Hydra System Commissioning Study

Paul Scherrer Institute
PANDA Test Facility Studies
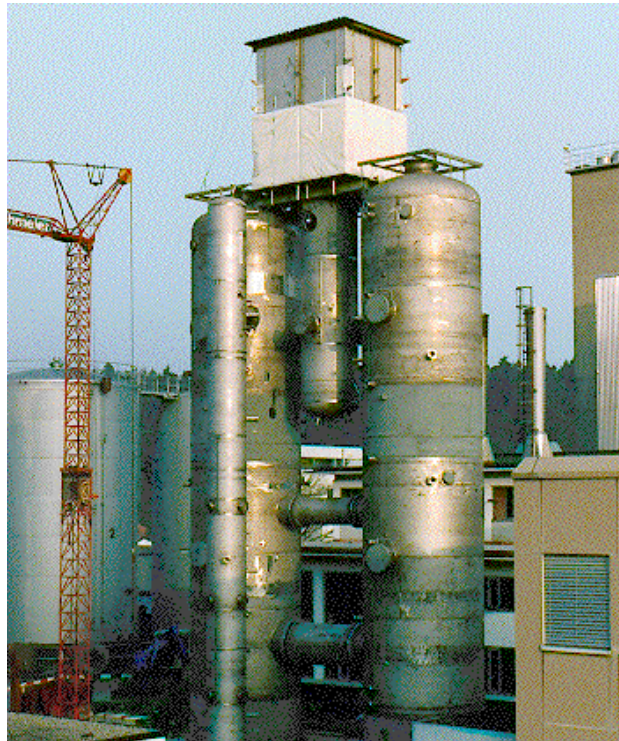
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- Analysis of the composition and characteristics of vent streams from a Passive Decay Heat Removal safety system for Advanced Light Water Reactor Systems

- The development of Passive Protection Systems eliminates sources of failure present for active systems e.g. Human error or power failure

