Modelling blowdown of a long CCS dense phase pipeline using Symmetry Dynamics

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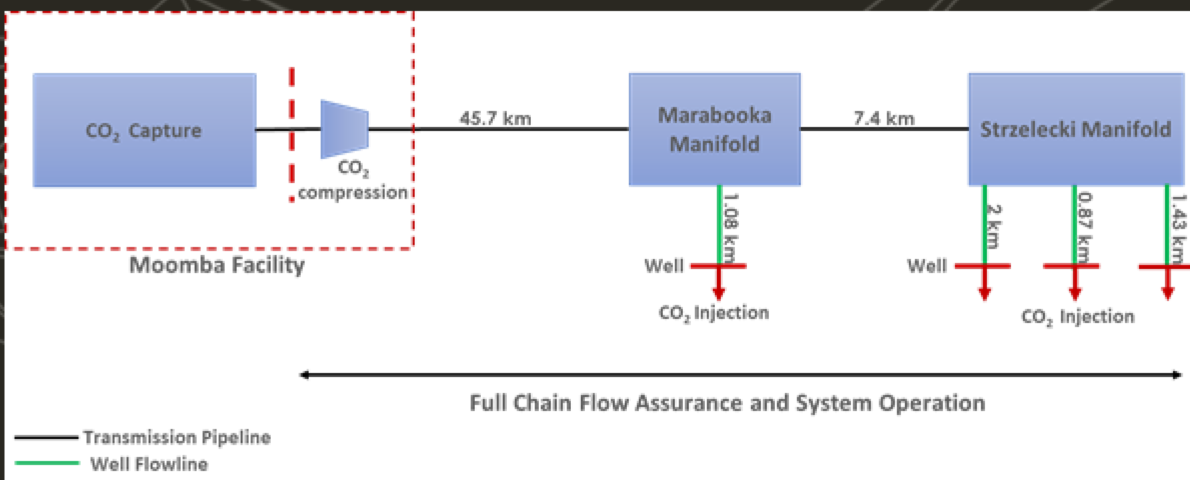
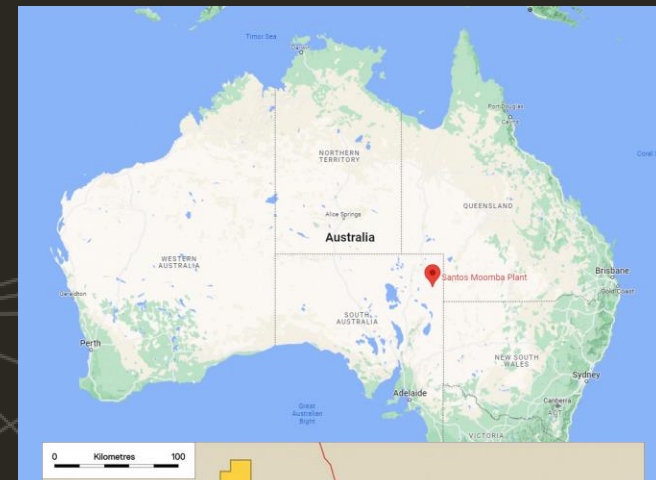
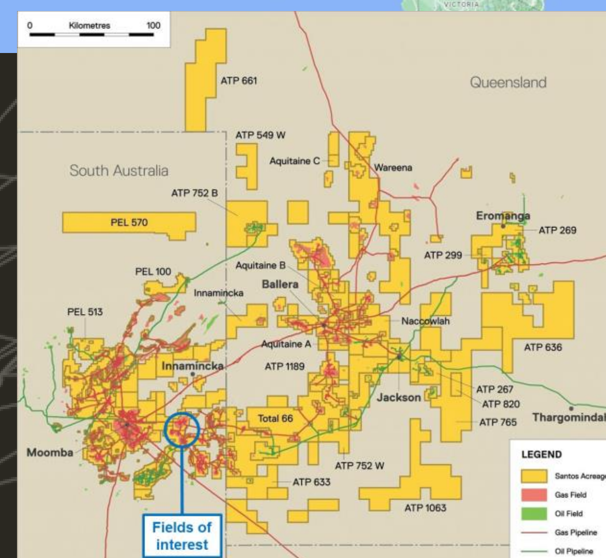
Cooper Basin Moomba CCS Project

- Capture 1.7 MTPA CO_2 from Moomba Gas Plant and sequester in depleted gas reservoirs in Cooper Basin
- Dense phase CO_2 transmission ~ 50km pipeline and 4 injection wells





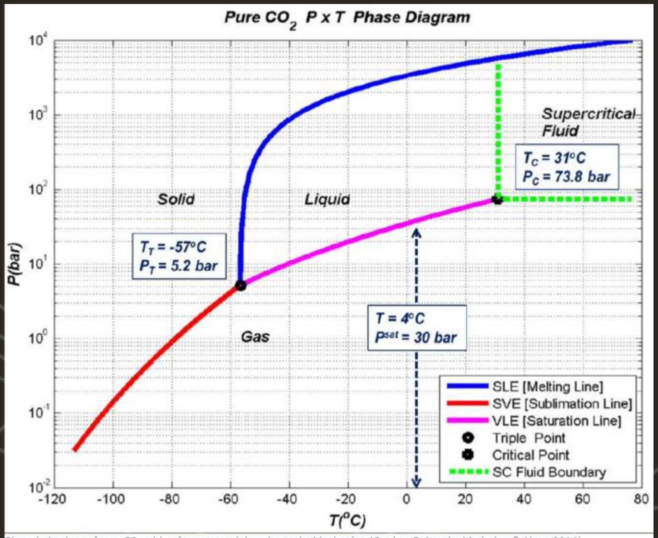


CCS Pipeline Depressurisation

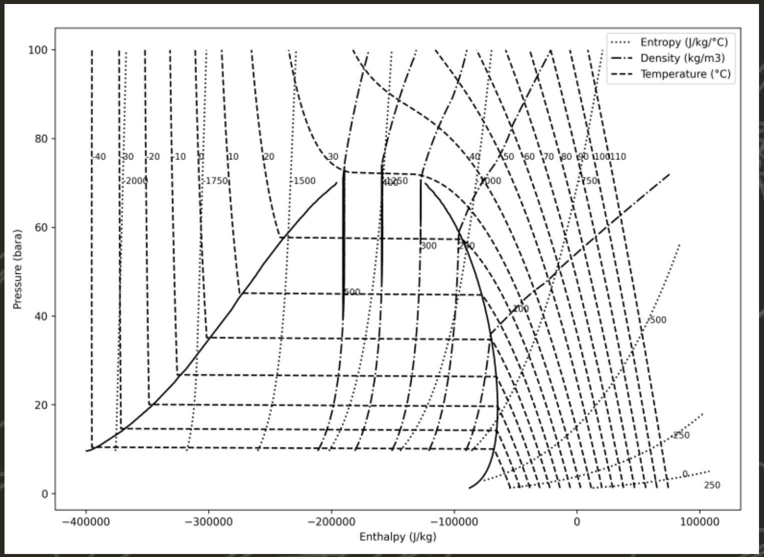
- Depressurisation is defined as the controlled disposal of pressurised fluids to a flare or vent system
- Systems are depressured for maintenance or in an emergency from operating pressure to atmospheric pressure
- Fairly simple and routine procedure in natural gas pipeline
- Much more complicated in CCS…

