6th Meeting of the
"European MELCOR User Group"

Bohunice V2 NPP containment model MELCOR to APROS comparison

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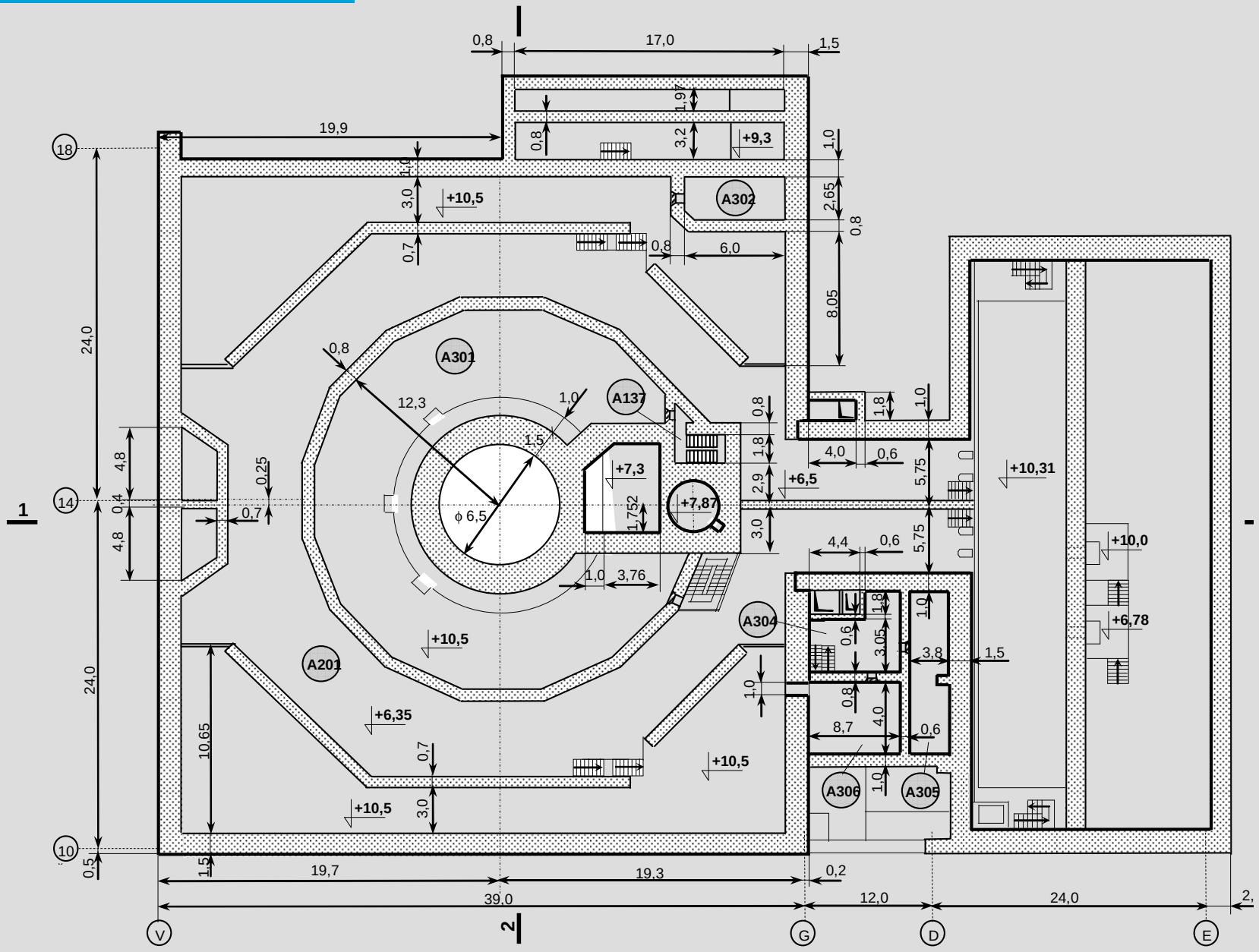
Overview

- Containment of NPP VVER 440/V213
- MELCOR containment model
- APROS containment model
- MELCOR to APROS comparison
- Future plans

