Modelling of Primary Overpressure Protection System using APROSv5.01 code

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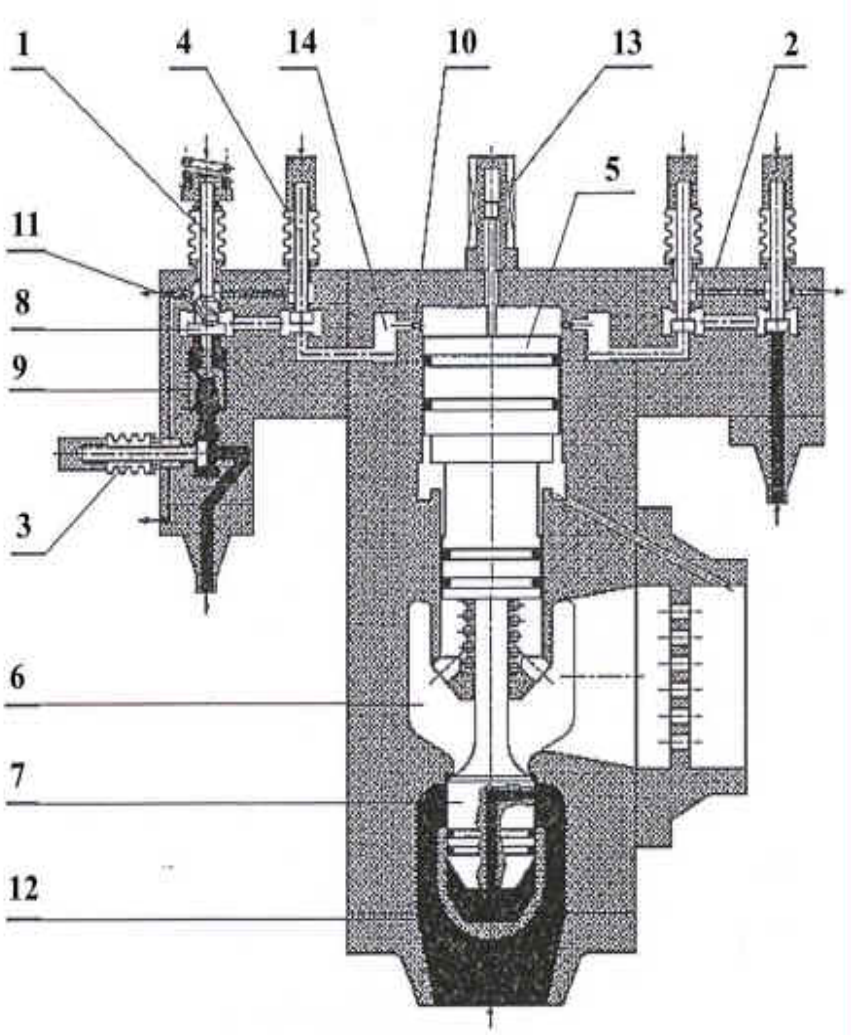
Introduction

The reconstruction of primary overpressure protection system at Paks NPP was carrried out within the scope of safety improvement measures. This modified primary overpressure protection system contains a new relief valve, safety valves and I&C system. The primary bleed function and cold overpressure protection of reactor vessel are also possible in the new system.

The purpose was developing the model of primary overpressure protection system and integrating in the general APROS model of PAKS VVER unit.

Behaviour of Safety Valve 1

Parts of the valve:
main valve (7)
two spring-loaded pilot valves (1)
two motor operated pilot valves for bleed function (4) and
manual valves (3, 4) for isolation of spring-loaded pilot valves



