Application Bulletin
PIPENET® Transient Module Case Study

AIRCRAFT REFUELLING SYSTEMS

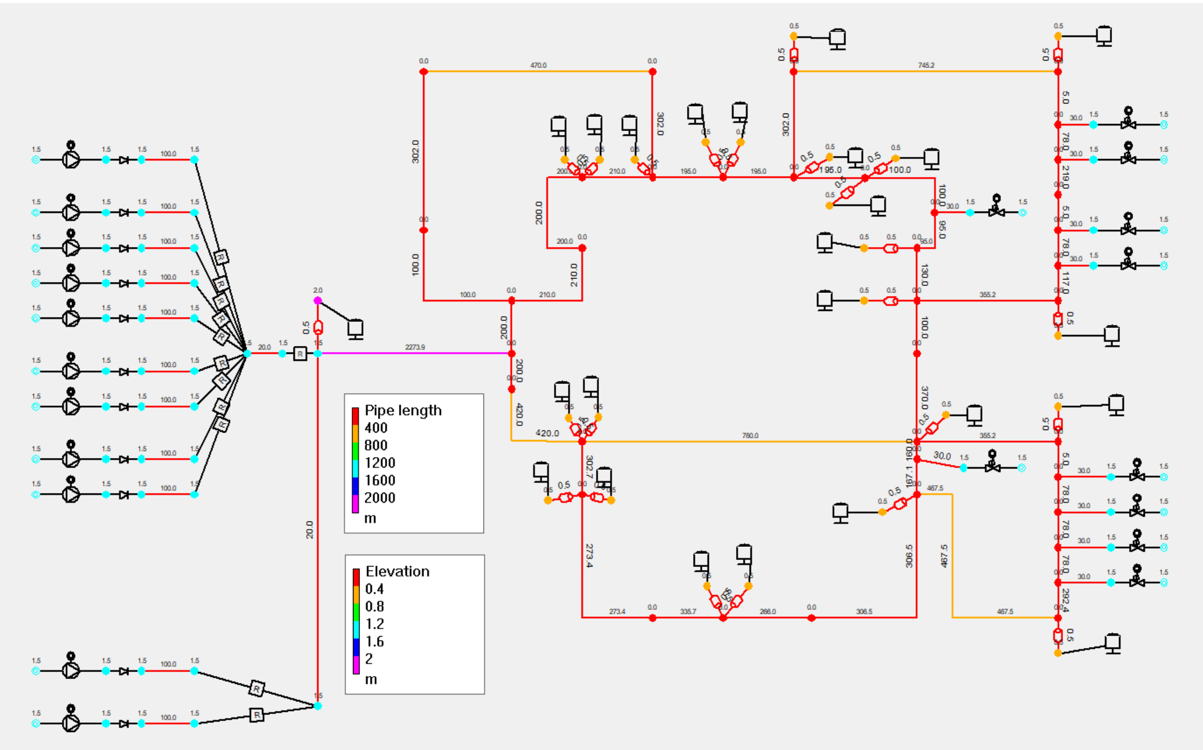
INTRODUCTION

PIPENET Transient module is an incredibly versatile tool. Its applications cover various industries, networks and types of analysis. In this application bulletin we consider aircraft refuelling systems in three international airports. In order to show the versatility of PIPENET Transient module we set different aims in modelling the three systems.

- Soekarno-Hatta International Airport – The aim in modelling this system is to size the accumulators in order to keep the pressure below the maximum allowable pressure.
- Kuala Namo International Airport – The aim of this simulation is to save cost by reducing the number of accumulators.
- A new international airport – In this case the delivery point at the aircraft has a flow control valve. The aim of this simulation is to analyse the stability of the control system and its ability to maintain the flow when an isolation valve is closed.

1. Soekarno-Hatta International Airport Refuelling System - Revamp

Soekarno–Hatta International Airport is the primary airport serving the Greater Jakarta area in Java. The airport commenced domestic operations on 1 May 1985. The airport was expanded in 1991 for international flights. It has two runways at present. Improvement work is ongoing to add a third runway and increase the capacity from around 70 to 100 million/year.