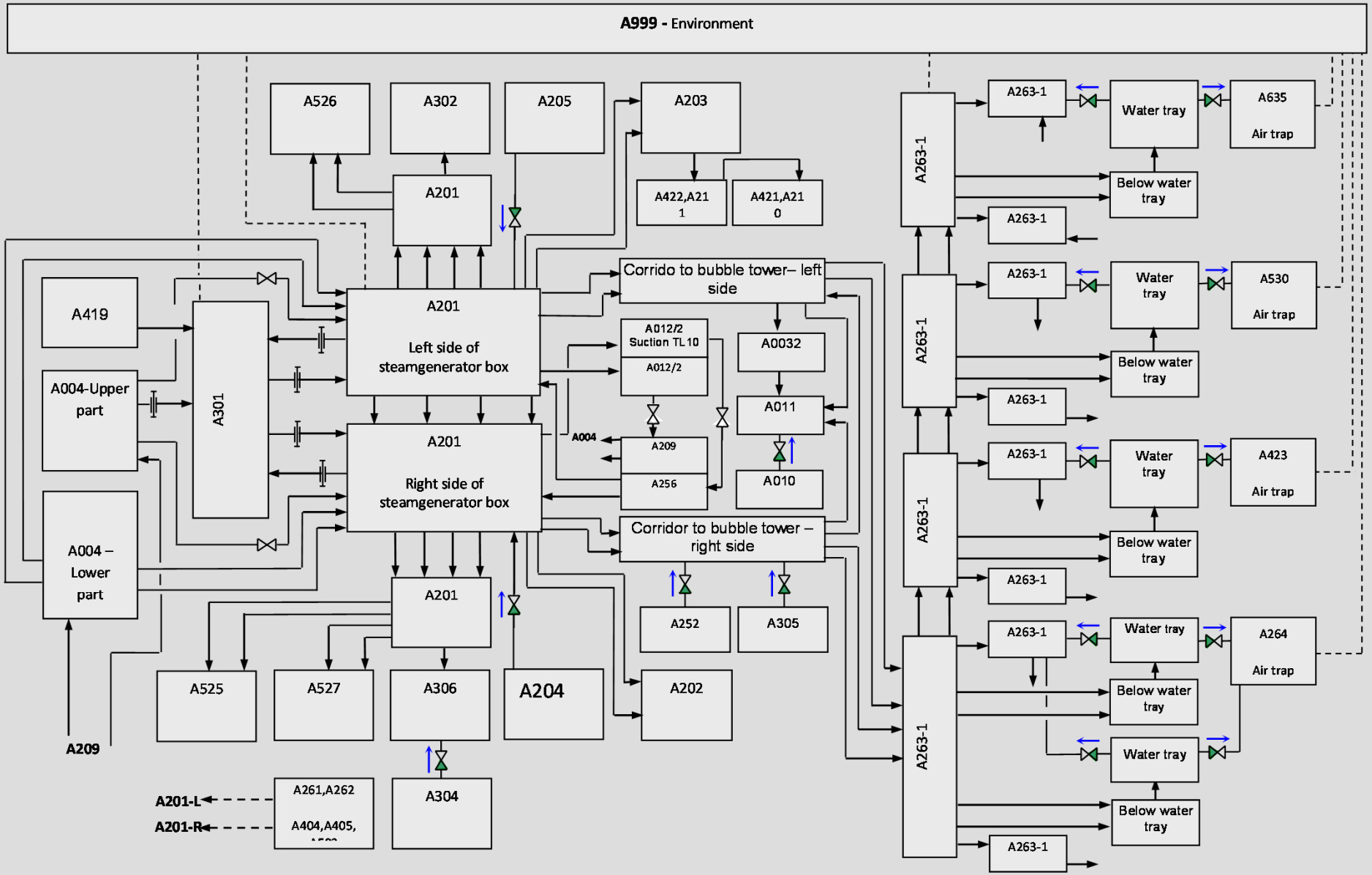
VVER 440/V213 Containment



MELCOR Containment Model Features

- MELCOR 1.8.5
- separated analysis of VVER 440/V213 containment phenomena without MCCI, applied for Safety analyses
- model contains:
  - 64 control volumes
  - 139 flow paths
  - 211 heat structures
- verification – code to code comparison with CONTAIN and ASTEC

MELCOR Containment Model



APROS containment model developing project

- intention of SE (Slovenské elektrárne) to use APROS computer code for analysis and simulation of processes in Bohunice V2 NPP
- plant model – primary and secondary circuit

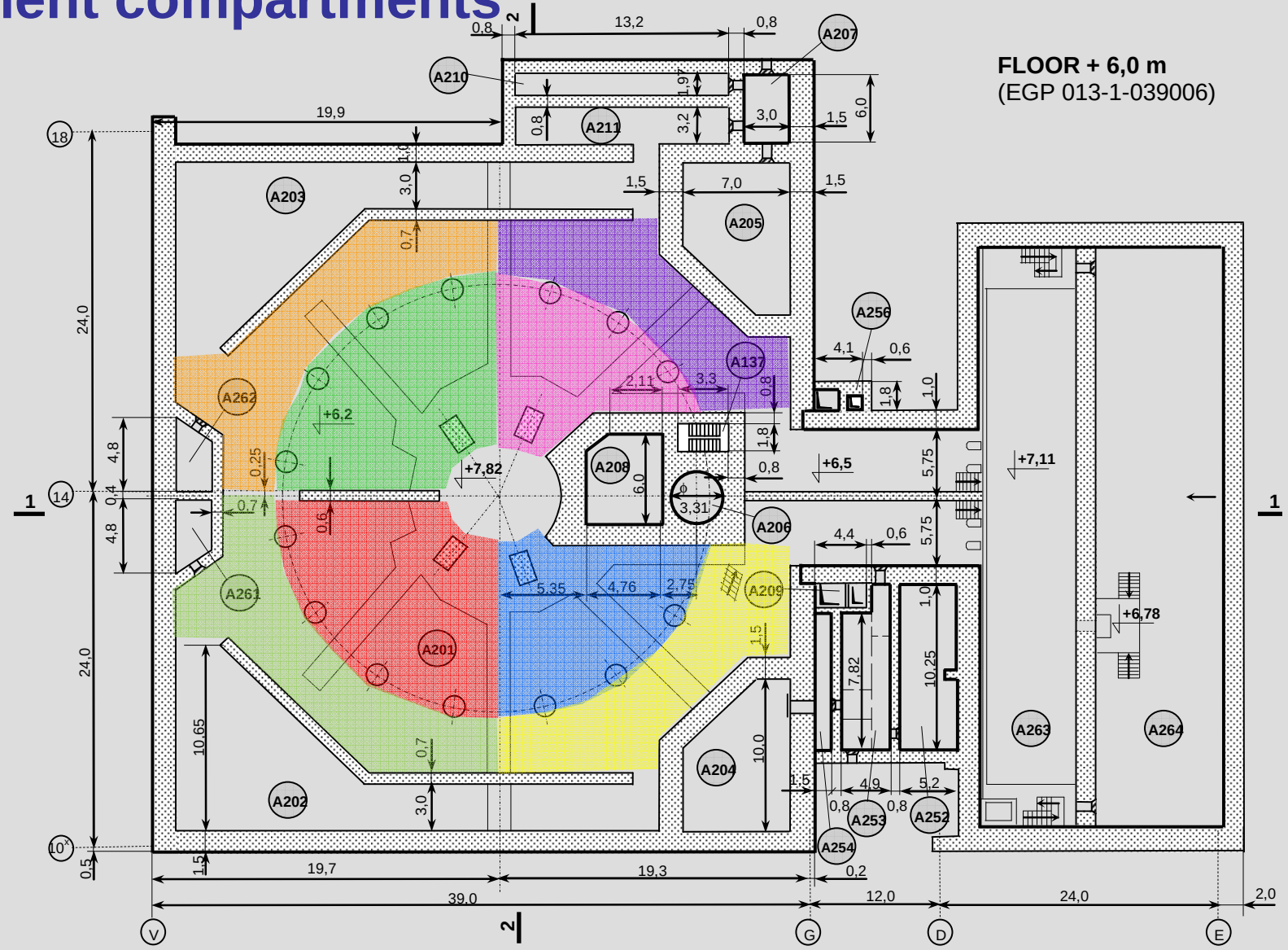
2013 – Containment project

- contracting party: SE, Fortum and VUJE
- to develop containment of NPP Bohunice V2 and integrate it into existing plant model
- verification of the model – code to code comparison

Extent of APROS containment model

- main containment compartments (with flow paths and heat structures)
- containment active spray system TQ20, TQ40, TQ60
- pressure suppression system XL
  - pressure suppression function
  - passive spraying of bubble tower
  - possibility of manual draining of coolant from suppression trays
  - vacuum breaker system
- model of the most important ventilation systems
  - inlet system TL41
  - outlet system TL71
  - circulation systems TL10 and TL11
- temperature and pressure measurements in containment (input for RTS and ESFAS)

Containment compartments



Verification of APROS model

- code-to-code comparison with MELCOR code
- 3 transients with stand alone containment model
  - LOCA 2x500 mm
  - LOCA 107 mm
  - Steam-line break
- 1 transient with integrated model (unit model)
  - LOCA 2x500 mm
- verification was based on qualitative assessment and engineering judgments according IAEA SRS No. 23

LOCA 2x500 mm (stand alone model)

