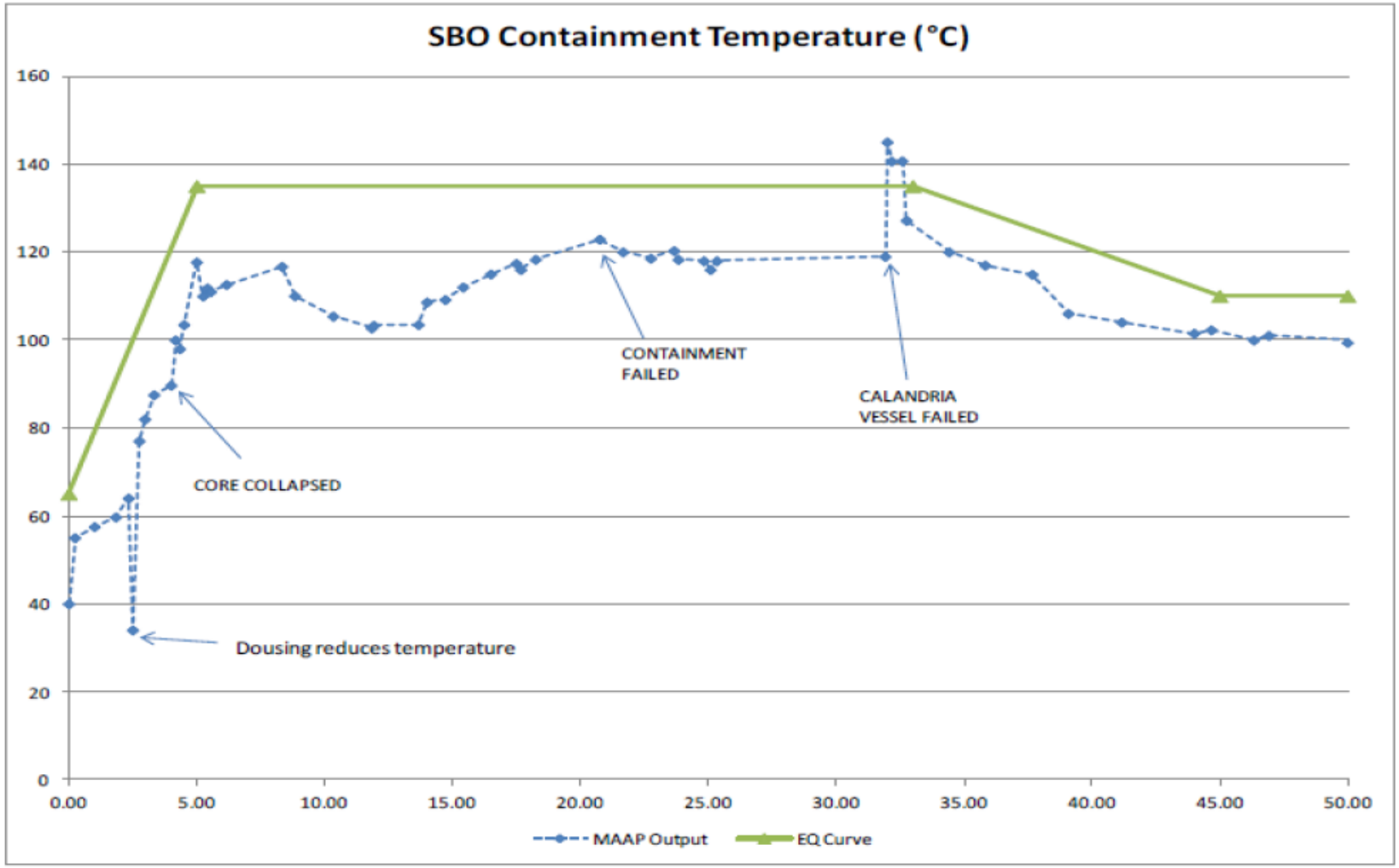
Environmental conditions for SSC Environmental Qualification – Severe Accidents

- The following accident sequences were analysed in order to define the worst conditions in severe accident
  - For the pressure and temperature inside RB two scenarios were analysed, (reference cases):
    - Station Blackout
    - Stagnation Feeder Break
  - For total integrated radiation doze (TID) inside RB the following scenario was analysed:
    - Stagnation Feeder Break
- The two selected scenarios were analysed with MAAP4 – CANDU computer code. Results obtained for SBO are presented as examples in the next figures.

Environmental conditions for SSC Environmental Qualification – Severe Accidents



Environmental conditions for SSC Environmental Qualification – Severe Accidents



Conclusions

- **Romania aligned to the best international practice** regarding:
  - ✓ Development of requirement regarding Environmental Qualification by the regulatory body
  - ✓ Re-assessment of bounding conditions for EQ of NPP SSC that fulfil safety functions in DBA
  - ✓ Verification of the qualified SSC, including in the frame of Periodic safety review of EQ SSC
  - ✓ Ageing management - of SSC qualified to EQ, etc.

- After Fukushima NPP nuclear accident in 2011, for Environmental Qualification in case of a severe accident, parameters relevant (pressure, temperature and total integrated radiation doze) were calculated for,
  - ✓ Qualification of instrumentation required for monitoring of the plant conditions during and after a SA
  - ✓ Qualification of SSC that are credited for prevention or mitigation of SA conditions (function of their location)

Thank you for your attention