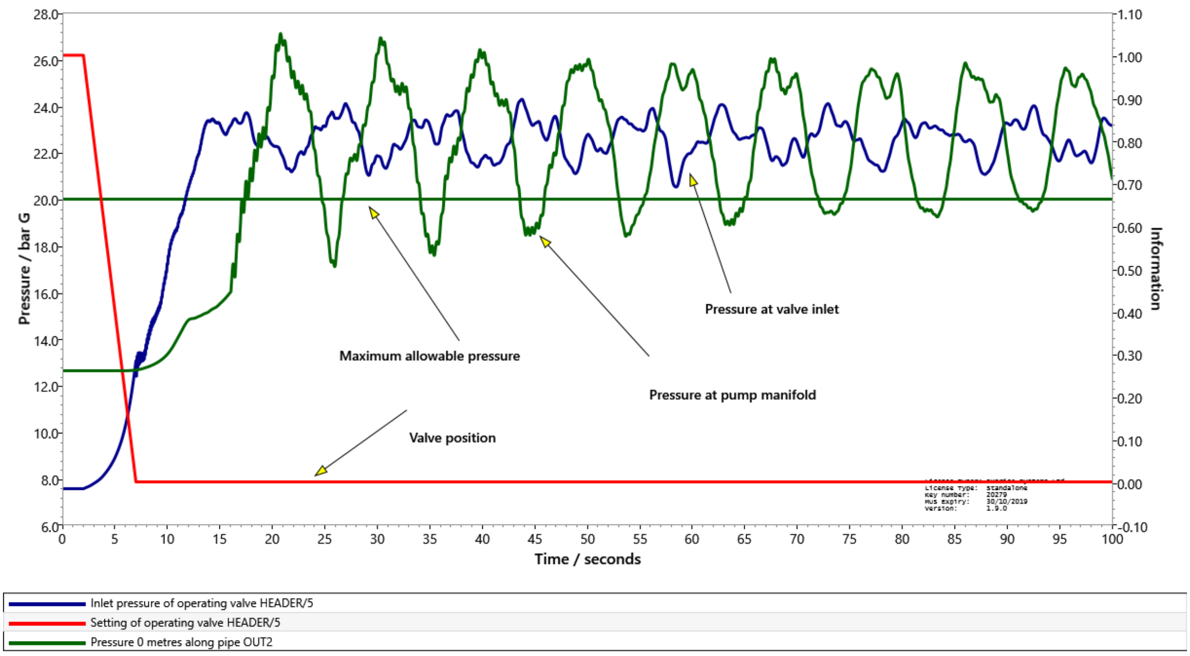
The maximum allowable pressure is 20 barg.

Case 1 – As built case

All accumulators are 12 inch diameter and 2.1 m tall except the accumulator at the pump header which is 16 inch diameter and 2.4 m tall.

```
PRESSURE EXTREMA
----------------

Maximum pressure is 27.0997 bar G
          on pipe OUT2 at the inlet
          at time 20.77600 seconds

Minimum pressure is 0.00000 bar G
          on pump PUMP1 at the inlet
          at time 0.000000 seconds
```

Graphical output of pressure against time



It is clear that the maximum allowable pressure is exceeded. Furthermore, the above graph indicates that the pressure is likely to settle down at a steady state pressure which is above the maximum allowable pressure.