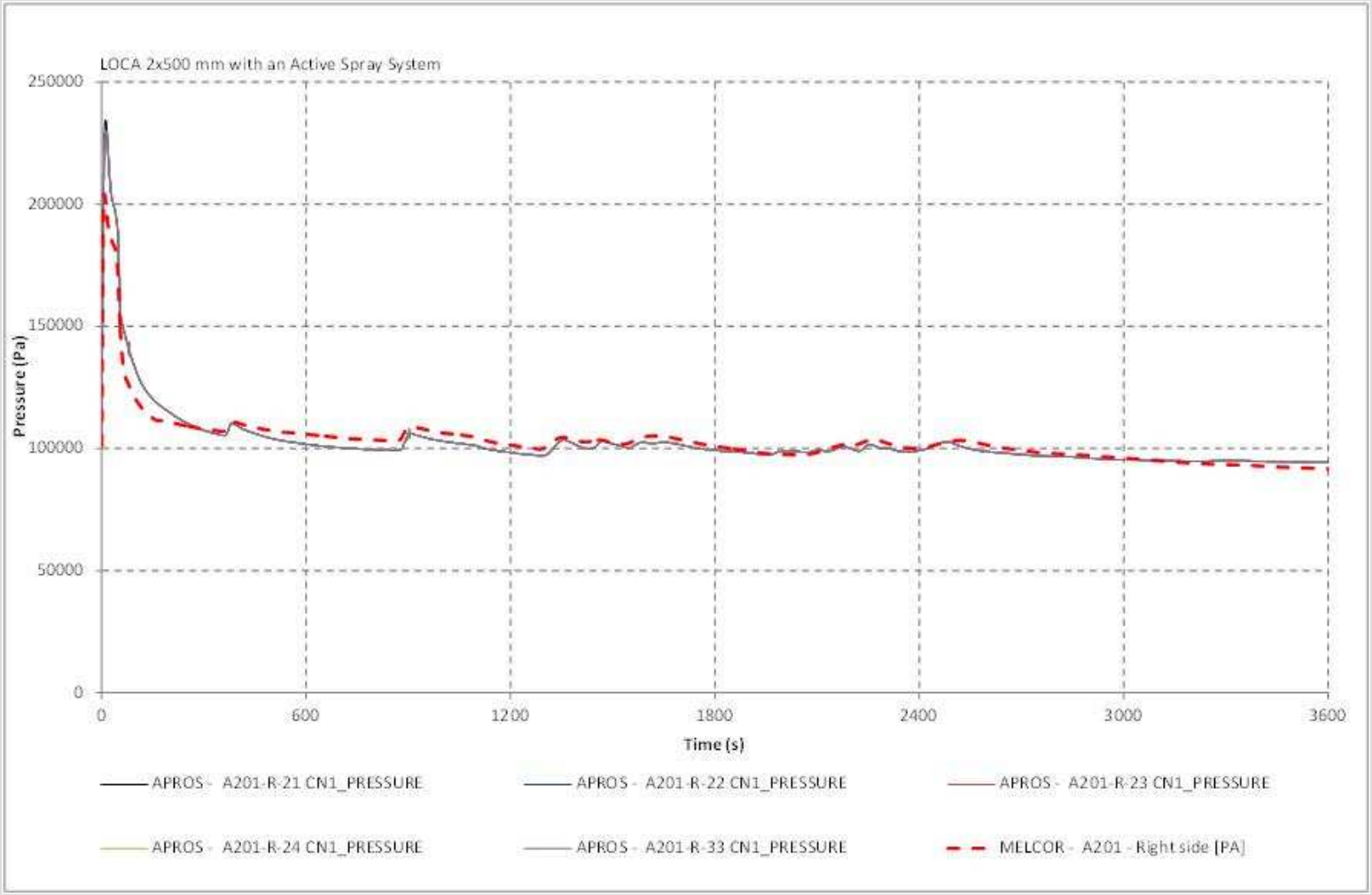
Chronological sequence of important events

Event	Time from initiating event [s] / Relevant value	
	APROS	MELCOR
Initiating event (break of main pipeline)	0	0
Signal ESFAS U01 „Confinement overpressure > 10 kPa“, signal for confinement spray start	0.5 s	0.5 s
Maximum SG boxes pressure	11 s 234.2 kPa^{abs}	9 s 203.8 kPa^{abs}
Maximum SG boxes temperature	11 s 126.5 °C	29 s 147.0 °C
Maximum SG boxes temperature at pressure peak	126.5 °C	137.1 °C
Maximum pressure inside air traps	31 s 195.6 kPa^{abs}	45 s 178.1 kPa^{abs}
Sub-pressure operation of the confinement	737 s*	1166 s*
Minimum pressure in SG boxes	94.3 kPa^{abs}	91.4 kPa^{abs}
Interval of the spray system operation	45 s - end	41 s - end
Start passive spraying	46 s	45 s
End of passive spraying	225 s	170 s
Initial and final mass of water in the trays	1.27E+06/4.23E+05 kg	1.12E+06/1.12E+05 kg
Recirculation regime initiation	1093 s	1093 s
End of calculation	3600 s	3600 s

*) sub-pressure operation of the containment is not preserved till the end of the calculation

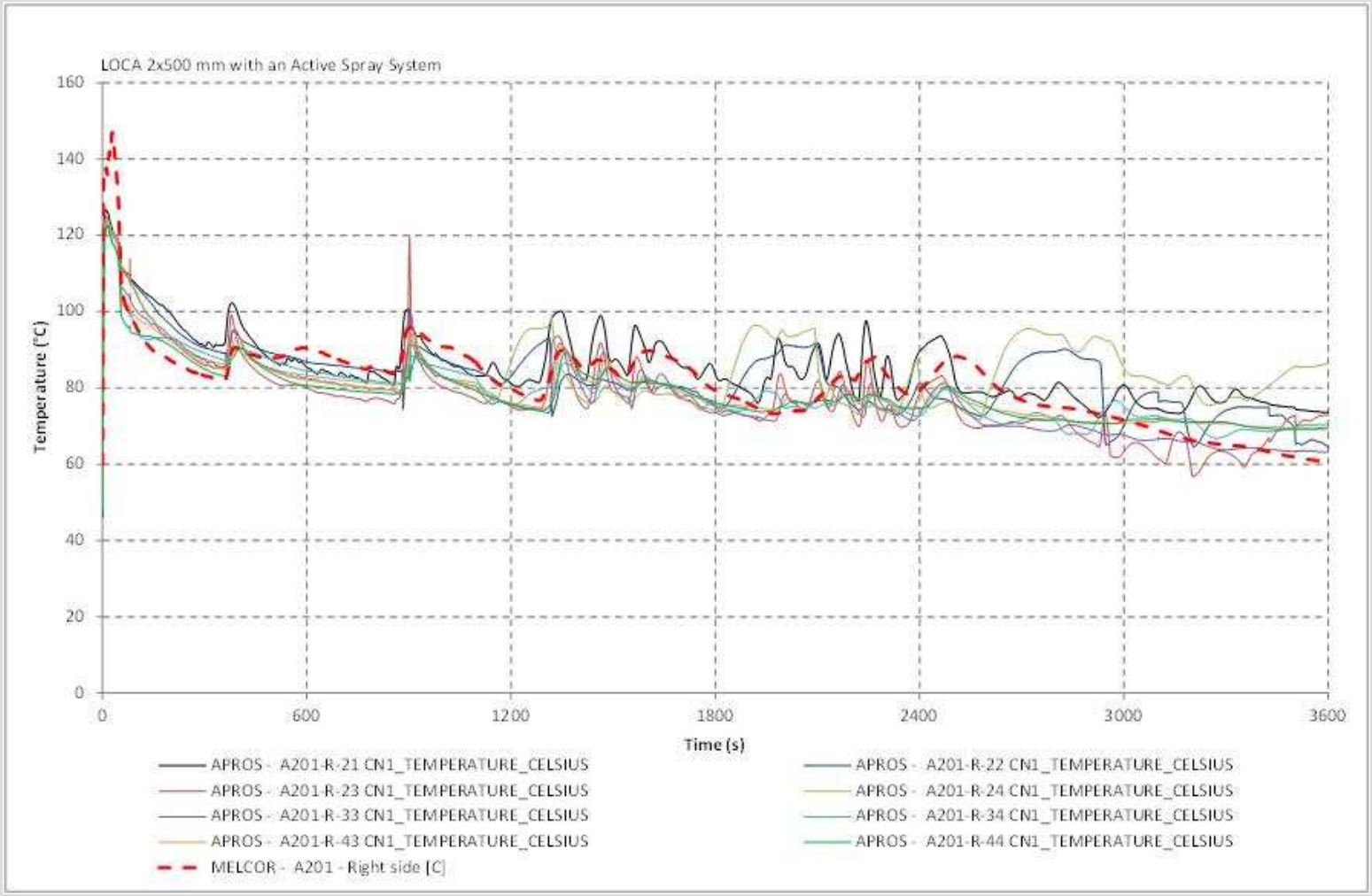
LOCA 2x500 mm (stand alone model)

