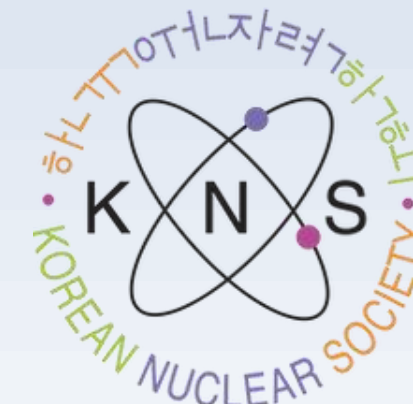


Preliminary Safety Assessment of the Methodology and Strategy for DEC-A in APR1000



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Introduction

- ◆ **Design Extension Condition (DEC)** comprise conditions in events without significant fuel degradation (DEC-A) and conditions in events with core melting (DEC-B)
- ◆ The **list of DEC-A events** are established in accordance with EUR requirements and incorporates the event lists provided by the Korea, IAEA, WENRA and APR1000 standard design
- ◆ Since DEC-A will be analyzed to support the **Dukovany 5&6 (DKN5&6) Preliminary Safety Analysis Report (PSAR) Chapter 20**, this study presents a preliminary safety assessment for DEC-A analyses, including analysis methodology and strategy

Analysis Methodology for DEC-A

- ◆ According to EUR requirements, the safety analysis for DEC-A shall rely on **Best-Estimate methodologies**
 - Normal operating conditions and plant design values
 - Additional **single failure** is not assumed
 - **Off-site power** is available
 - Automatic actuation of **control systems**
 - Adequate margin with regard to **Cliff-Edge effects** (IAEA, SSG-2)
- ◆ The **acceptance criteria** of DEC-A are defined for physical barriers, including the fuel, Reactor Coolant System (RCS) and containment assigned for **DiD level 3b**
 - **Peak cladding temperature** : 1,204°C (2,200°F)
 - **RCS pressure** : 125% of the design pressure
 - **Containment pressure** : Factored Load Category (FLC)
 - **Radiological dose limit** : 10 mSv
- ◆ The **operator actions** are not assumed during the first **30 minutes** in the Main Control Room (MCR) or **60 minutes** outside the MCR

Strategy for DEC-A

- ◆ The accident is mitigated by **safety features** (such as overpressure protection devices, reactor protection system and engineered safety features) during the **first 30 minutes** following event initiation, **with no operator action**
- ◆ **Decay heat will be removed** via Passive Auxiliary Feedwater System (PAFS), and the **RCS will be depressurized** to Shutdown Cooling System (SCS) entry condition **after 30 minutes** following event initiation, **with operator action**. Also, the design should preferably ensure that the **safe state is reached within 24 hours**
- ◆ **Dedicated features** are newly implemented for DEC-A events

Table 1. Event Lists and Dedicated Features for DEC-A

PSAR	DEC-A Events	Dedicated Features
20.1.1	Anticipated Transient Without Scram (ATWS) due to Mechanical Blocking of Rods	EBS
20.1.2	ATWS due to Failure of RPS	DPS
20.1.3	Station Blackout (SBO)	AAC-DG
20.1.4	Total Loss of Feedwater to the Steam Generators (TLOFW)	N/A
20.1.5	Loss of Coolant Accident (LOCA) with Loss of Safety Injection	N/A
20.1.6	Uncontrolled Boron Dilution	N/A
20.1.7	Loss of Ultimate Heat Sink during Normal Operation (LOUHS)	Diverse System (DESW, DCCWS, DUHS)
20.1.8	Total Loss of Cooling Chain during Normal Operation	Diverse System (DSFPCS)
20.1.9	Loss of Spent Fuel Cooling Functions during Normal Operation (LOSFPC)	SGEBDS
20.1.10	Multiple Steam Generator Tube Ruptures (MSGTR)	N/A
20.1.11	Main Steam Line Break with Consequential Steam Generator Tube Ruptures	N/A
20.1.12	Loss of Residual Heat Removal System (LORHR)	N/A
20.1.13	Interfacing System LOCAs (ISLOCA)	N/A