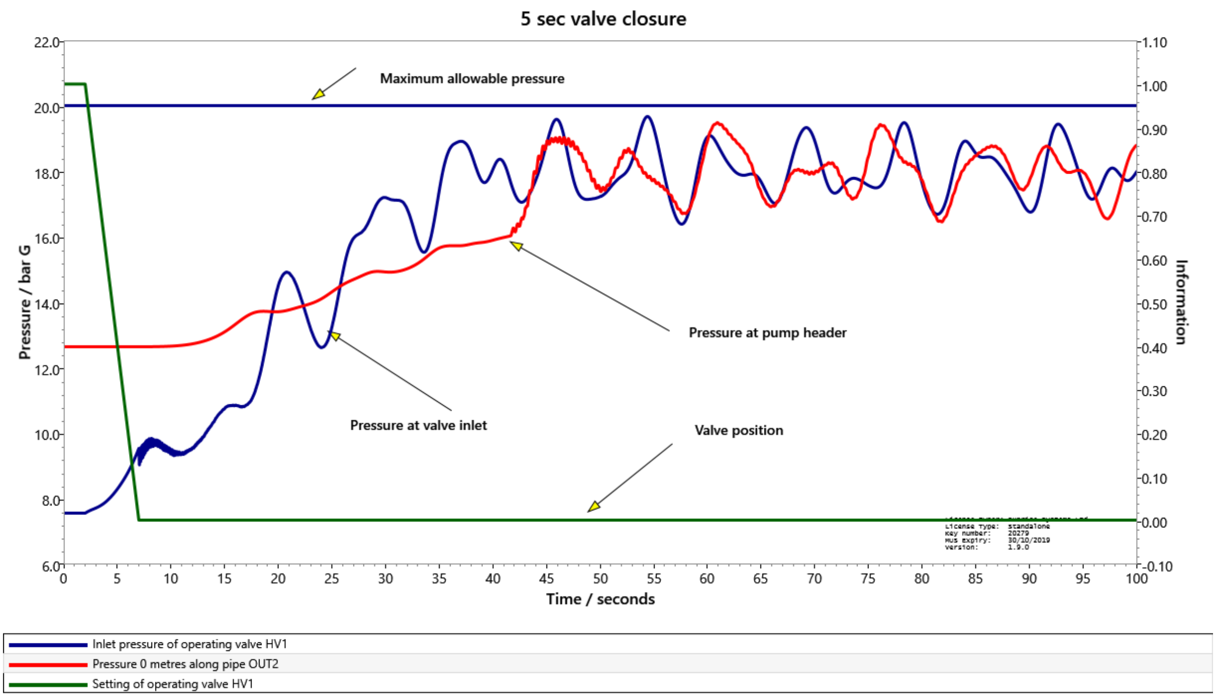
Case 2 – Larger accumulators

All accumulators are increased in size to 52 inch diameter and 3 m tall. It can be seen that the maximum pressure comes down to less than 20 barg.

Summary tabular output

```
PRESSURE EXTREMA
----------------

Maximum pressure is 19.8042 bar G
          on pipe 15 at the outlet
          at time 54.36800 seconds

Minimum pressure is 0.00000 bar G
          on pump PUMP1 at the inlet
          at time 0.000000 seconds
```