Behaviour of Safety Valve 2

Opening process

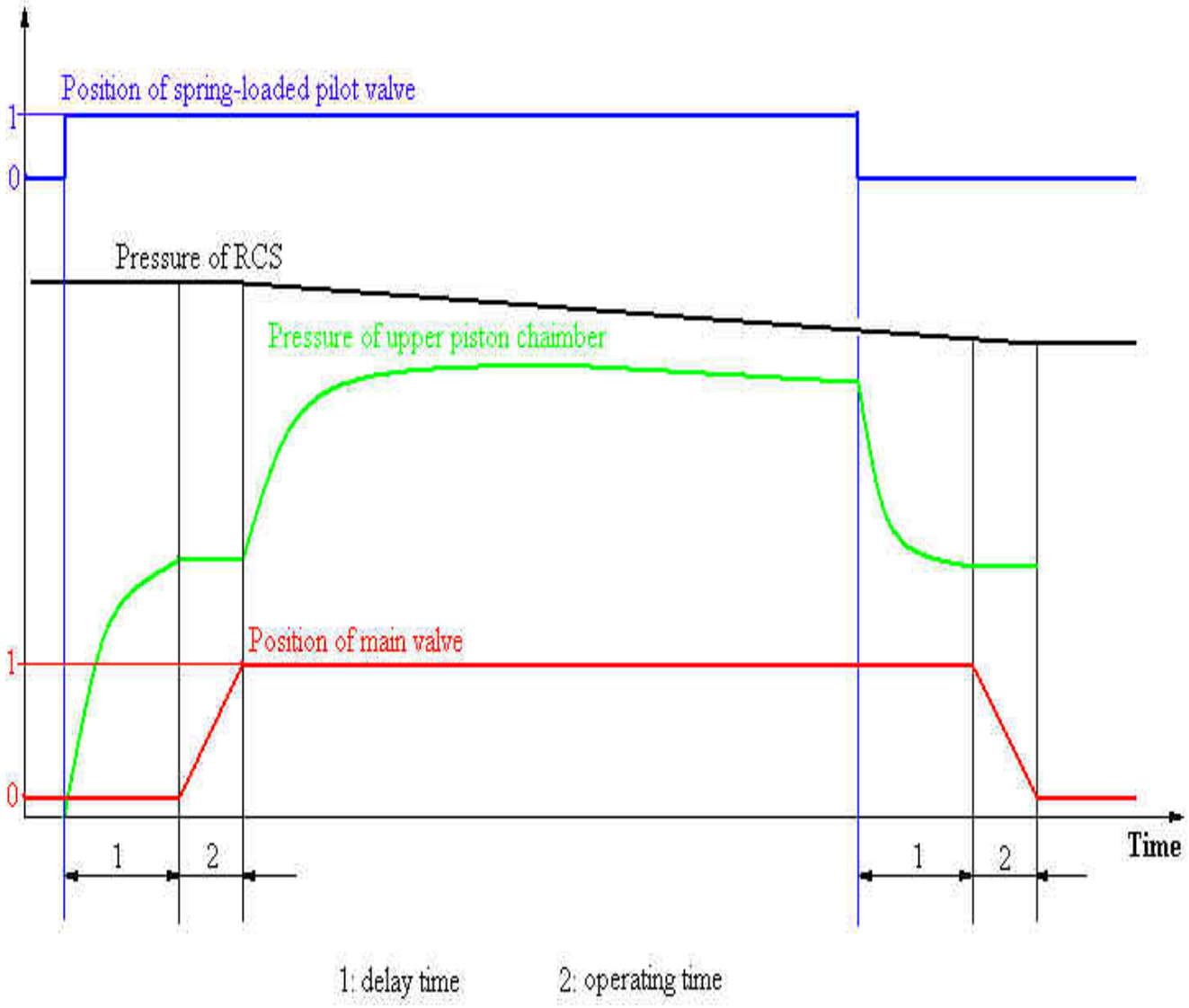
Pilot valve is opened

Delay time: pressure of upper piston ch. is rising, rising speed is reduced by condensation, main valve starts to open at approx. 50% of RCS pressure

Closing process

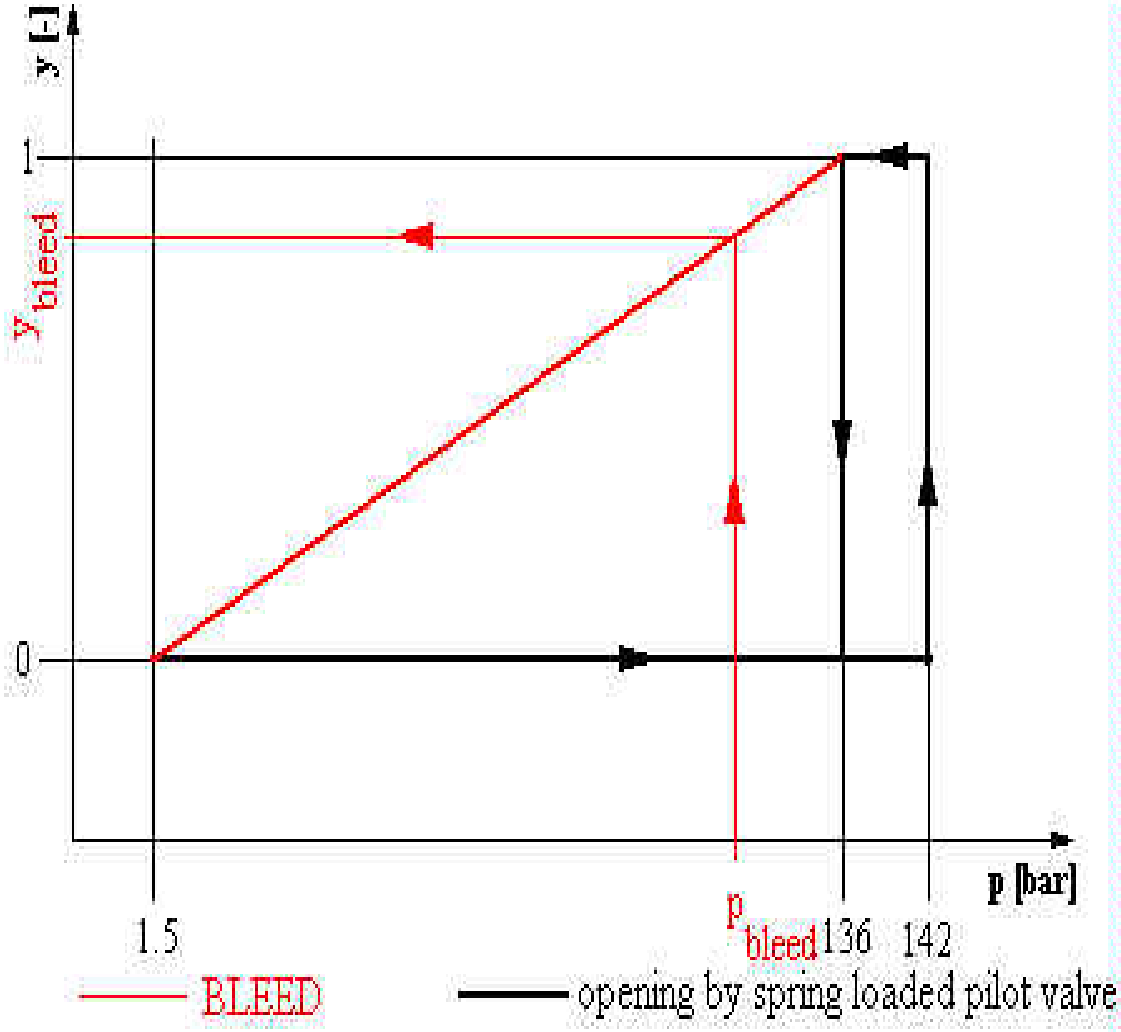
Pilot valve is closed the pressurization of upper piston chamber is interrupted.