Preliminary Safety Analysis Results

Analysis Modeling for ATWS due to Mechanical Blocking of Rods

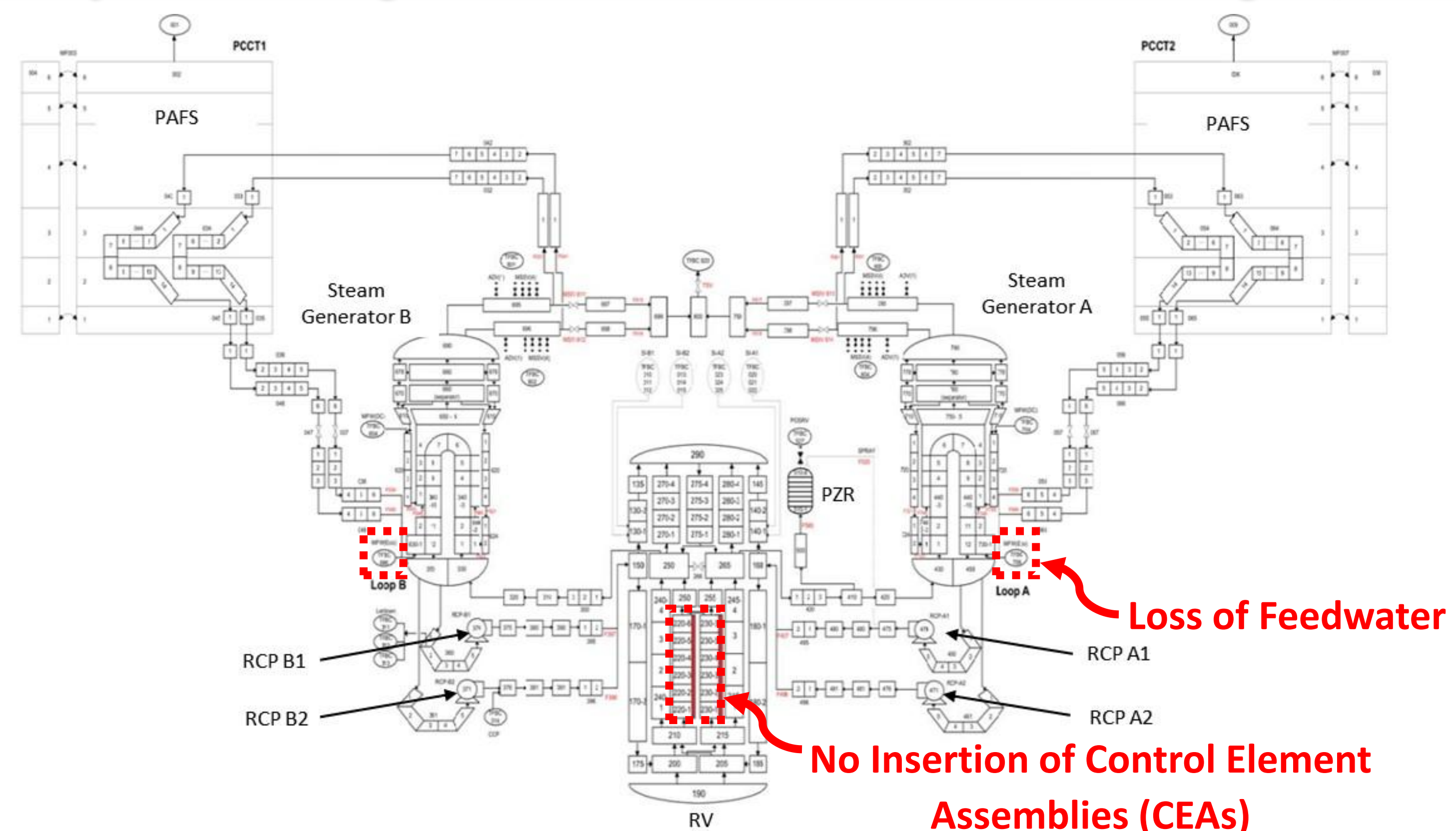


Figure 1. SPACE Nodalization in APR1000

- ◆ **Limiting event** : ATWS with Loss of Normal Feedwater (ATWS-LONF)
- ◆ **Nuclear design data** : First fuel cycle with the **least negative MDC**
- ◆ **Other assumptions** : Based on Best-Estimate methodologies