CO_2 Joule-Thomson Effect

- JT cooling refers to the drop in temperature that occurs when a gas such as CO_2 expands from high pressure to low pressure at constant enthalpy



Phase behaviour of pure CO_2 with reference to triple point and critical point. (Queiroz F. Araujo, Mederios, & Alves, 2014)



- JT coefficient of CO_2 is much higher than O&G fluids, therefore significantly larger temperature drops when depressuring down to -88°C
- Full depressurisation will lead to excessive JT cooling with the risk of solid CO_2 "snow"
- Freezing water will occur if the water dewpoint is reached

Why is this a problem?

- Pipeline normal operating conditions ~146 barg
- Low temperatures during depressurization down to -88°C
- Material selection to design for all scenarios at extreme ends of design becomes very expensive

Challenge:

- Review system to see if any mitigations exist to allow for the selection of a piping spec that does not need to cater for both extremes.

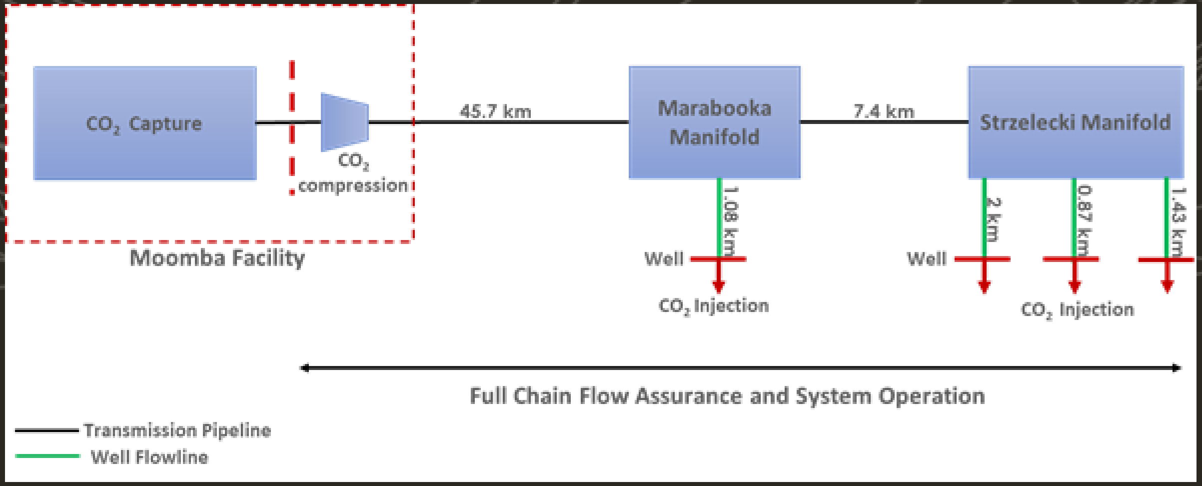
Solution:

- Use of Schlumberger's Symmetry Dynamics to develop dynamic simulation of blowdown procedure
- Determine what the minimum metal temperature of piping and corresponding pressures will be