Delay time : pressure decreases in the upper piston chamber to approx. 40% of system pressure and the main valve starts to close

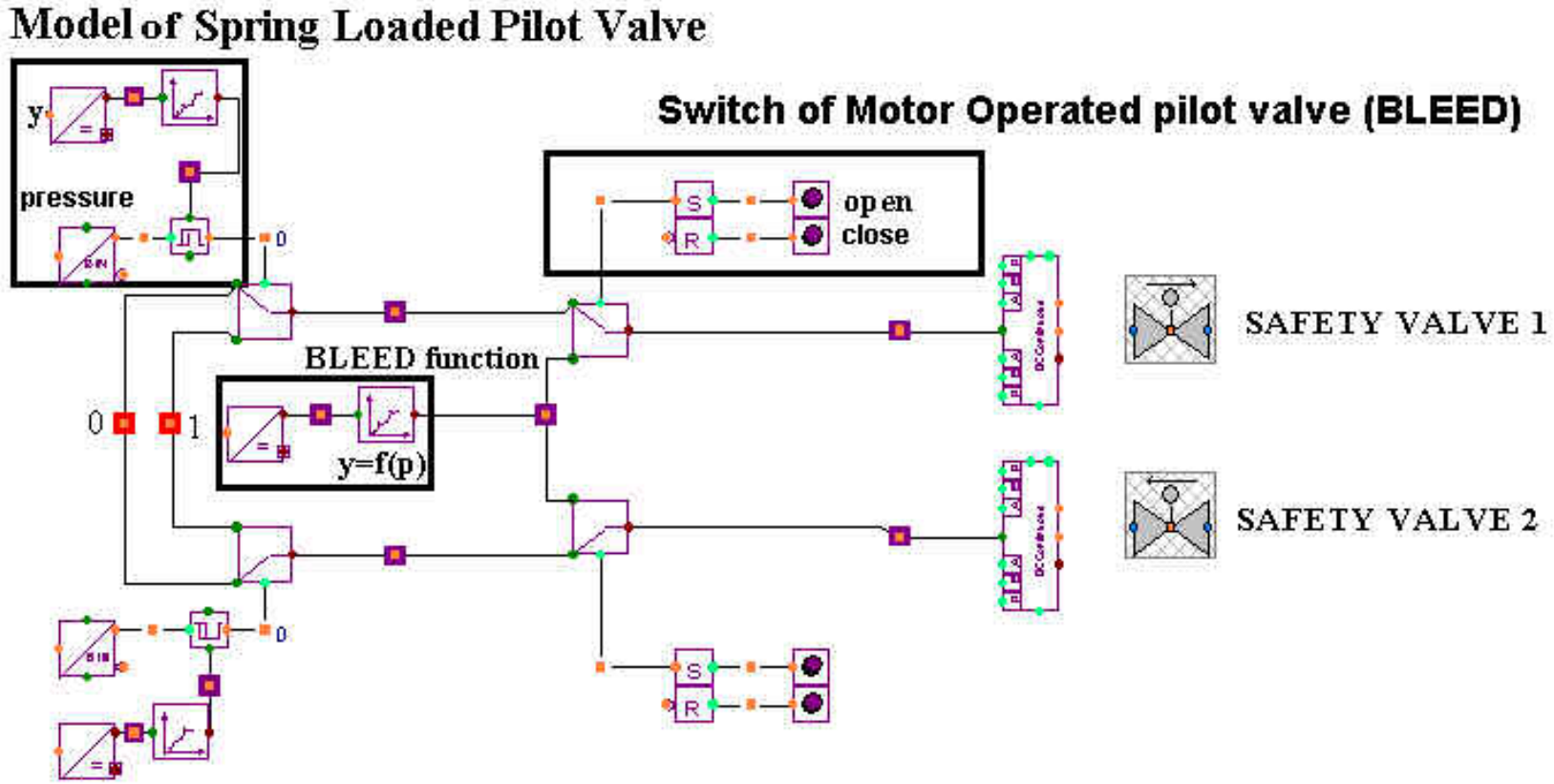


Behaviour of Safety Valve 3

Opening pressure:
142 bar
Closing pressure:
136 bar
Nominal mass flow:
31,9 kg/s (14,2MPa)
„BLEED" function:
Operator is able to open the valve under 136 bar until 1.5 bar.
The BLEED characteristics is calculated from experimental data:
available and required opening force.