- The Hydra was commissioned to investigate the function and reliability of passive condensers under severe accident conditions, in presence of "non-condensable" gases e.g. N_2, which can markedly affect the efficiency of the PPS
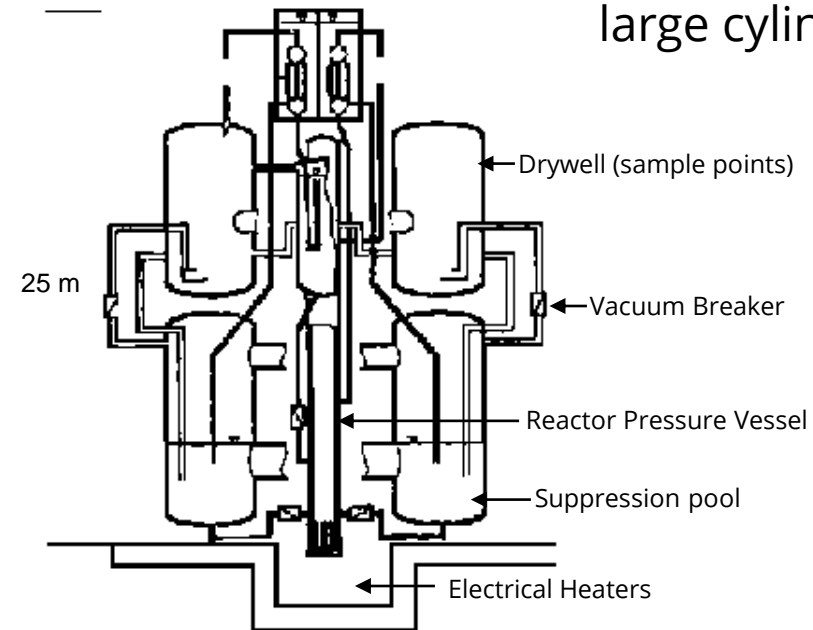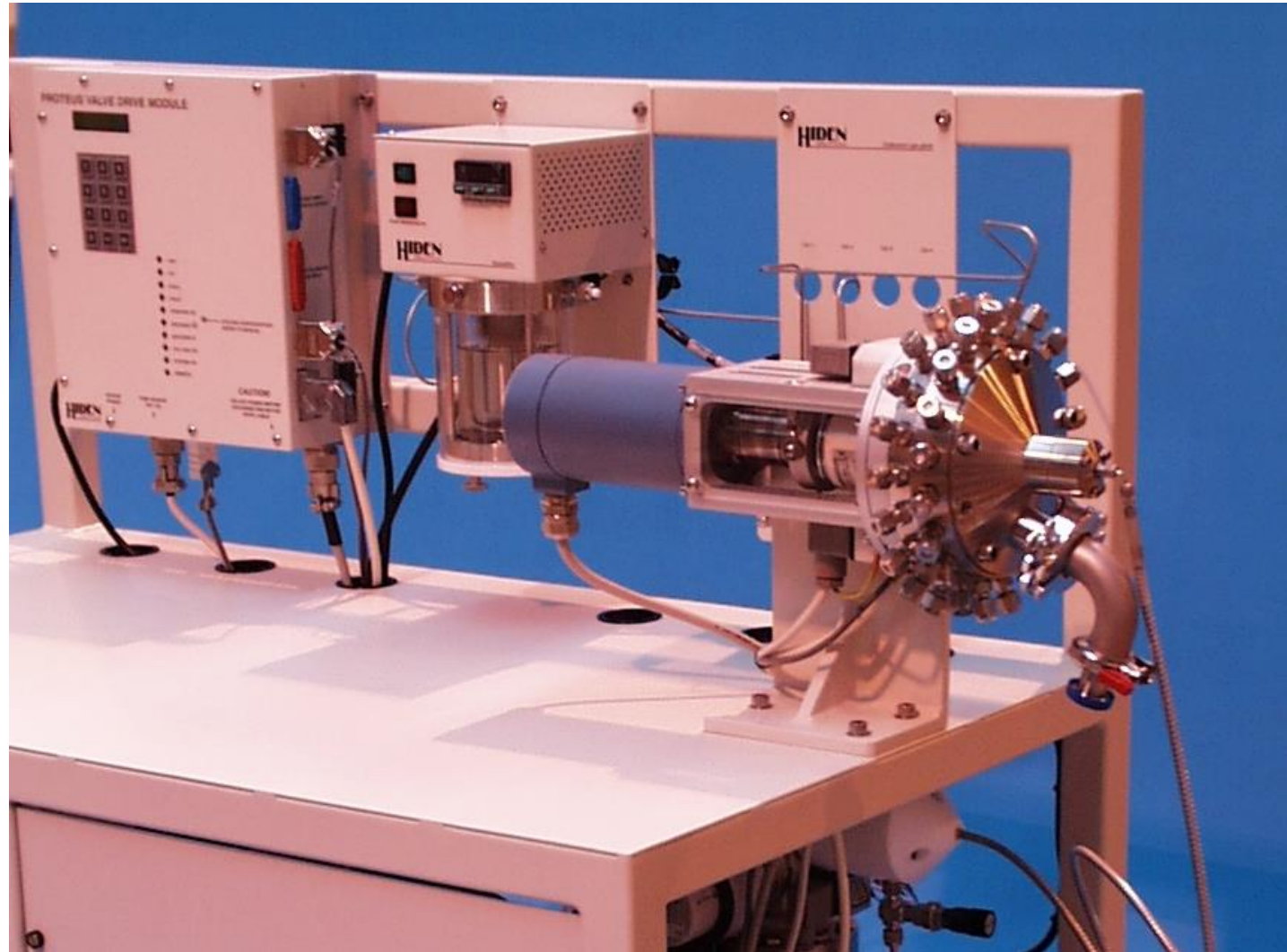
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PANDA during construction
Passive condensers are at the top of the large cylindrical vessels

25 m

Drywell (sample points)

Vacuum Breaker

Reactor Pressure Vessel

Suppression pool

Electrical Heaters

PSI Hydra Configuration

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Sensitivity, Response & Reproducibility