Pressure in the right side of Steam Generator Box



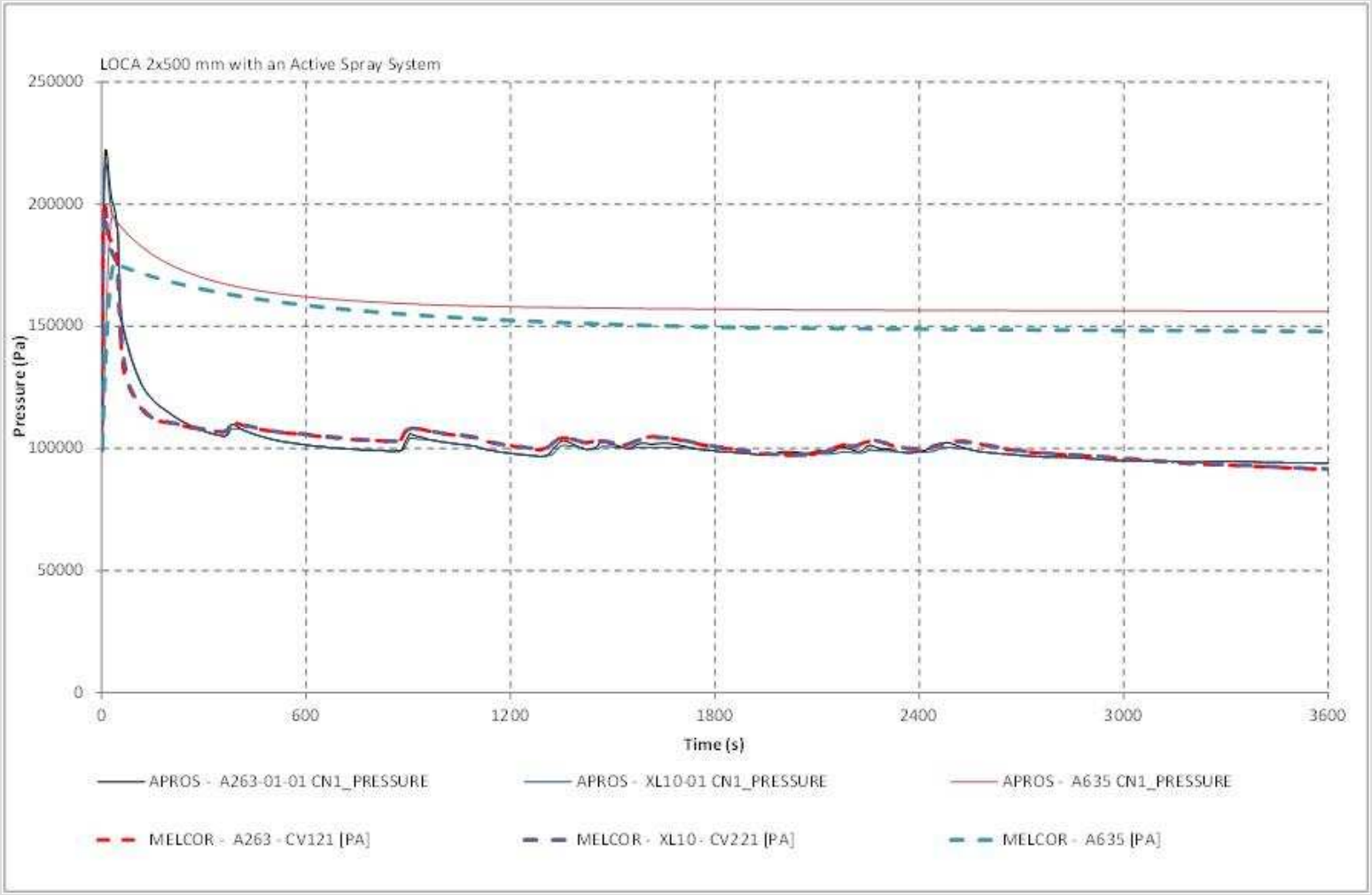
LOCA 2x500 mm (stand alone model)