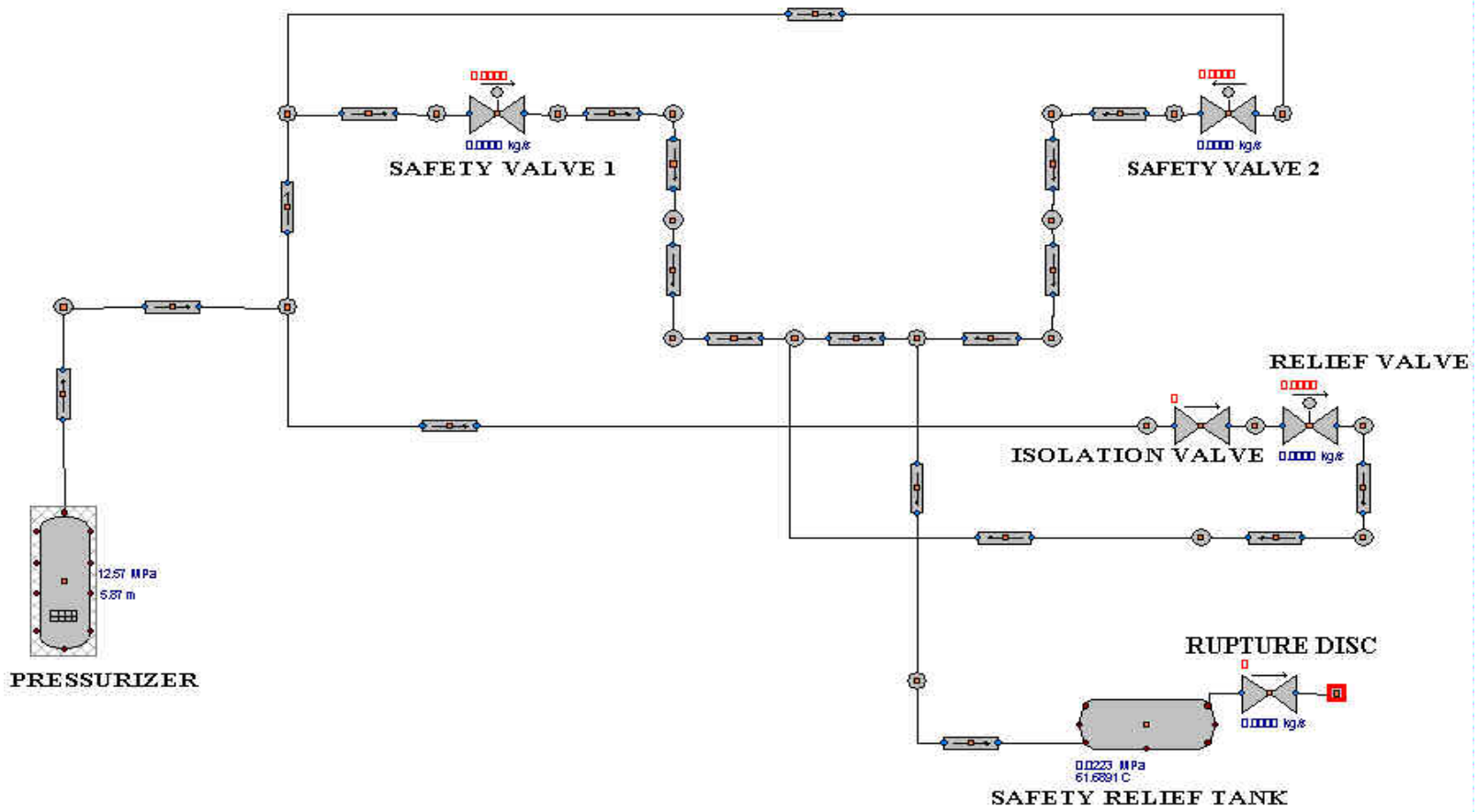


APROS model of Safety Valve



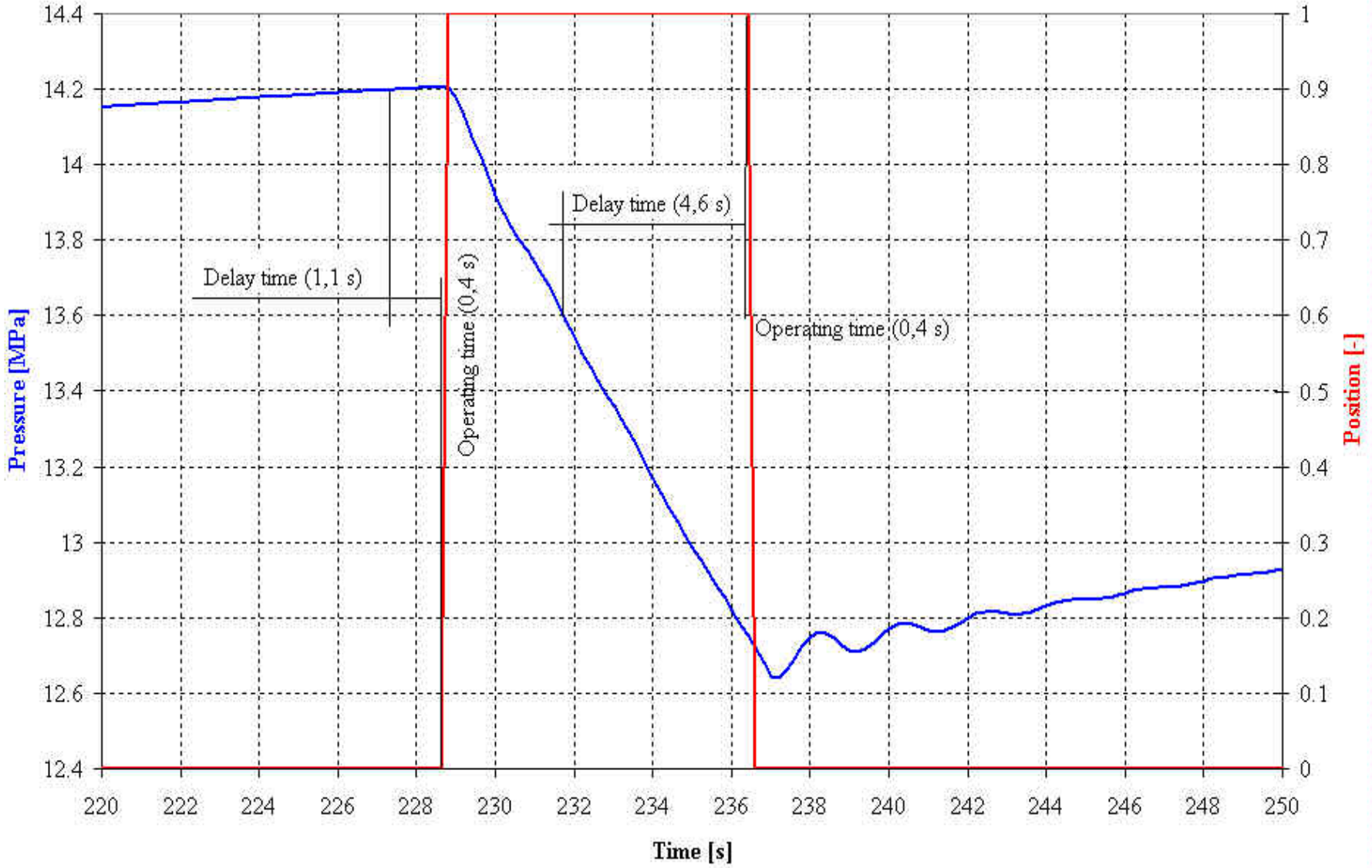
- **Spring-loaded pilot valve:** I&C modules (pressure meas., binary delay, delay time as a function of main valve position)
- **Motor op.pilot valve:** I&C modules (open switch, close switch, pressure meas. and BLEED function)