Case Study - Proposed Solution

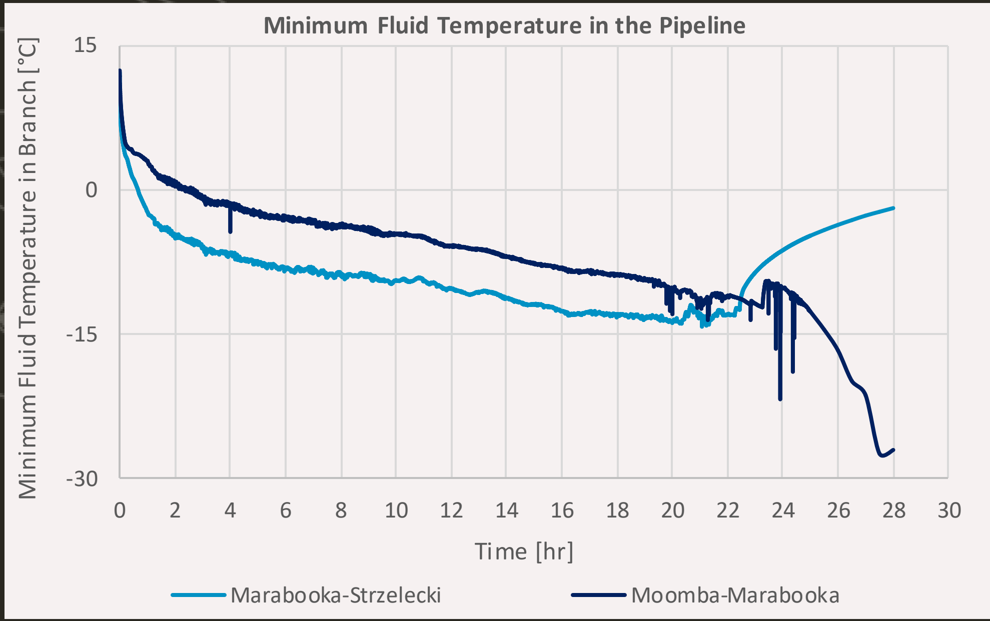
<u>Step 1</u>

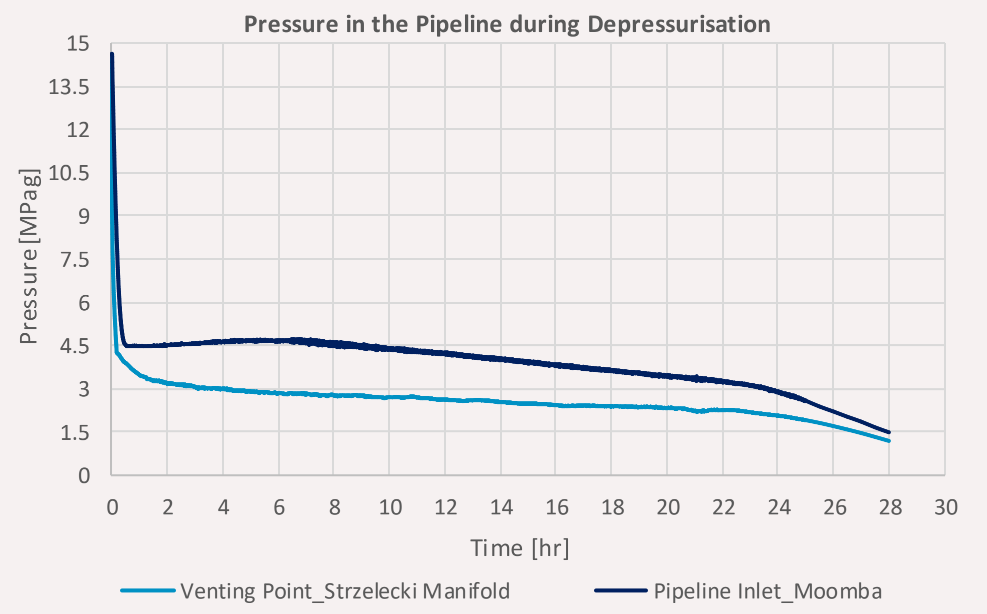
- Dissipate as much pressure as possible into the injection wells – pipeline pressure reduced from 146 barg to 80 barg
- Advantages:
  - Lower pressure starting point for full depressurization results in less JT cooling effects
  - Blowdown system only needs to be designed for 80 barg pressures
  - Sequester as much CO_2 as possible



Case Study – Upstream of Blowdown Valve

- In 28 hours the minimum temperature seen in the pipeline at any point in time is -27°C
- Minimum temperature occurs in the Moomba-Marabooka section and it occurs towards the end of the depressurisation
- The location of the minimum temperature changes over time. The absolute lowest temperature occurs around 1-1.5 km from the Moomba station

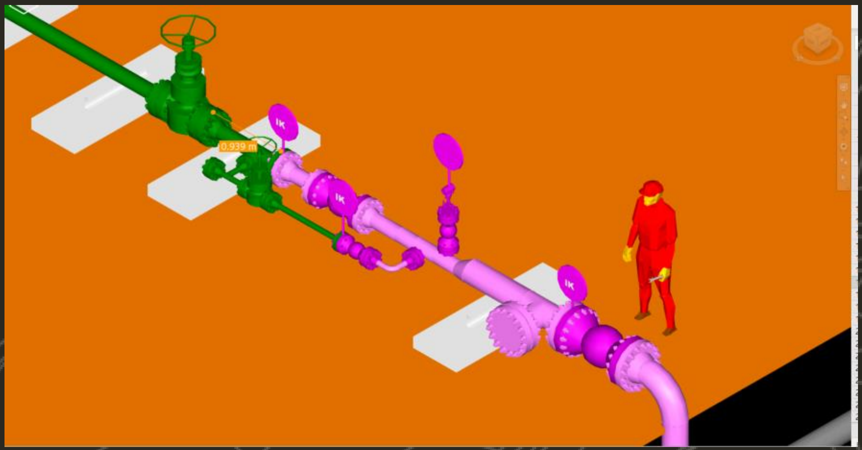


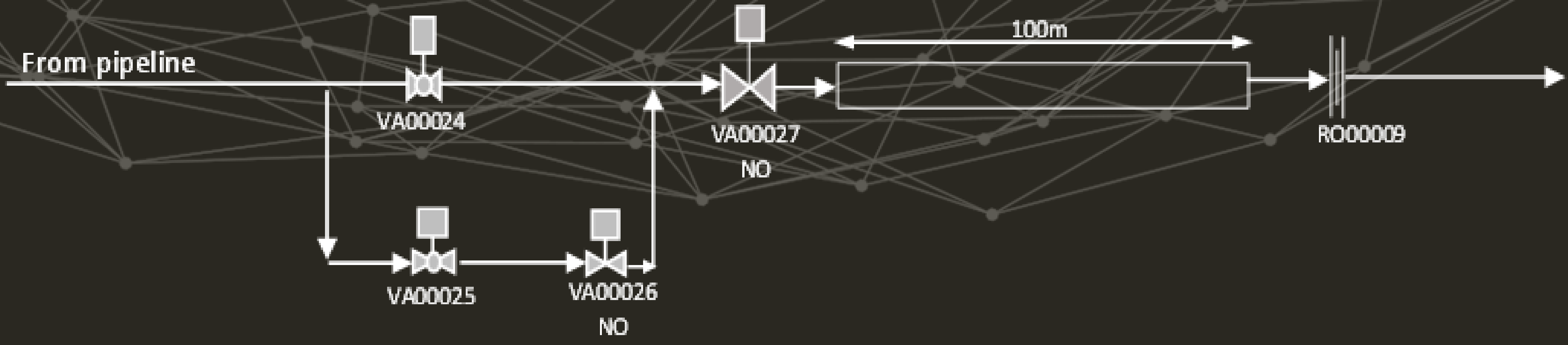


Case Study - Proposed Solution

Step 2

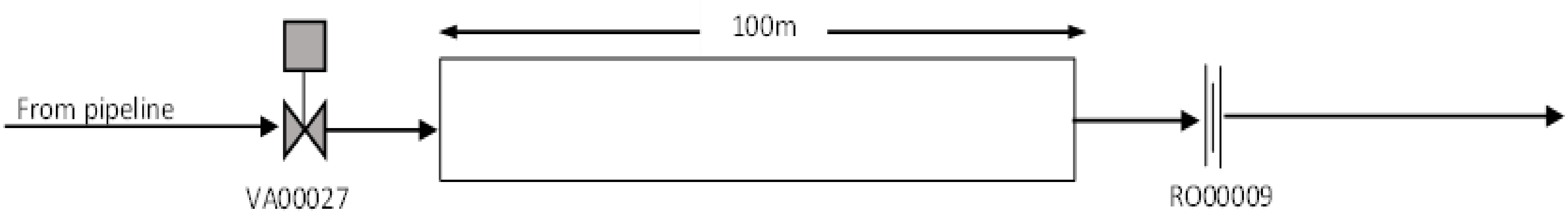
- Controlled blowdown over prolonged period of time to manage JT cooling impact
- Process Pressure : 80 bar (max operating 146 bar)
- Process Temperature : 25°C (winter) 55°C (summer)
- Blowdown valve size: 6”
- Restriction orifice size: 50mm