Analysis Results for ATWS due to Mechanical Blocking of Rods

- ◆ **ATWS-LONF** → **Decrease in heat transfer** → **Increase in both pressurizer level and pressure** → **Reactor trip signal by Low Steam Generator Level (LSGL)** → **But, no insertion of CEAs by mechanical blocking of rods** → **POSRVs open and PAFS is actuated as SG inventory depletes** → **continuous boron injection by EBS**
- ◆ **Acceptance criteria** (21.5MPa) : **Satisfied** (17.97MPa, 106.4sec)
- ◆ **EBS (dedicated feature)** : **Performance** for emergency boron tank capacity, boron concentration, and EBS pump flow rate **is evaluated**

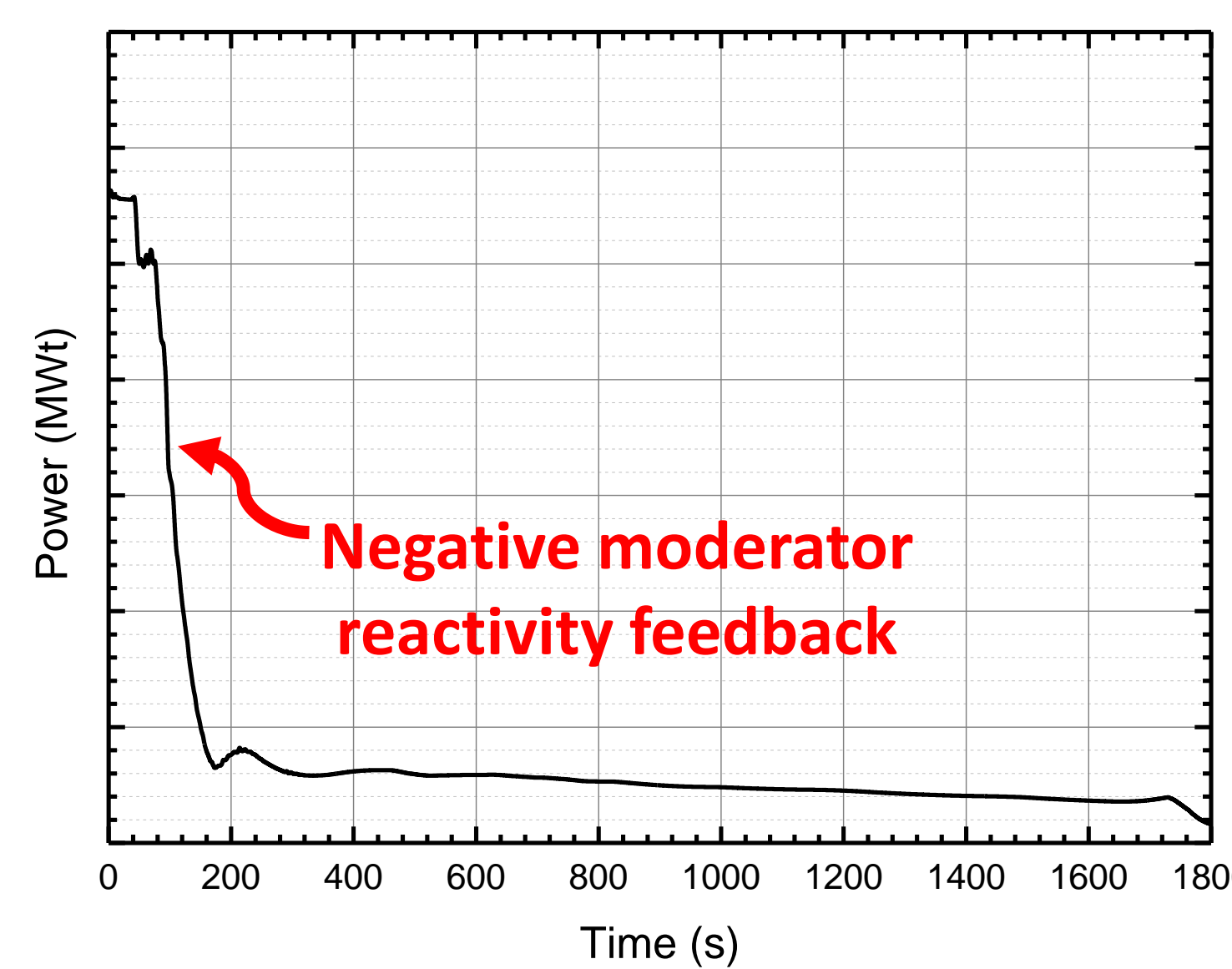


Figure 2. Core Power (MWt)