Permanent gases - 3s switching cycle - peak-to-peak response 1.4s
No memory effects, high stability and reproducibility
Simultaneous MS acquisition and analogue input e.g. Port number
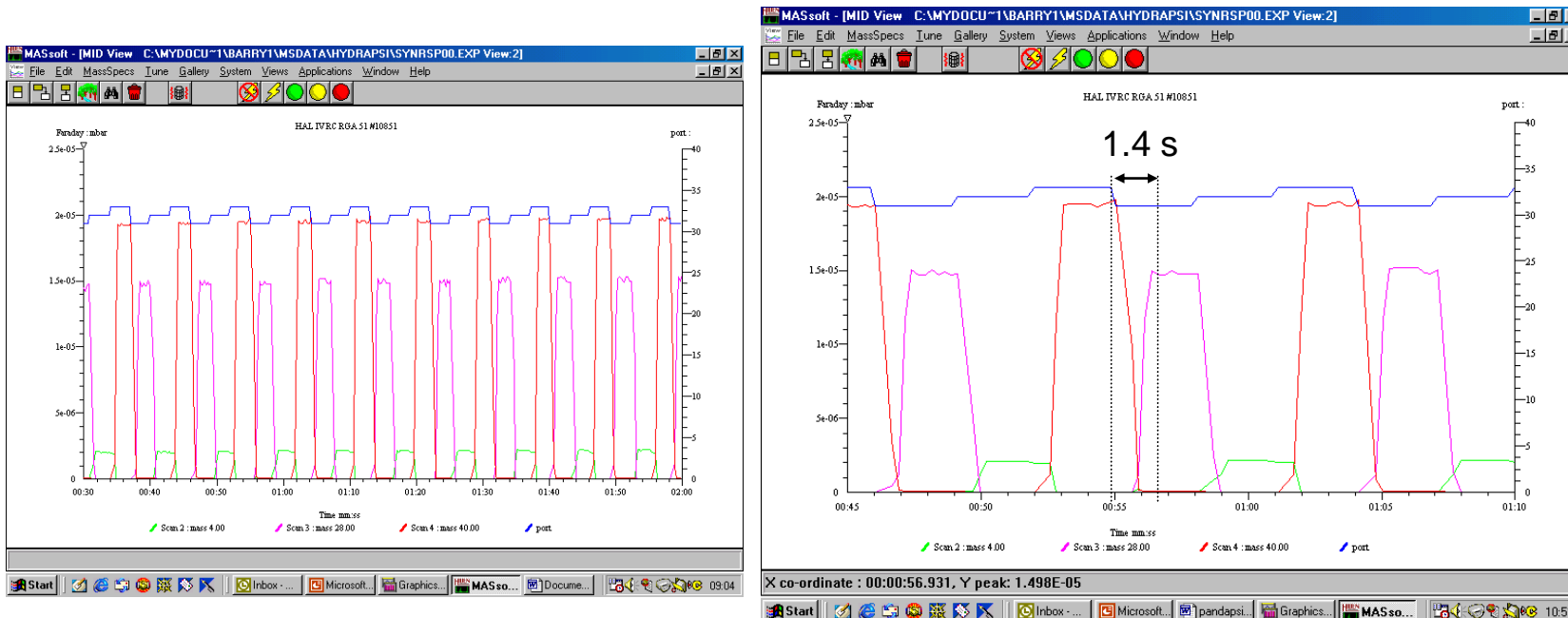
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Sensitivity / Response for Steam Introduction / Switching

Hydra shows a good response to the gradual introduction of Steam
Followed by switching '100'% → 0% steam in 20 / 20s cycle
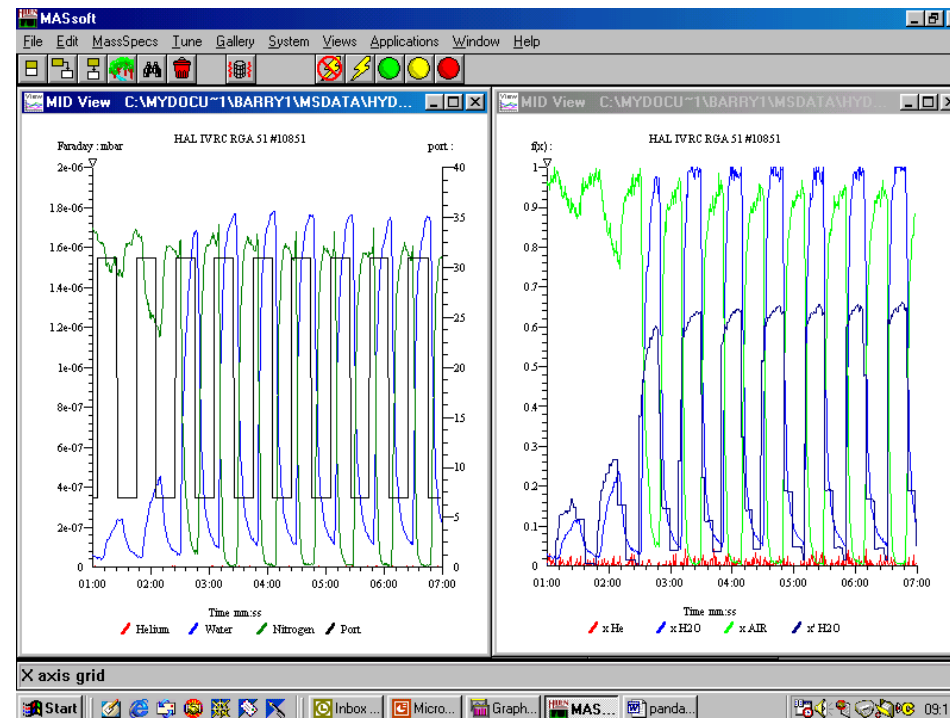Hydra response – min / max 26s with reproducible response