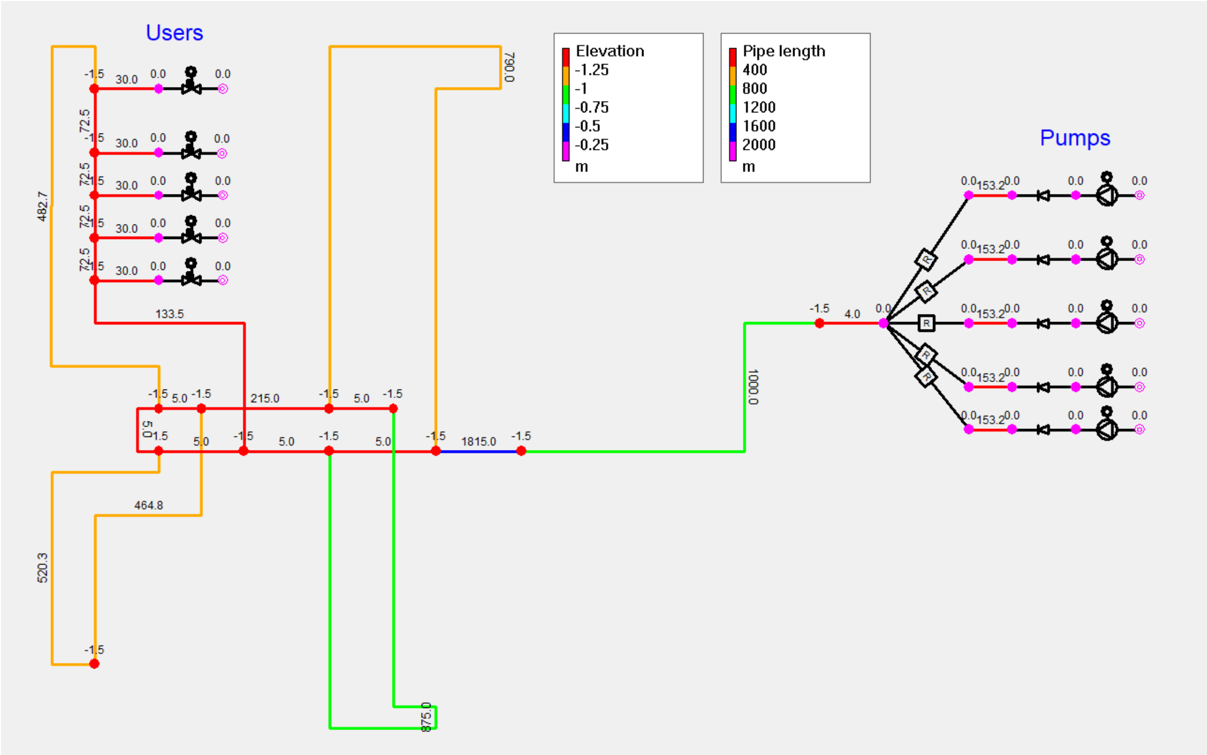
Graphical output of pressure against time



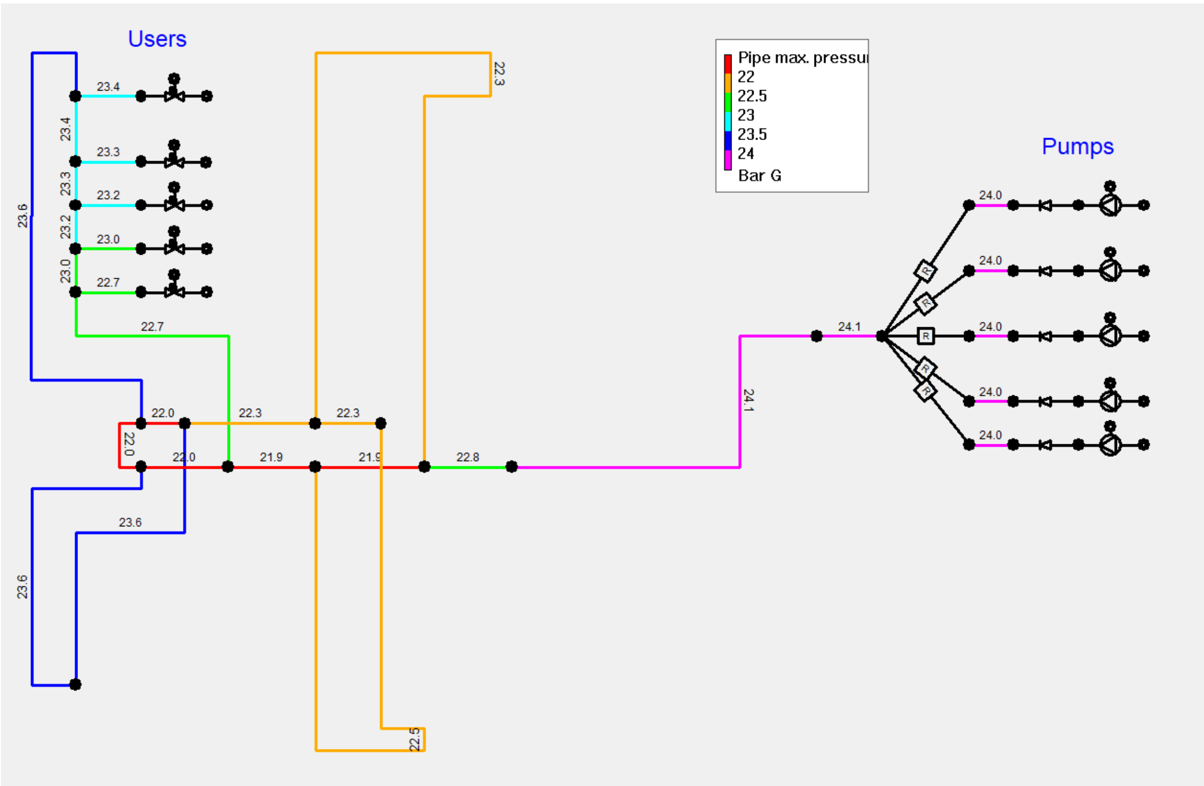
2. Kuala Namu International Airport in Medan