Case Study - Modelling Challenge

- Carbon steel has a limit of -45°C for pressures up to 153.2 bar
- Where is the cut off point for using carbon steel within the blowdown system?
- Modelling in Symmetry Dynamics can show us how the wall temperature will change at each segment along the blowdown line

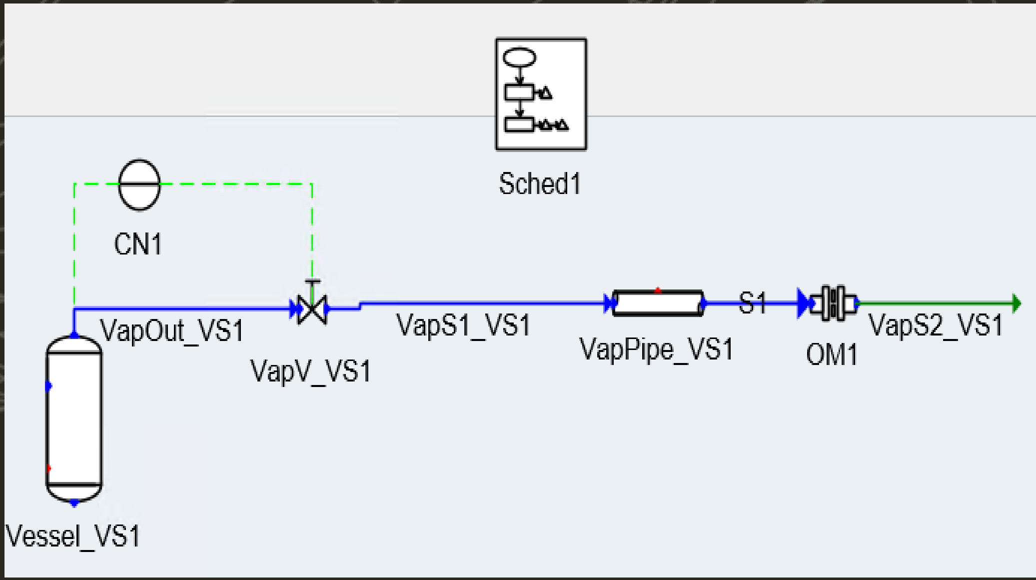


Case Study - Building the Model

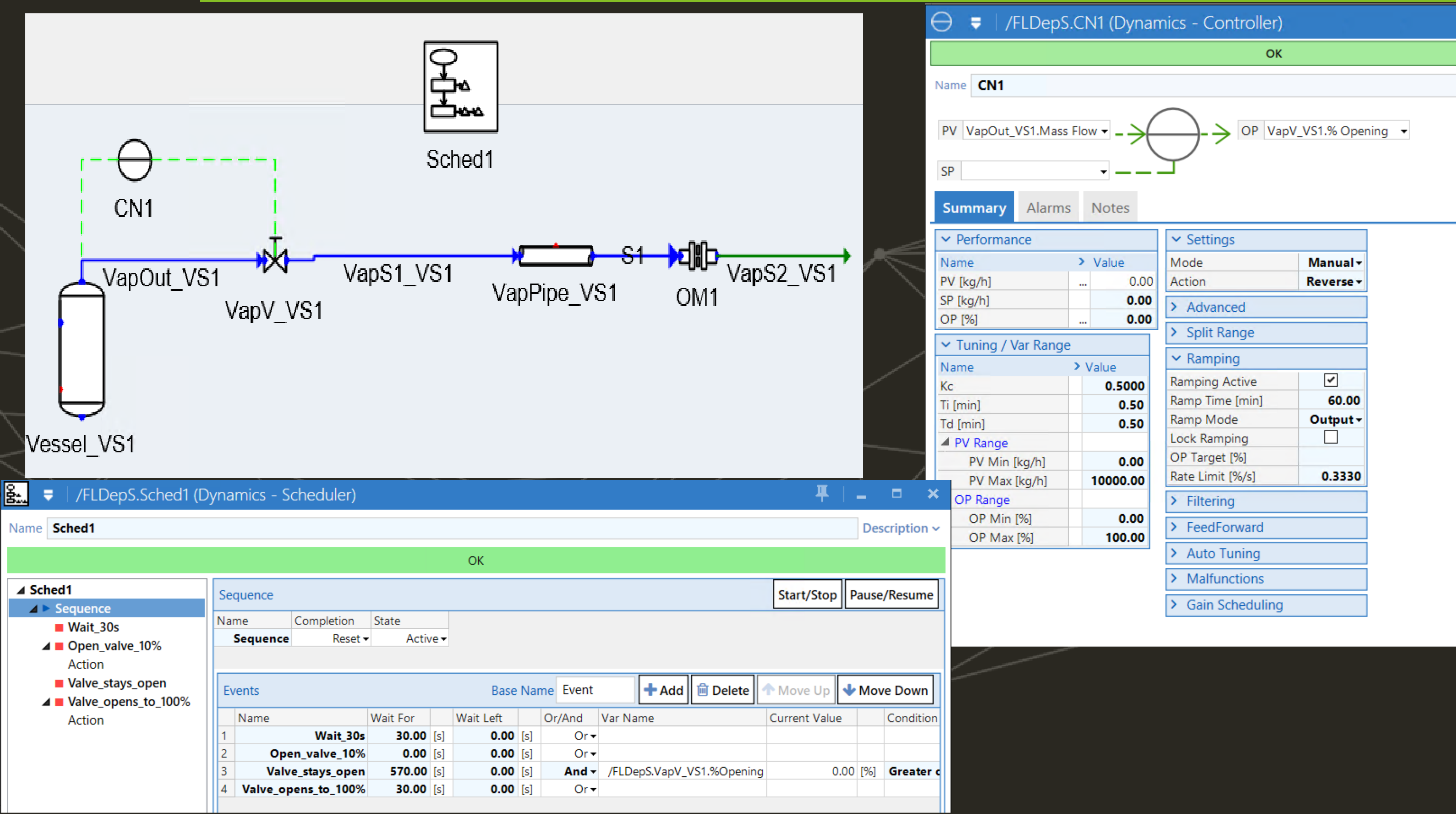
- System volume = 2356m^3
- The pipe between the blowdown valve and the restriction orifice is 100m
- Blowdown valve is open by 10% until the system is pressurized before being fully open
- Summer process (55°C) case not modelled as the winter case of (25°C) presents worst case for low piping temperatures.