APROS model of Overpressure Protection System

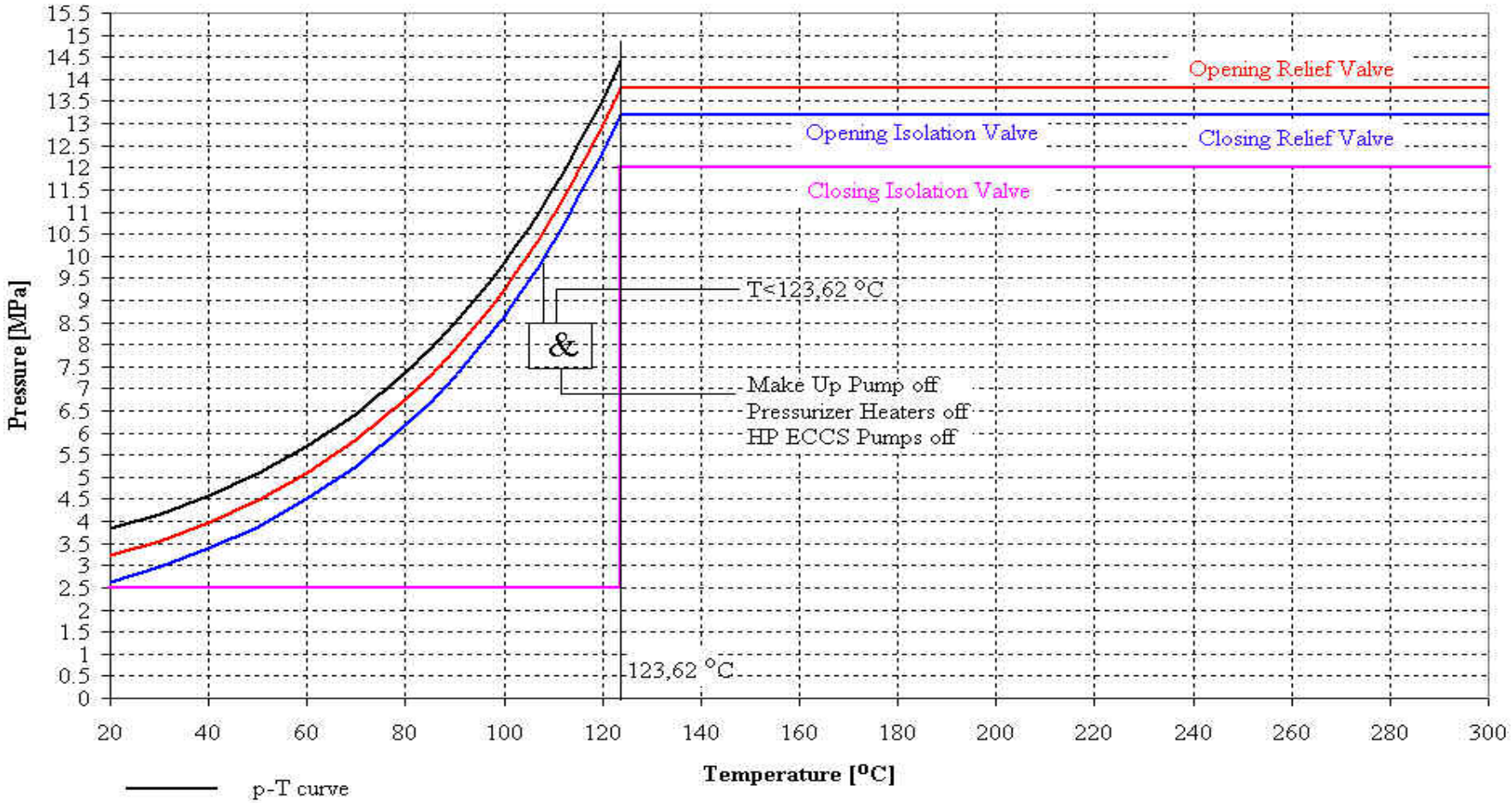


The simulated transient: pressurizer heaters were on (max. power, 1640 kW), pressurizer spray valves are closed, relief valve is stayed closed, scram (p>13,6 Mpa) was not working.