This international airport located on Sumatra is one of the busiest airports in Indonesia. The design criterion in this case was a maximum allowable pressure of 20 barg at the valve inlet.

Case 1 - System with no accumulators



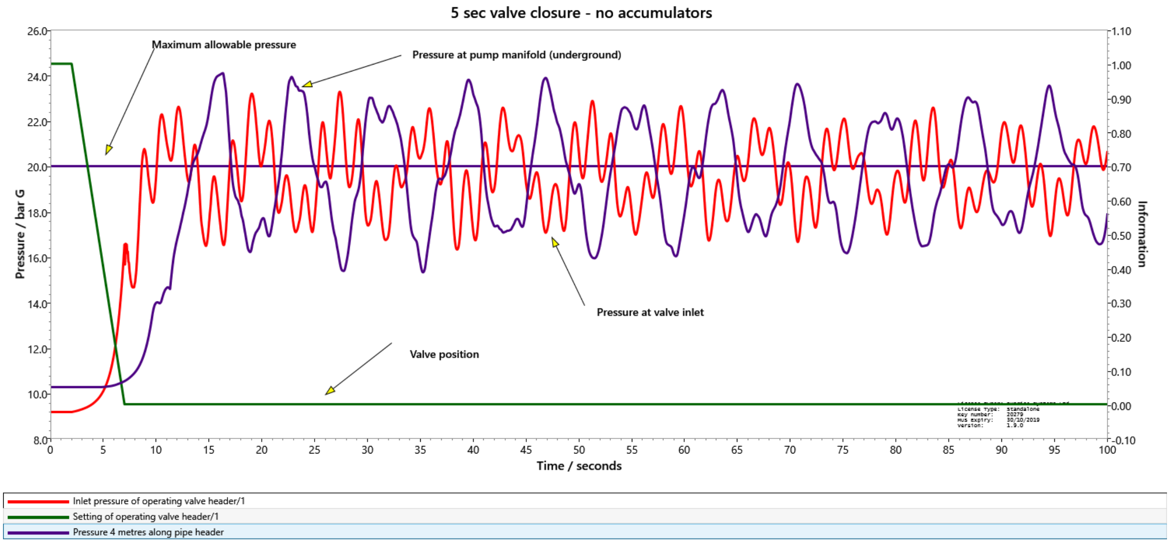
Maximum pipe pressures are displayed on the schematic. In this case all user valves closed in 5 seconds.