T = 0,
port 7 = N_2 p32 = 30% H_2O / N_2
T =2.5min,
P7 = N_2, p32 = >95% H_2O / N_2

Process pressure 1Bar
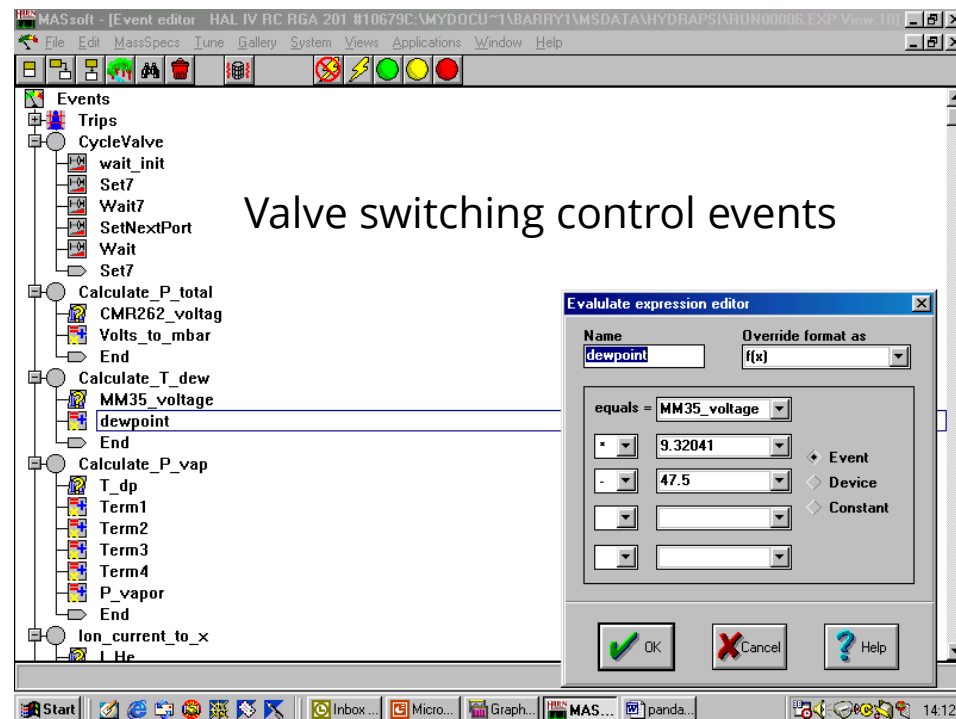Inlet pressure 25mBar
MS pressure $1.6e^{-6}$
Proteus Temperature 120°C

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Process Control & Online Real Time Derived functions

The MASsoft events sequence is used to control valve switching

MASsoft also allows REAL-TIME calculation of derived functions:

e.g. Calculation of Dewpoint from an analogue voltage signal

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Mixed Mode Scanning with Real Time Derived functions

MASsoft provides optional data displays of MS and derived functions

e.g. Vapour Pressure from Dew Point temperature T_{dp},

$$P_{vap} = 2.3269e^{-4}*T_{dp}^3 + 1.3426e^{-2}*T_{dp}^2 + 0.46265*T_{dp} + 6.058$$