Assumptions
- 6" Blowdown valve VA00027 opens linearly
- Valve opening is ramping opening (0.33%/s)

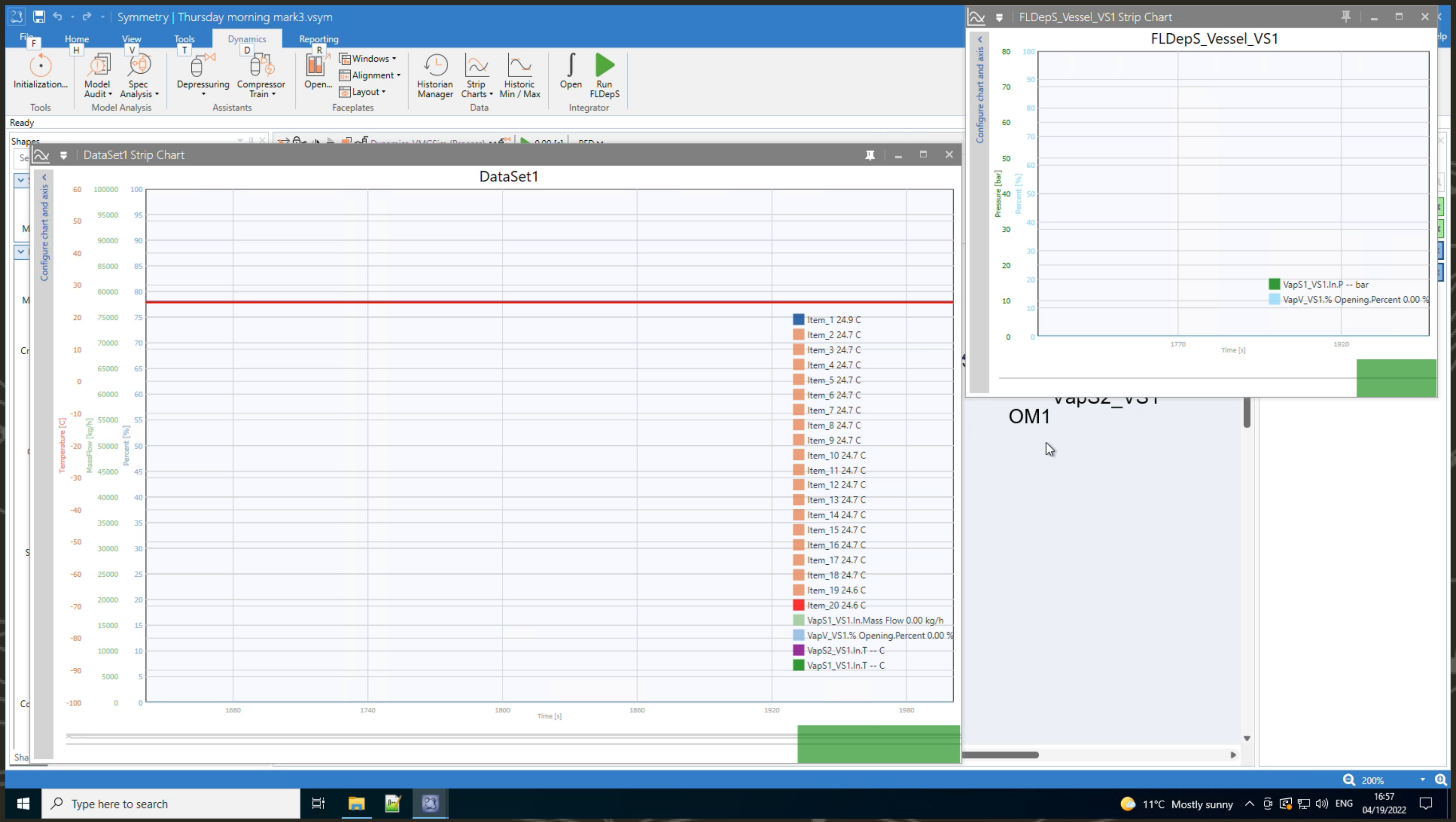
Aim
- Identify a valve size that allows downstream piping to stay within CS limits