Summary tabular output

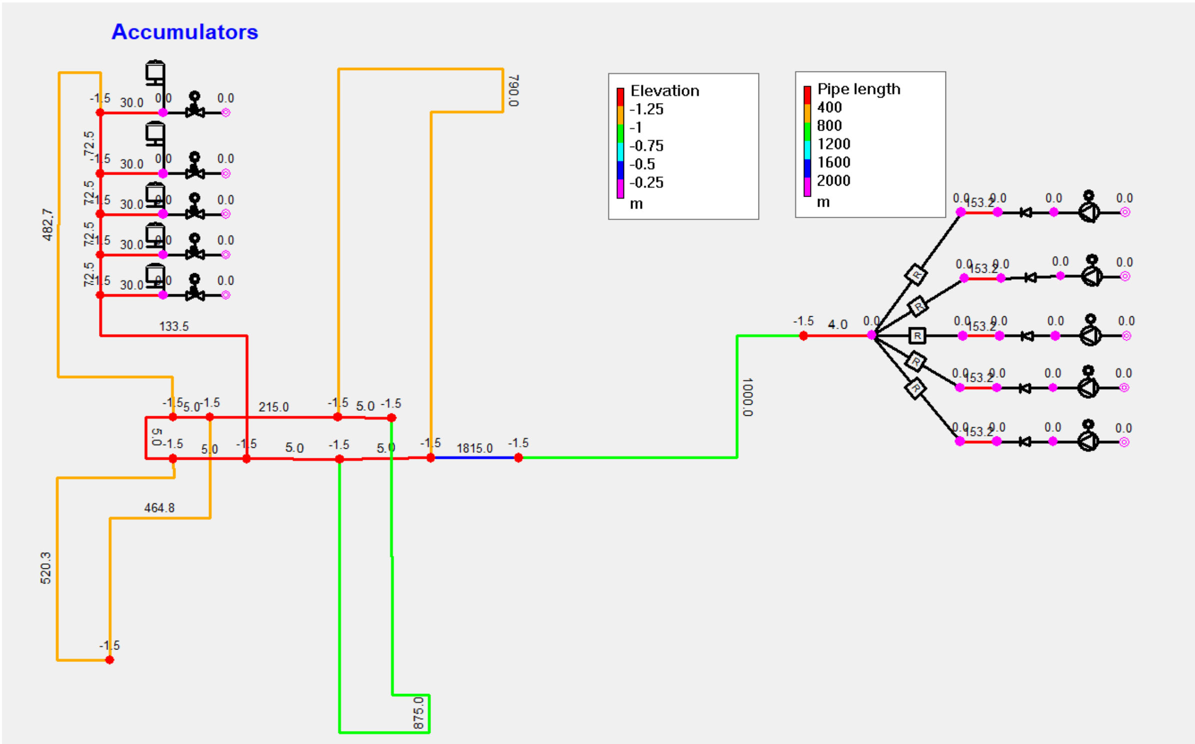
```
PRESSURE EXTREMA
----------------

Maximum pressure is 24.0867 bar G
          on pipe header at the outlet
          at time 16.32000 seconds

Minimum pressure is 0.00000 bar G
          on pump Pump1 at the inlet
          at time 0.000000 seconds
```