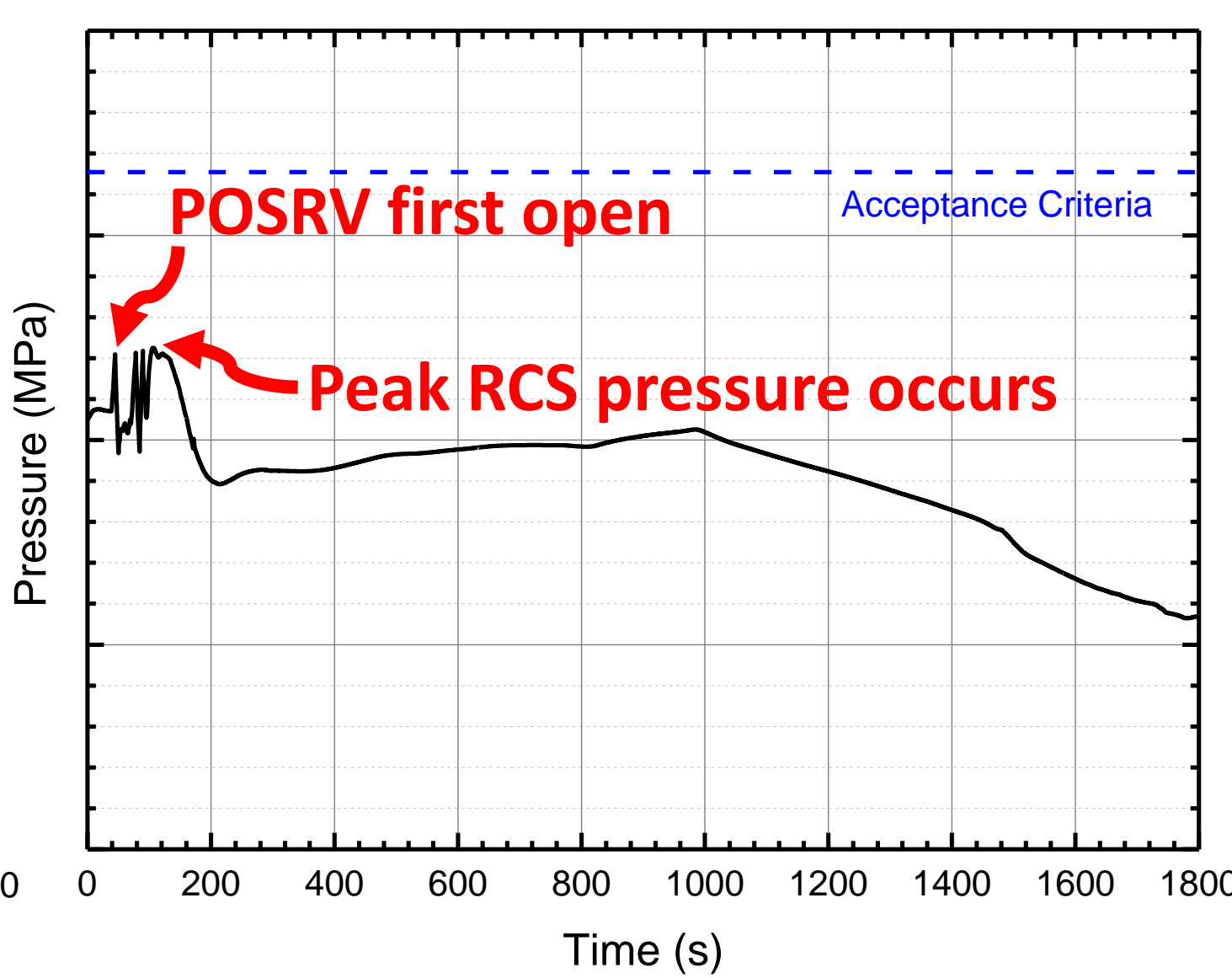


Figure 3. RCS Pressure (MPa)