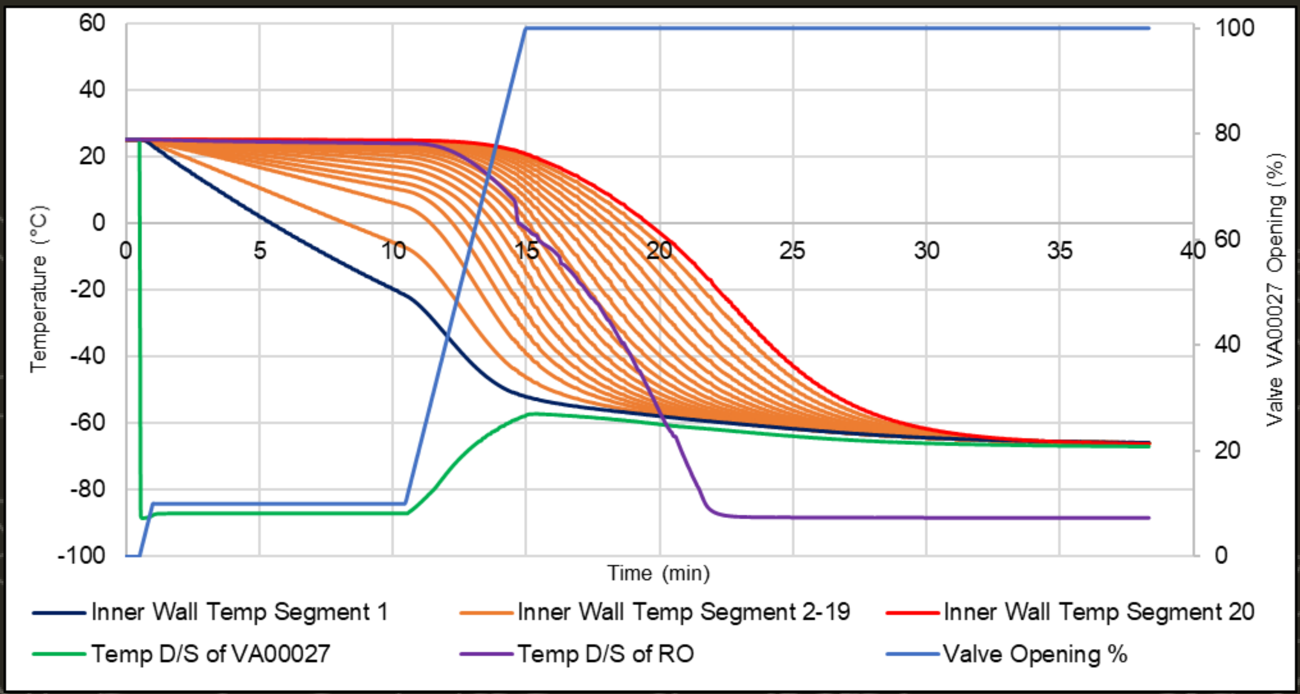
Case Study – Dynamic Control



Case Study – Dynamics Running



Case Study - Small Control Valve

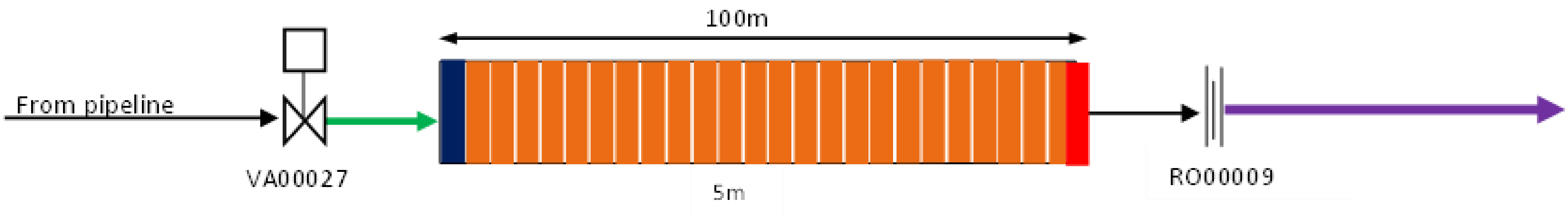


Temperature profiles for a valve Cv of 2

Operating conditions of 80barg and 25ºC

Piping wall breaches the -45ºC limit

The piping wall temperature (orange) is -60ºC



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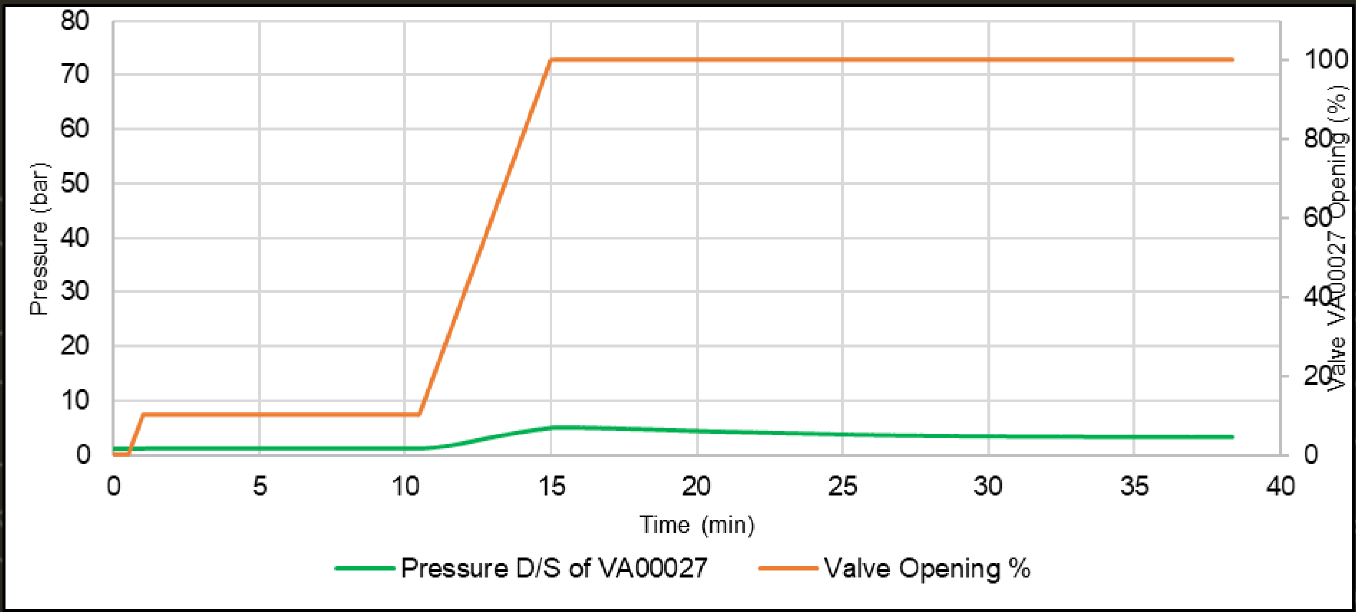
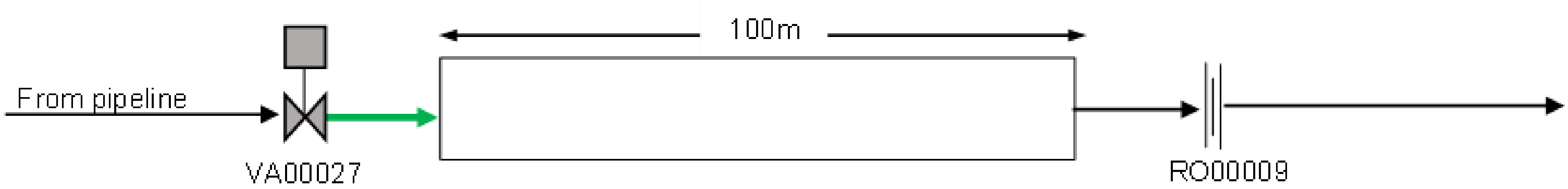