Simulation results

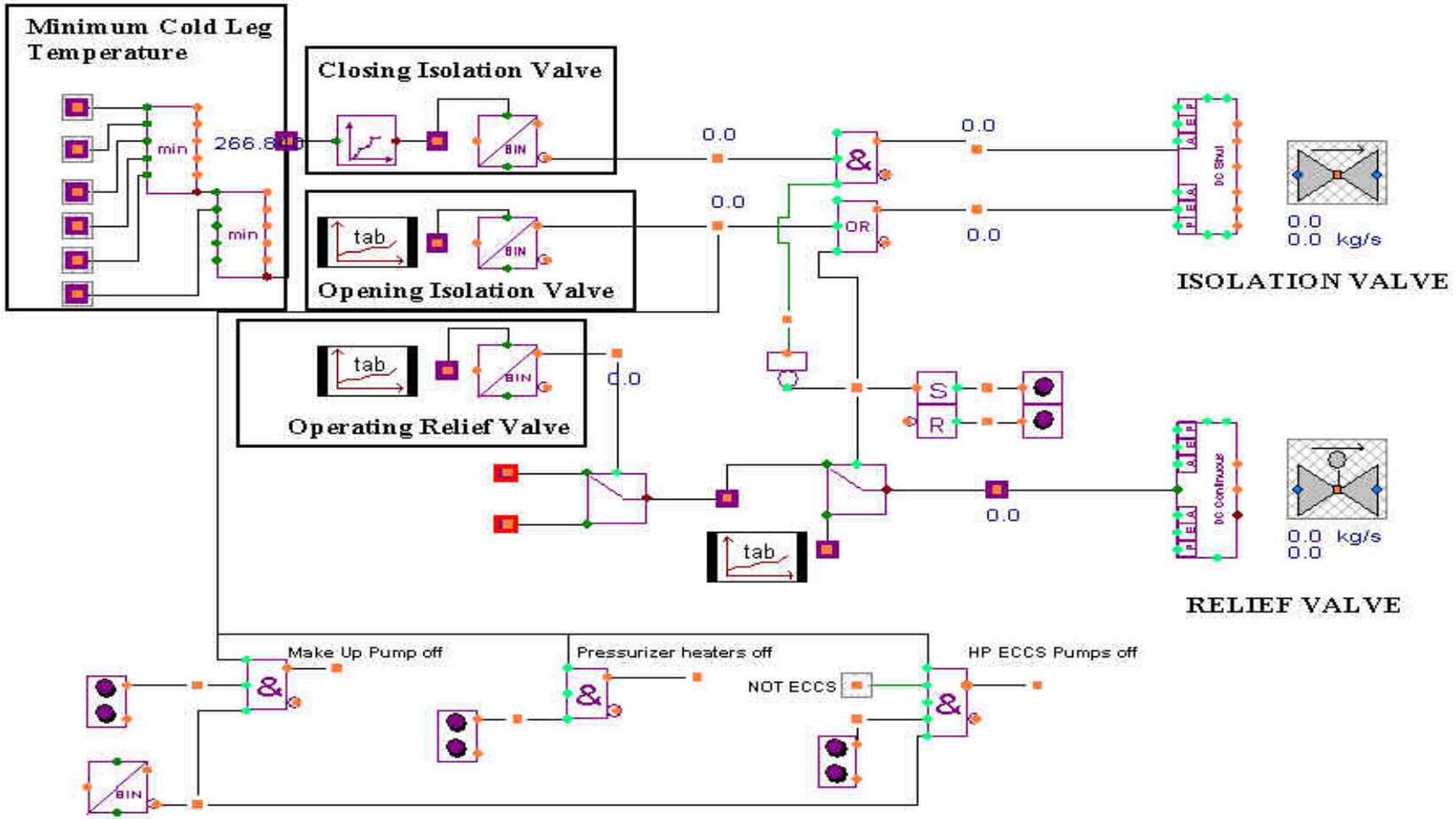


Cold Overpressure Protection System



- p-T curve: brittle fracture limit curve (transition temperature: 123,62 °C)
- Two level of protection:
  - (p-T curve) –1.2 MPa: pressurizer heaters, make up pumps, HP ECCS Pumps off