Temperature in the right side of Steam Generator Box



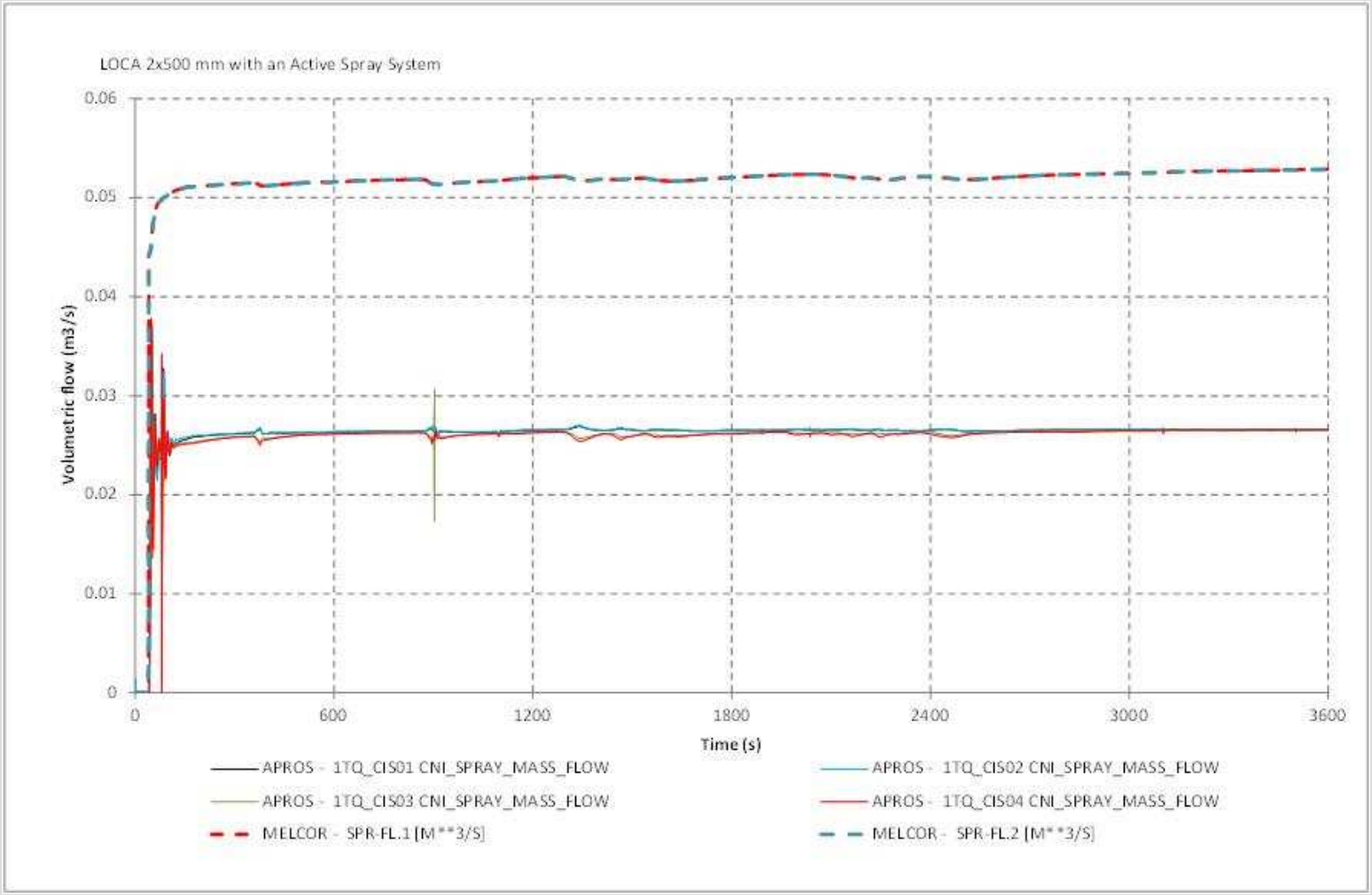
LOCA 2x500 mm (stand alone model)

Pressure in bubble tower 1st floor



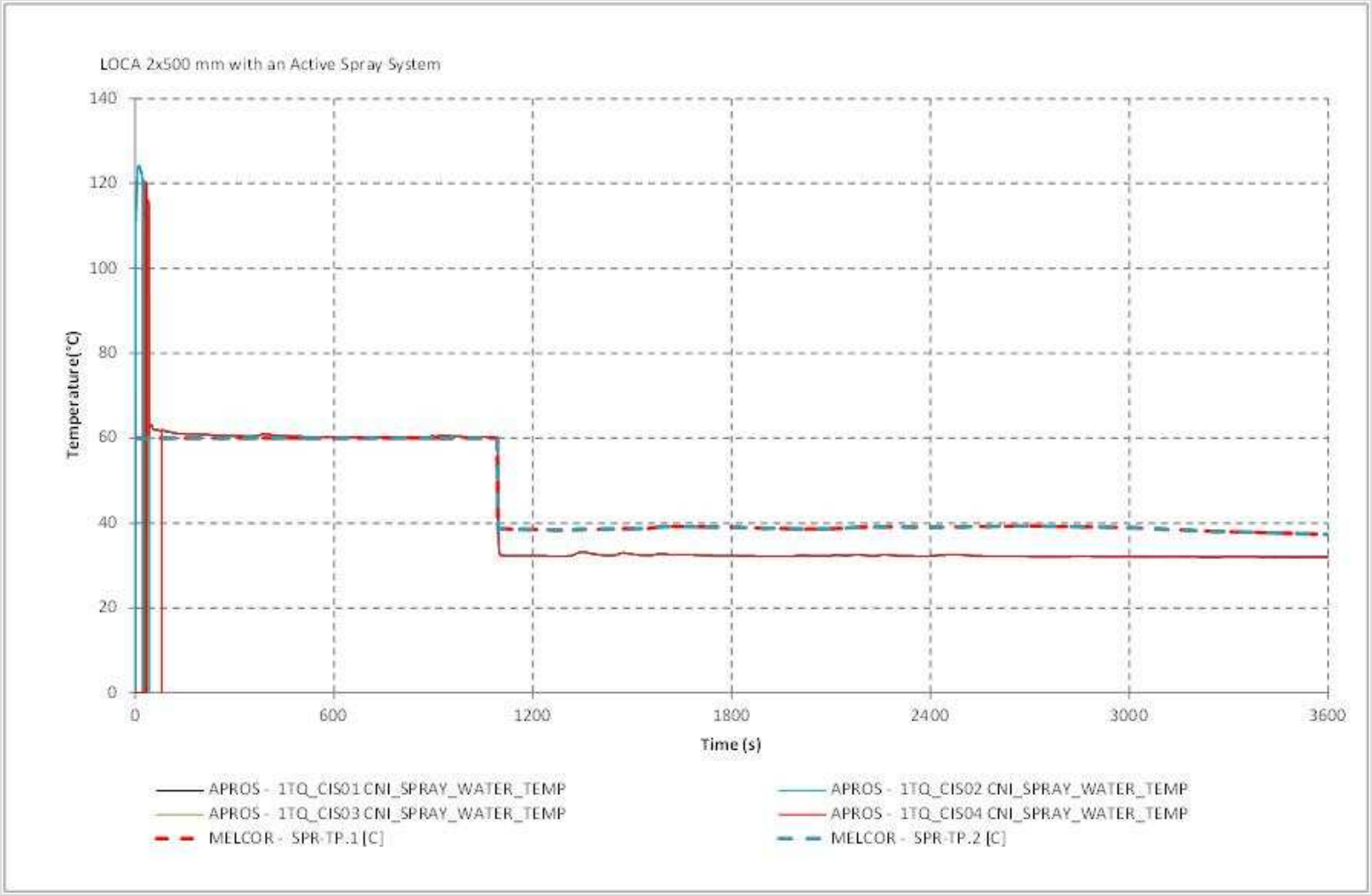
LOCA 2x500 mm (stand alone model)