Pressure profiled for a valve CV of 2

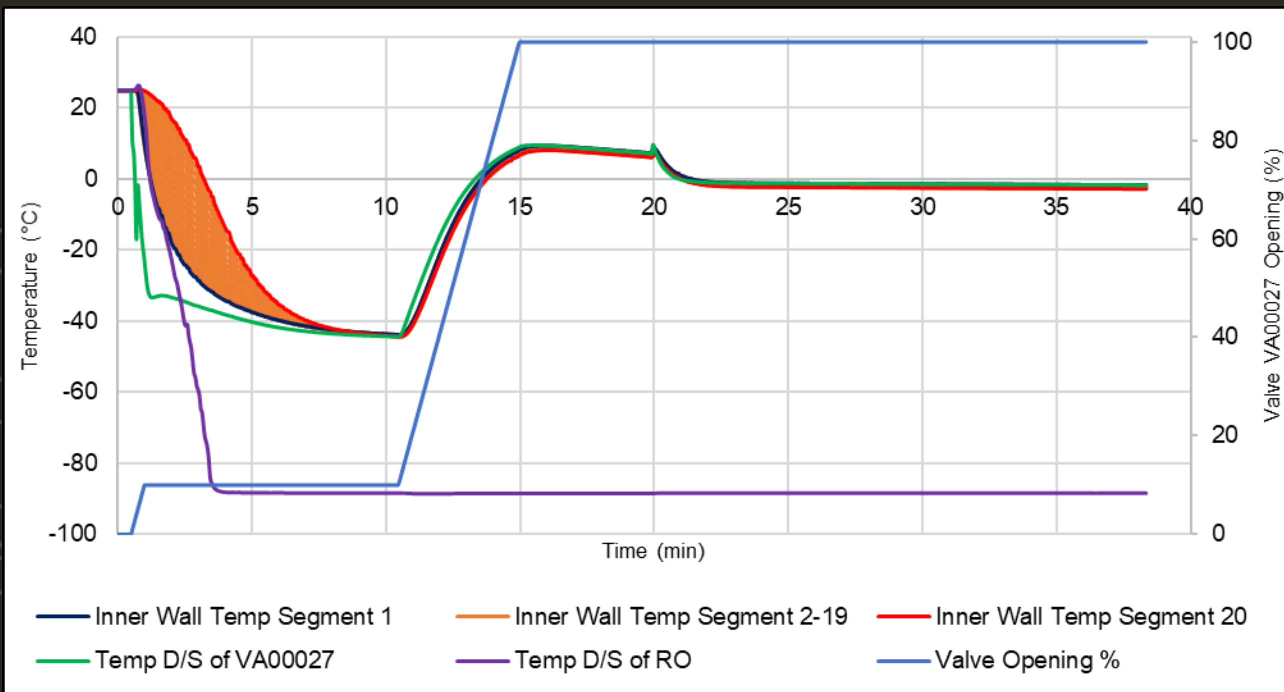
Operating conditions of 80barg and 25ºC

Maximum pressure (green) is 5 bar

After 24hrs the pressure of the system is 69 bar



Case Study - Optimum Control Valve Size

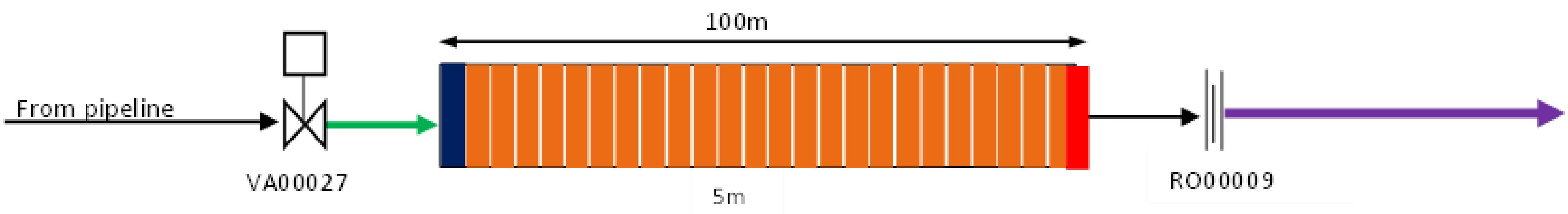


Temperature profiles for a valve CV of 53

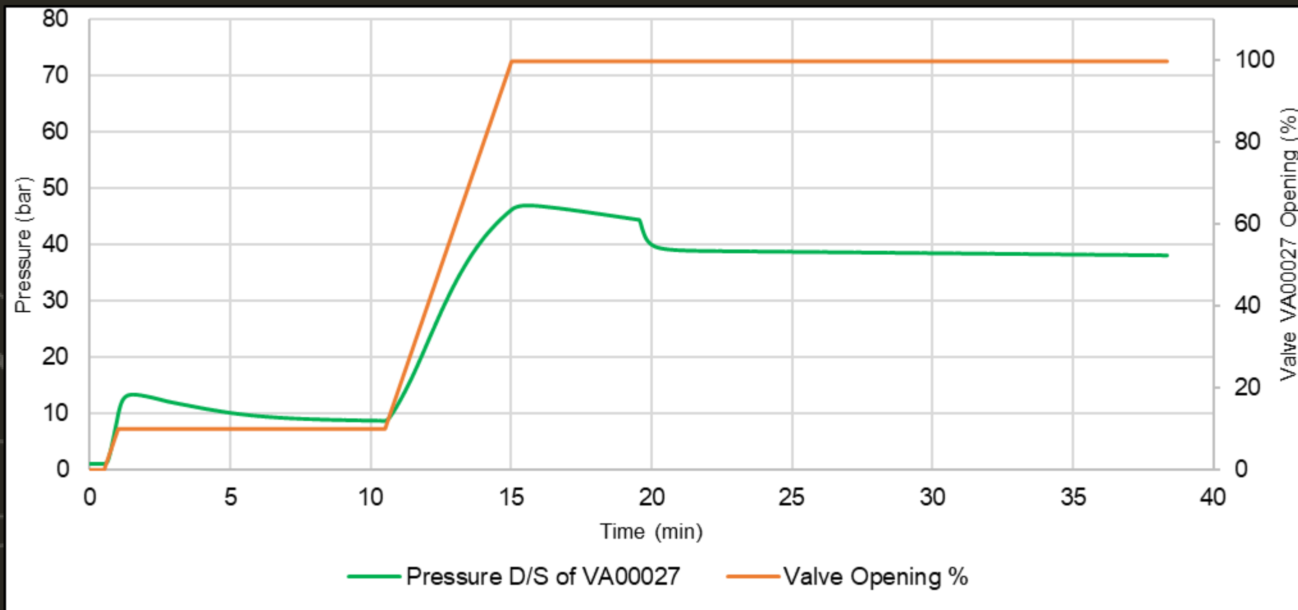
Operating conditions of 80barg and 25°C

Process fluid temperature (green) lowest is -43°C

The piping wall temperature (orange) is -44°C

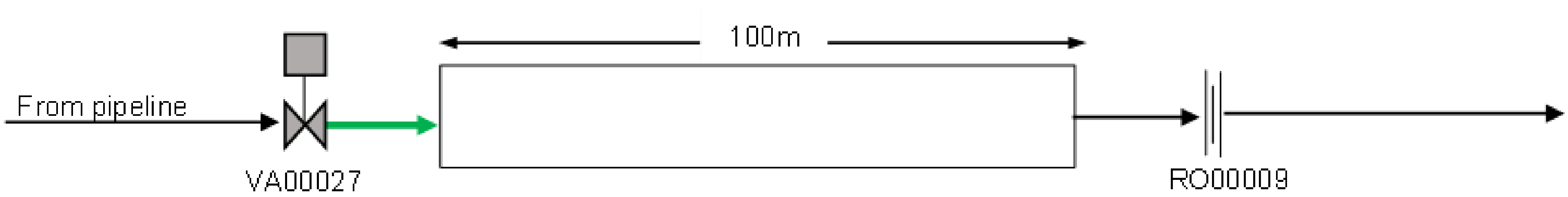


Case Study - Optimum Control Valve Size



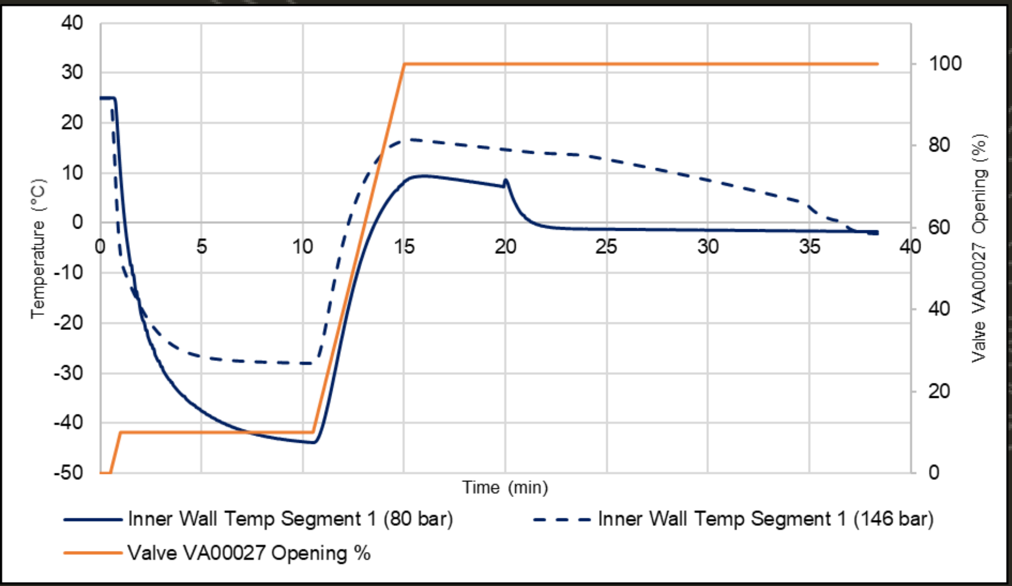
Pressure profiled for a valve CV of 53
Operating conditions of 80barg and 25°C

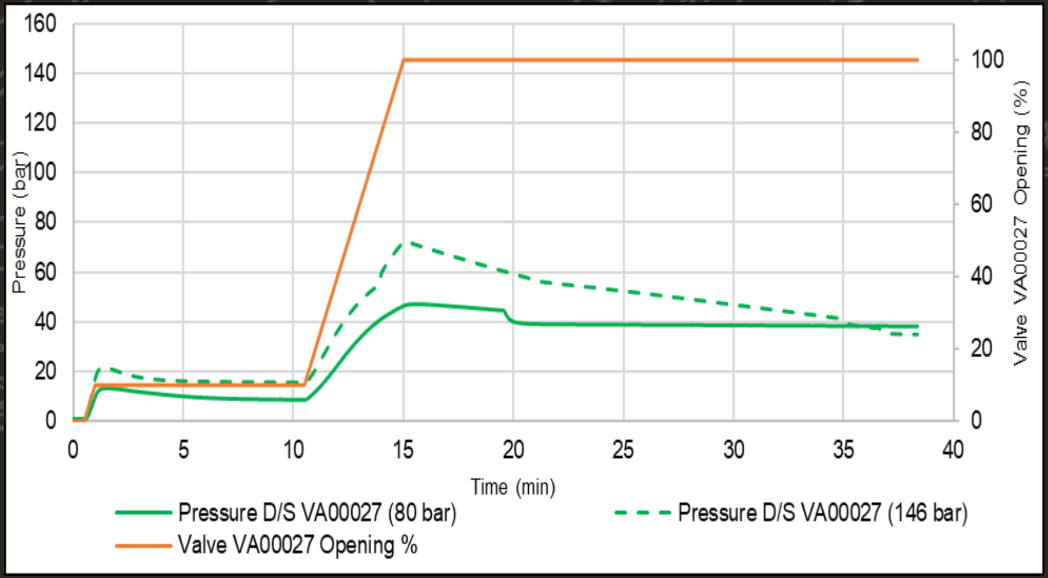
Maximum pressure (green) is 47 bar
After 24hrs the pressure of the system is 36.6 bar
Complete depressurisation takes place after 48 hours



Case Study - Pressure Sensitivity

- Max operating pressure 146 bar vs 80bar
- Operating temperature 25ºC
- Lower operating pressure for the same valve Cv results in the worst case for low piping wall temperatures
- Higher operating pressure for the same valve Cv results in the worst case for maximum pressure downstream the valve





Case Study – Project Recommendations

- Two stage depressurisation required
- Maximum blowdown valve size of Cv 53 & RO size 50mm
- Minimum piping wall temperature downstream of blowdown valve -44°C
- Maximum pressure seen downstream of blowdown valve 47 barg
- Entire duration of second stage of blowdown (from 80 to 0 barg) to take 48 hours

Case Study – Conclusions

- Using Schlumberger's Symmetry Dynamics we were able to provide a solution to the project with confidence that carbon steel minimum design temperatures would not be breached.

- Design conditions of blowdown system reduced:

  - Before: 146 barg and -88°C

  - After: 46 barg and -44°C

- Enabled significant cost savings to the project not requiring expensive specialist materials

- Added benefit of Symmetry Dynamics was being able to perform blowdown valve sizing

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