  - (p-T curve) –0.6 MPa: opening relief valve

APROS model of Cold Overpressure Protection System

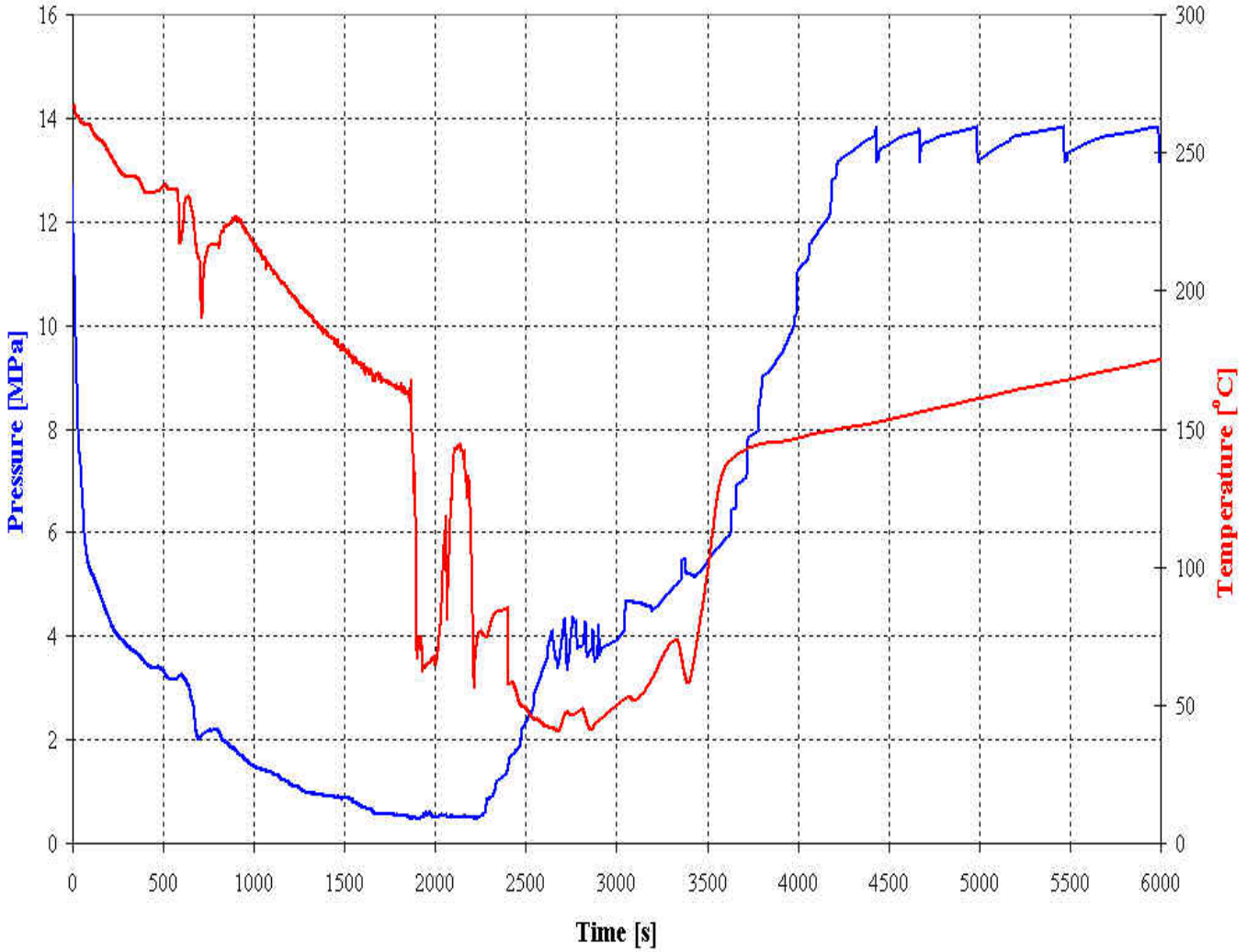


- The control of isolation valve and relief valve is based on minimum cold leg temperature
- The control system contains the previous functions and both protection levels.