Volumetric flow through active spray



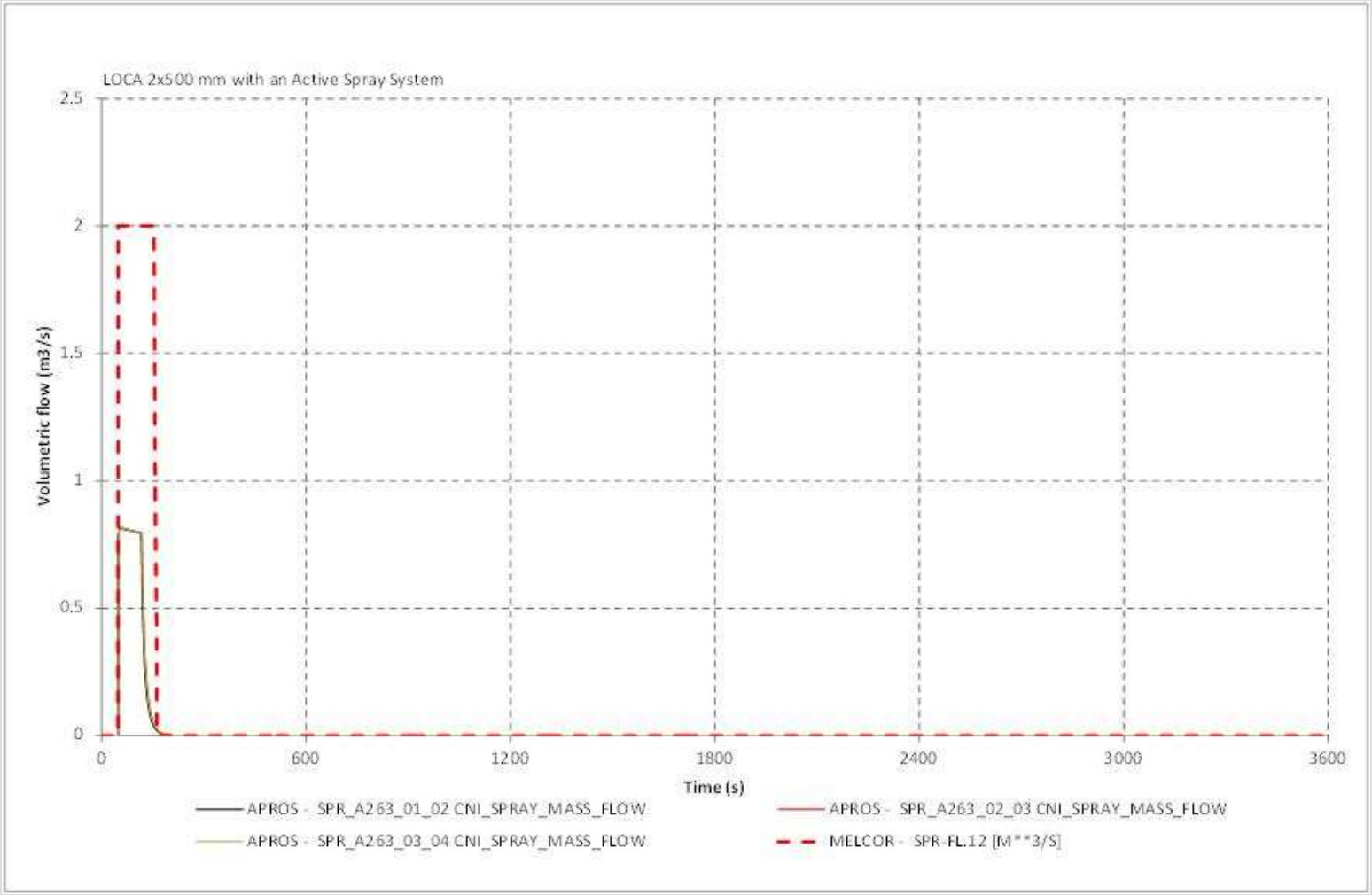
LOCA 2x500 mm (stand alone model)

Active spray water temperature



LOCA 2x500 mm (stand alone model)

Flow through passive spray 1st – 3rd floor



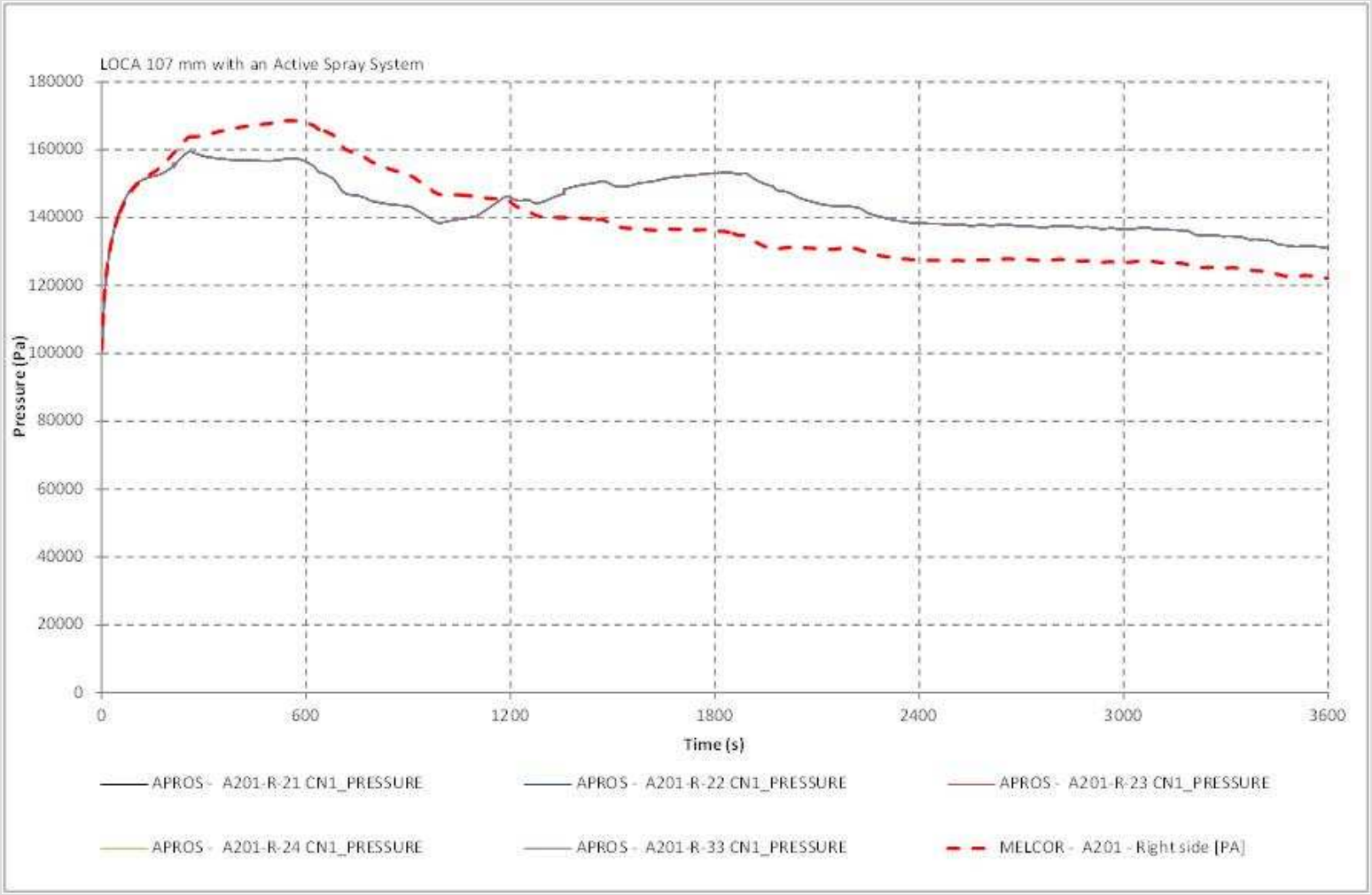
LOCA 107 mm (stand alone model)