Graphical output of pressure against time

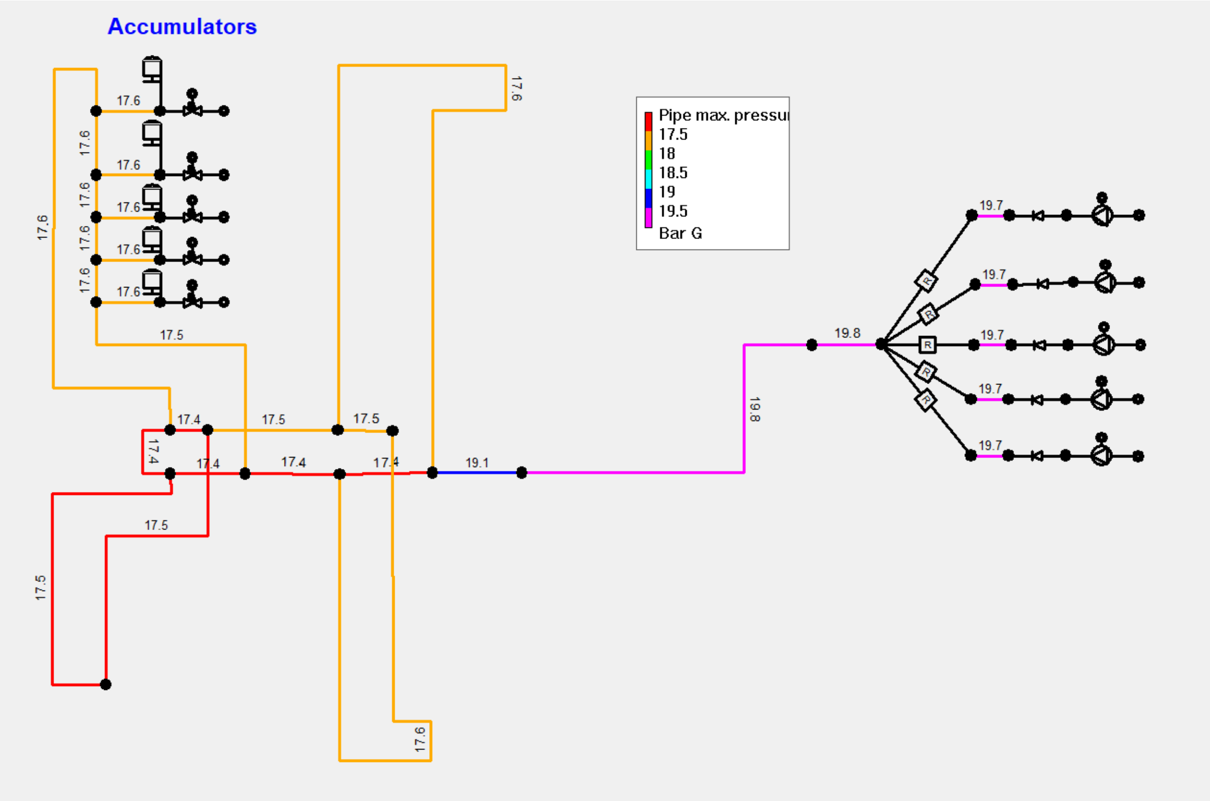


Case 2: One accumulator at every valve

Each accumulator is 60 inch diameter and 2 m tall.



Maximum pipe pressures are displayed on the schematic. In this case all user valves closed in 5 seconds and every user had an accumulator.