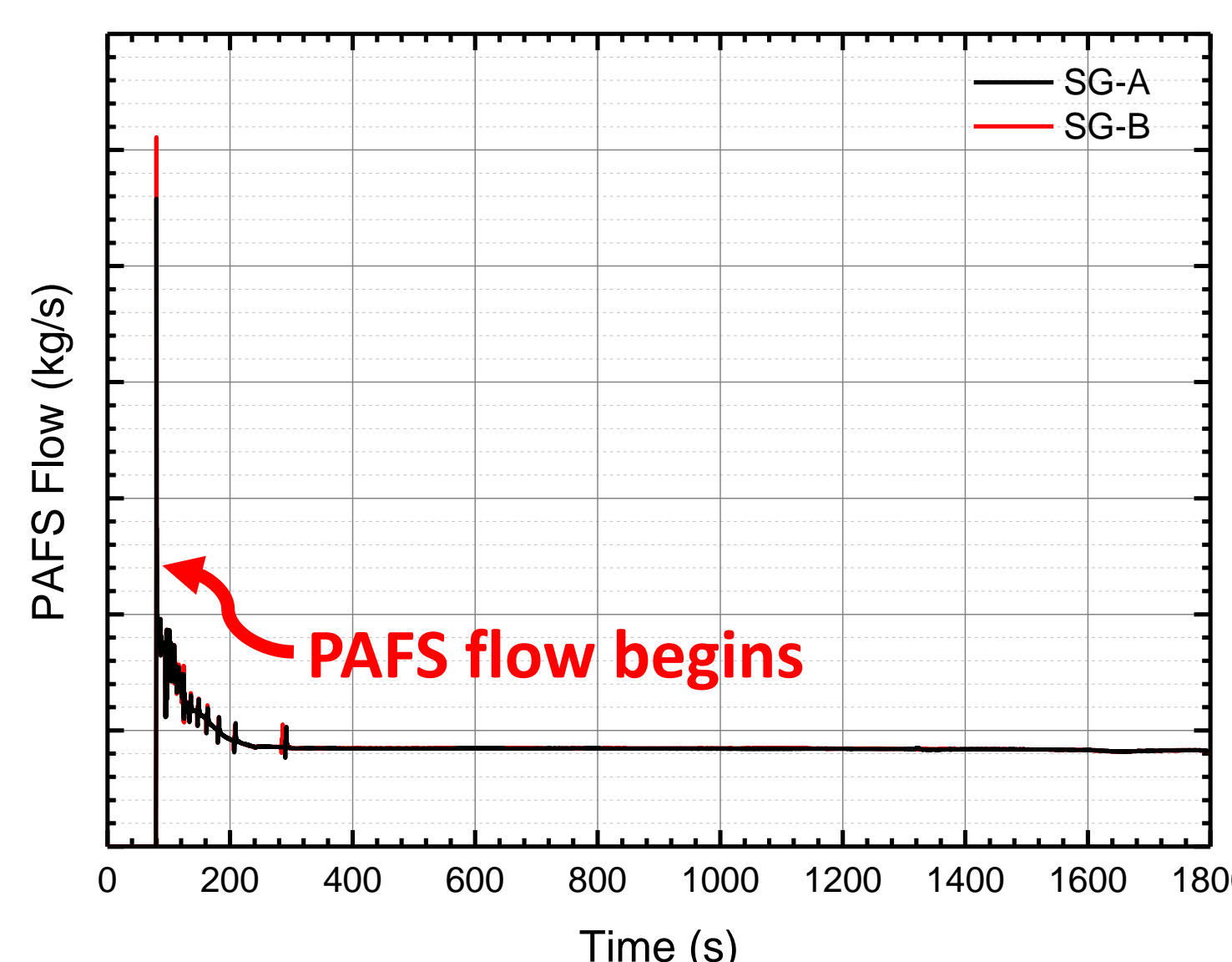


Figure 4. PAFS Flow Rate (kg/s)