Chronological sequence of important events

Event	Time from initiating event [s] / Relevant value	
	APROS	MELCOR
Initiating event (break of main pipeline)	0	0
Signal ESFAS U01 „Confinement overpressure > 10 kPa“, signal for confinement spray start	4.4 s	4.2 s
Maximum SG boxes pressure	259 s 159.5 kPa^{abs}	546 s 168.6 kPa^{abs}
Maximum SG boxes temperature	591 s 176.7 °C	590 s 148.5 °C
Maximum SG boxes temperature at pressure peak	113.2 °C	145.9 °C
Maximum pressure inside air traps	258 s 153.7 kPa^{abs}	570 s 163.4 kPa^{abs}
Sub-pressure operation of the confinement	-	-
Minimum pressure in SG boxes	130.9 kPa^{abs}	122.0 kPa^{abs}
Interval of the spray system operation	47 s - 1100 s; 1950s - end	45 s - end
Start passive spraying	-	-
End of passive spraying	-	-
Recirculation regime initiation	1104 s	1104 s
End of calculation	3600 s	3600 s

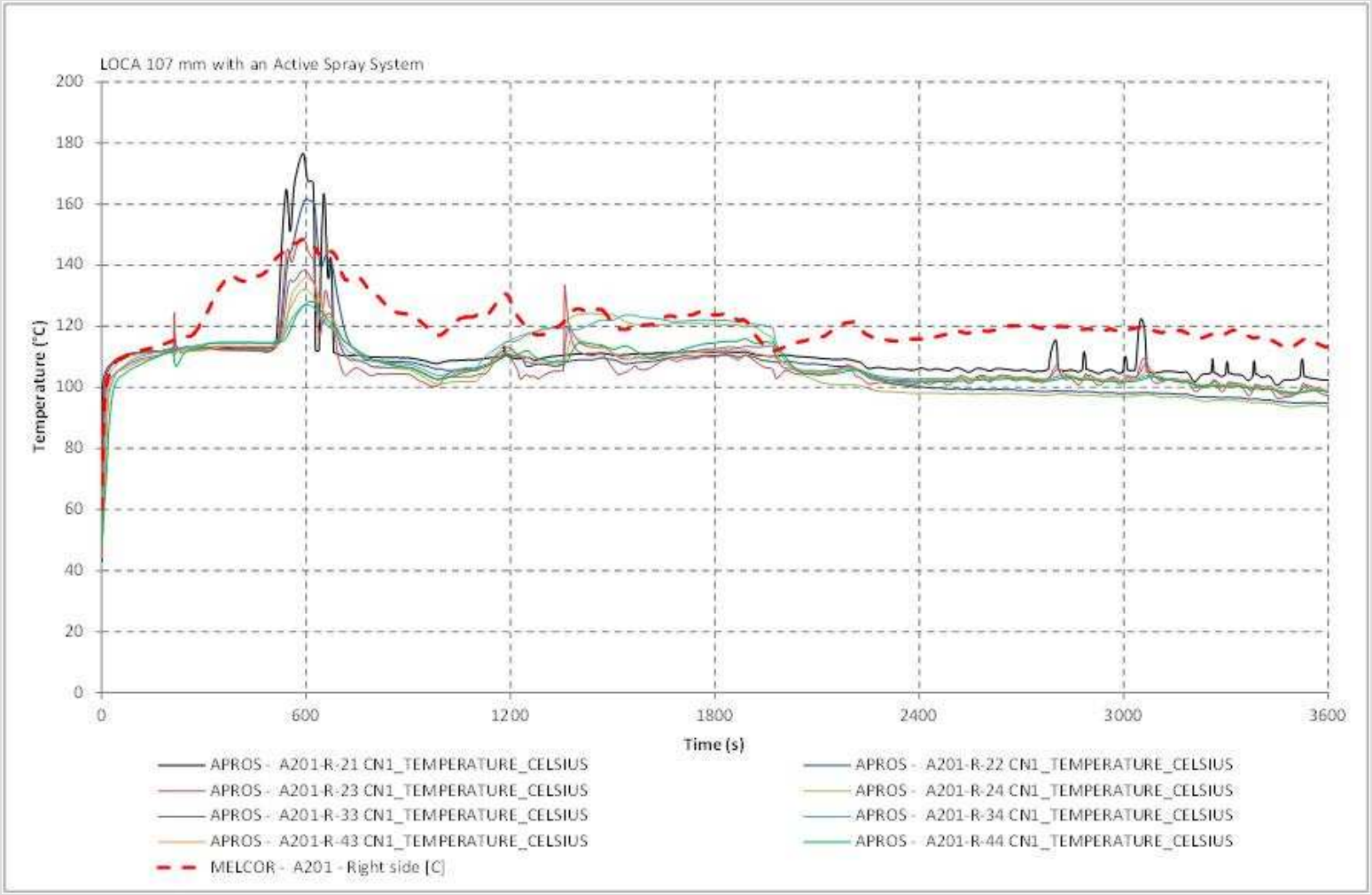
LOCA 107 mm (stand alone model)