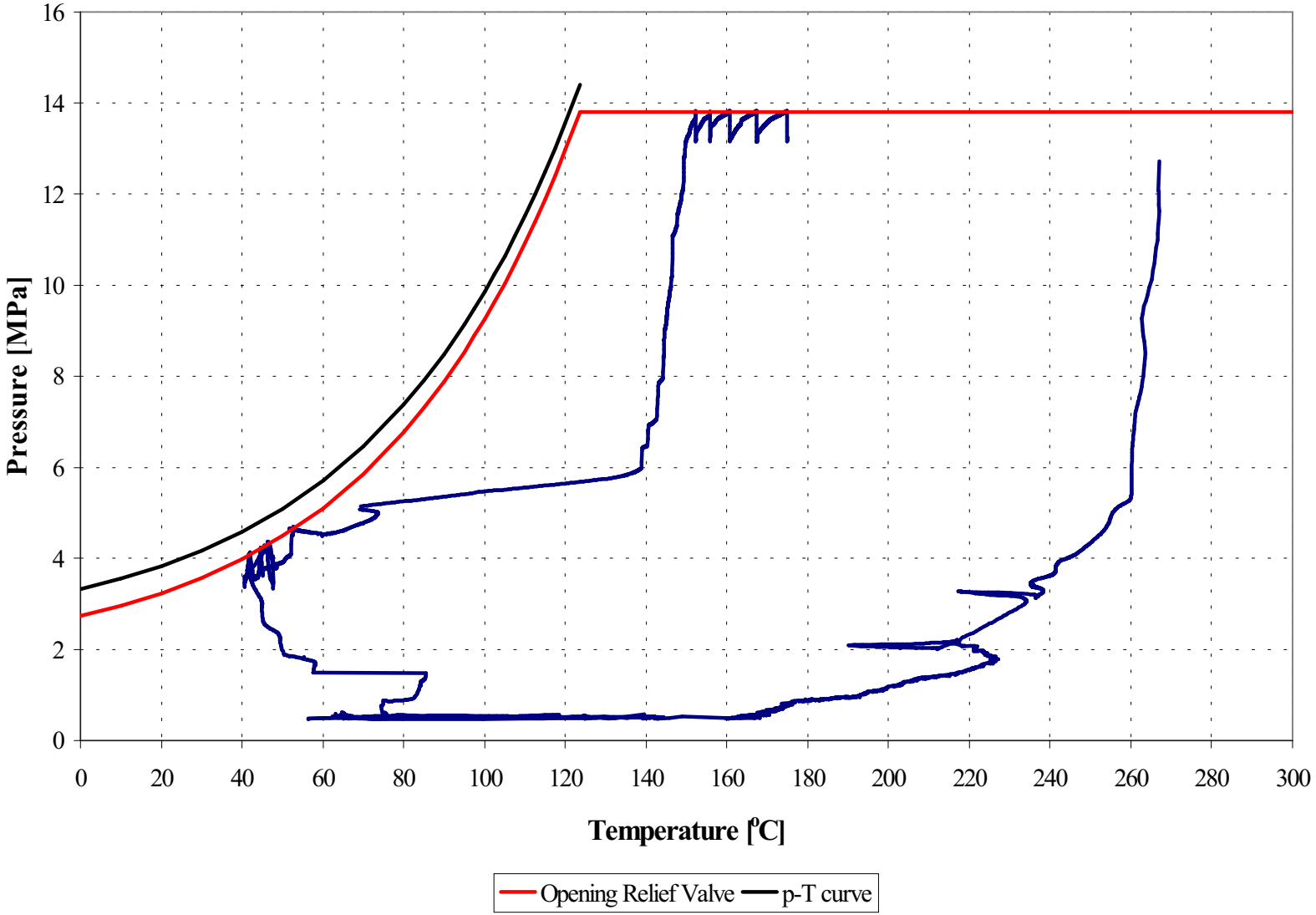
Simulation Results of 110 mm Cold Leg Side break 1

Events:

0.s	break
3.s	SCRAM, MCP trip
2000.s	**break closed**
2800.s	2 HP ECCS pumps stop
3000.s	SG Blowdown Control valve closed



Simulation Results 2



Summary

The developed model of Primary Overpressure Protection System (safety valve, relief valve, safety relief tank and pipeline) is integrated in the general APROS model of PAKS VVER unit.

The model is adequate detailed and it is not too complicated so there is no significant increasing in processing time.