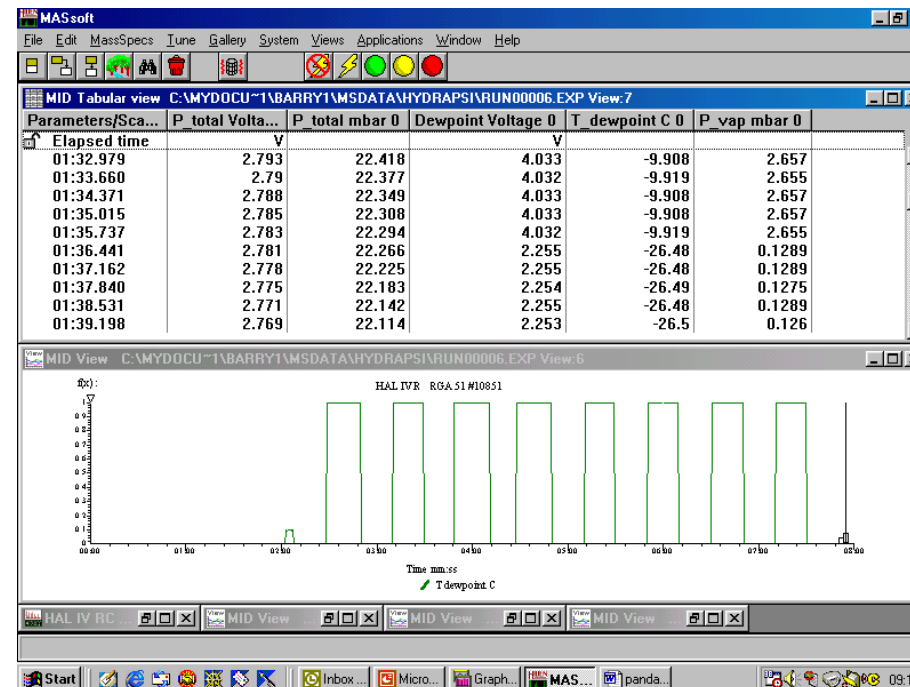T = 0,

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P7 = N_2, p32 = >95% H_2O / N_2

Process pressure 1Bar

Inlet pressure 25mBar

MS pressure $1.6e^{-6}$

Proteus Temperature 120°C
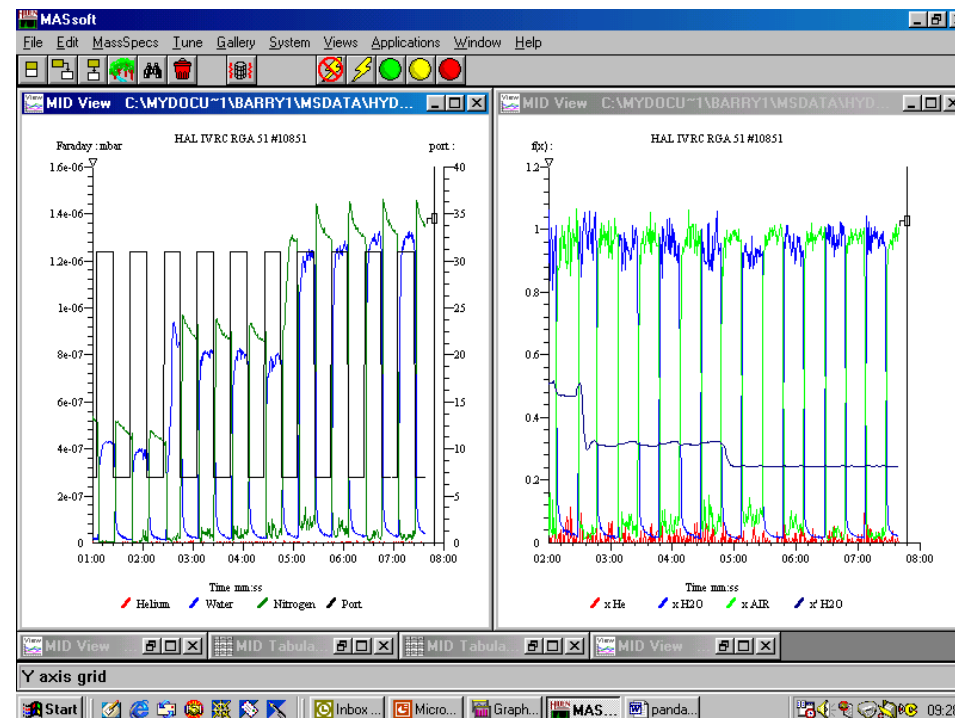
Hydra System Commissioning Study
Pressure Variation Study

The system is required to display insensitivity to pressure fluctuations.
Mimicked by increasing source pressure.
Data shows partial pressures increase but composition ratio unchanged

T = 0,
port 7 = N_2 p32 = >95% H_2O / N_2

Process pressure 1Bar

Inlet pressure 50mBar

MS pressure T = O, 8.3 e^{-7}

MS pressure T = 7, 1.6 e^{-6}

Proteus Temperature 120°C

Hydra System Commissioning Study

Step Change Response

The system is required to display insensitivity to pressure fluctuations.
Mimicked by switches between mixed gas/ vapour / gas only streams.
Data confirms response in seconds with NO memory effects

T = 0,

port 7 = 50/ 50 N_2 H_2O

p32 = 90% N_2 / 10 H_2O

P33 = 88.5% He / 11.5% N_2

Process pressure 1Bar

Inlet pressure 50mBar

MS pressure T = O, 1.6 e^{-6}

Proteus Temperature 120°C