Pressure in the right side of Steam Generator Box



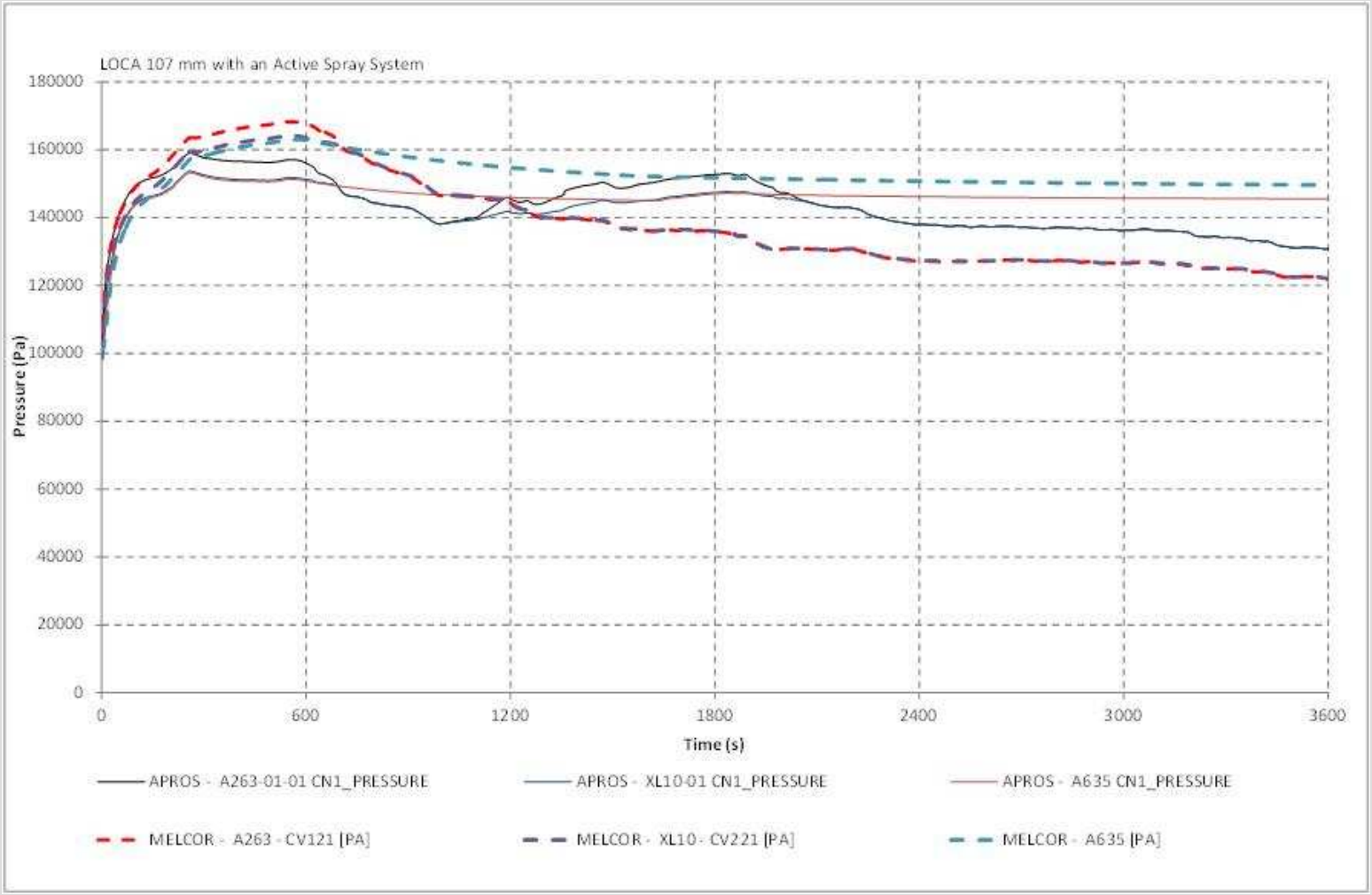
LOCA 107 mm (stand alone model)

Temperature in the right side of Steam Generator Box



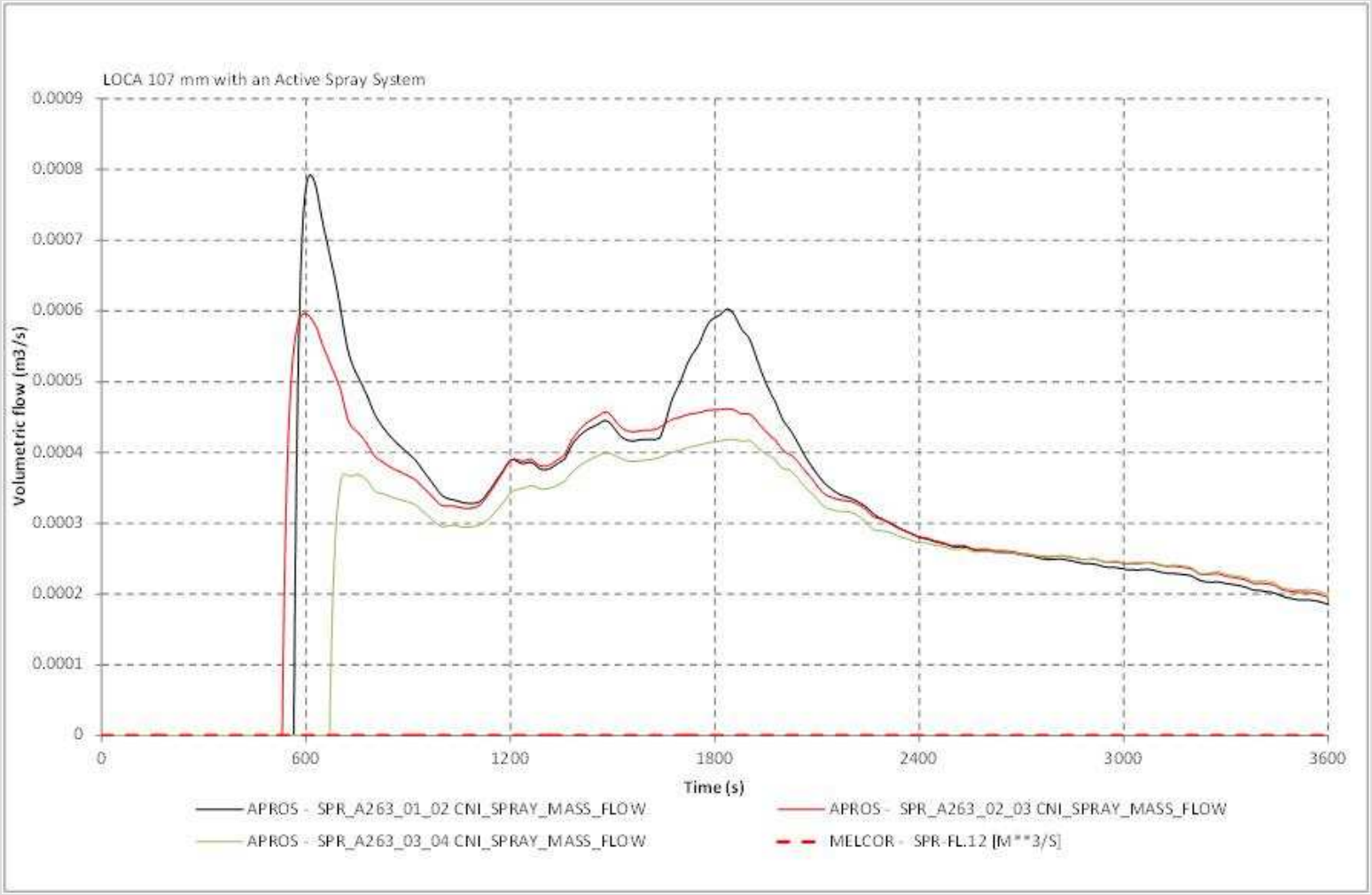
LOCA 107 mm (stand alone model)

Pressure in bubble tower 1st floor



LOCA 107 mm (stand alone model)

Flow through passive spray 1st – 3rd floor



Conclusion

- In spite of flashing phenomenon results show good agreement of compared analysed scenarios.
- APROS containment model is fully capable to analyze containment response to a wide range of postulated initiating events.
- Comparison of the APROS containment model using detail nodalization of room A201 of VVER 440/V213 containment with the MELCOR 1.8.5 containment model showed applicability of the proposed detailed nodalization. Similar nodalization is being prepared for new containment model for MELCOR 2.1.

Future plans

- Containment model for MELCOR 2.1 (May 2014)
- Complex model for MELCOR 2.1 (September 2014)
- Verification and validation of models for MELCOR 2.1
- To use new MELCOR models for present projects related to containment phenomena
- Upcoming project – Developing DBA a SA model for APROS
  - verification of developed models will be done by code to code comparison with models for RELAP5, MELCOR 1.8.5 and 2.1

Thank you for attention