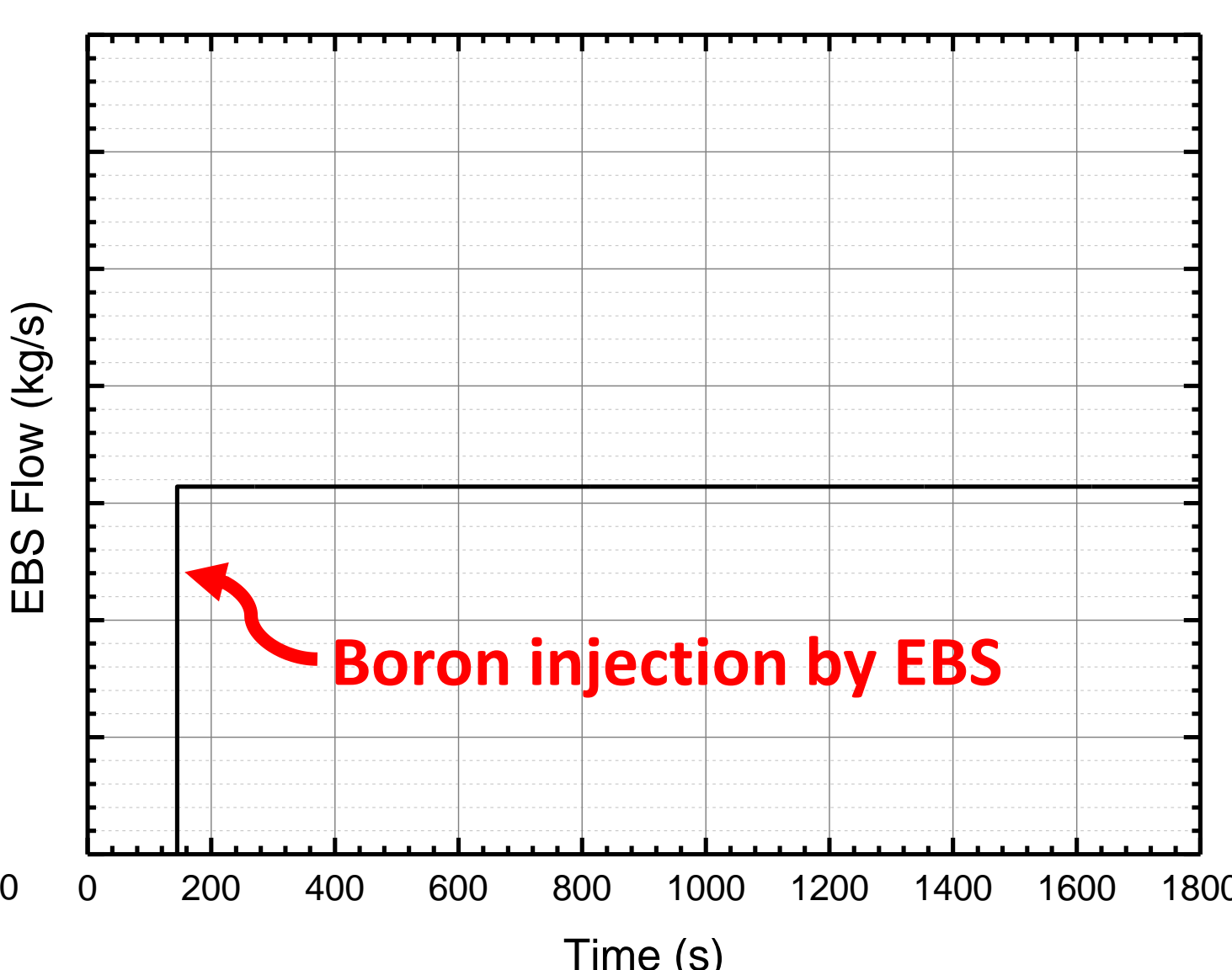


Figure 5. EBS Flow Rate (kg/s)

Conclusions

- ◆ **ATWS due to mechanical blocking of rods**, one of the DEC-A events, **was analyzed** using SPACE code **based on the methodologies and strategies** presented in this paper
- ◆ **DEC-A events will be re-analyzed** to support Chapter 20 of the DKN5&6 PSAR for the export of nuclear power plants
- ◆ **DEC-A methodologies and strategies will be refined** through clarification processes with Czech and regulatory requirements