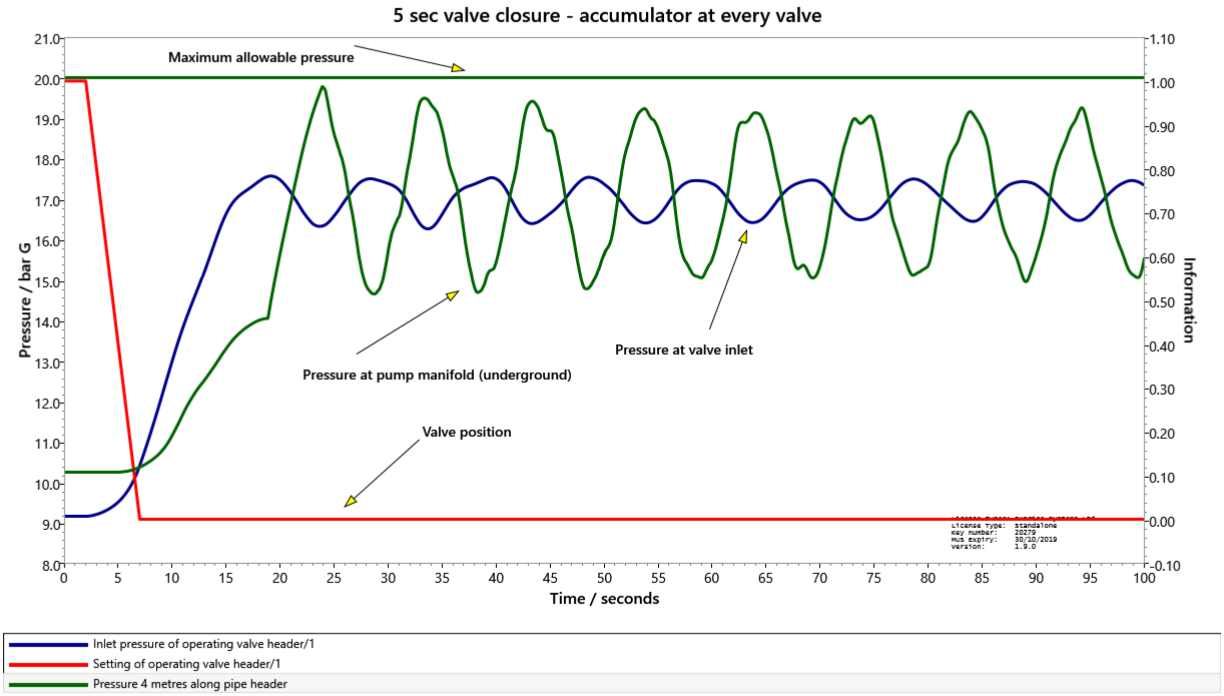


Summary tabular output

```
PRESSURE EXTREMA
----------------

Maximum pressure is 19.7799 bar G
          on pipe header at the outlet
          at time 23.91000 seconds

Minimum pressure is 0.00000 bar G
          on pump Pump1 at the inlet
          at time 0.000000 seconds
```

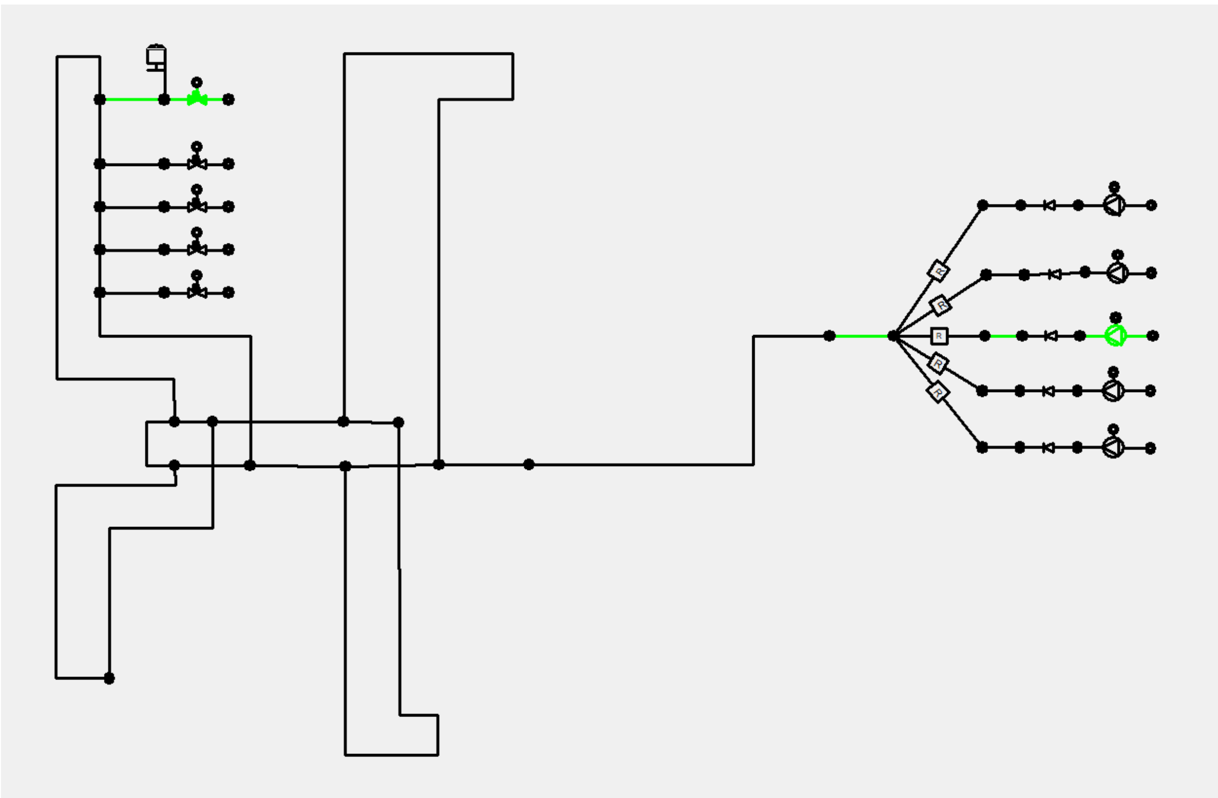
Graphical result of pressure against time

We note that both the maximum pressure and oscillations are reduced.



Case 3: One bigger common accumulator

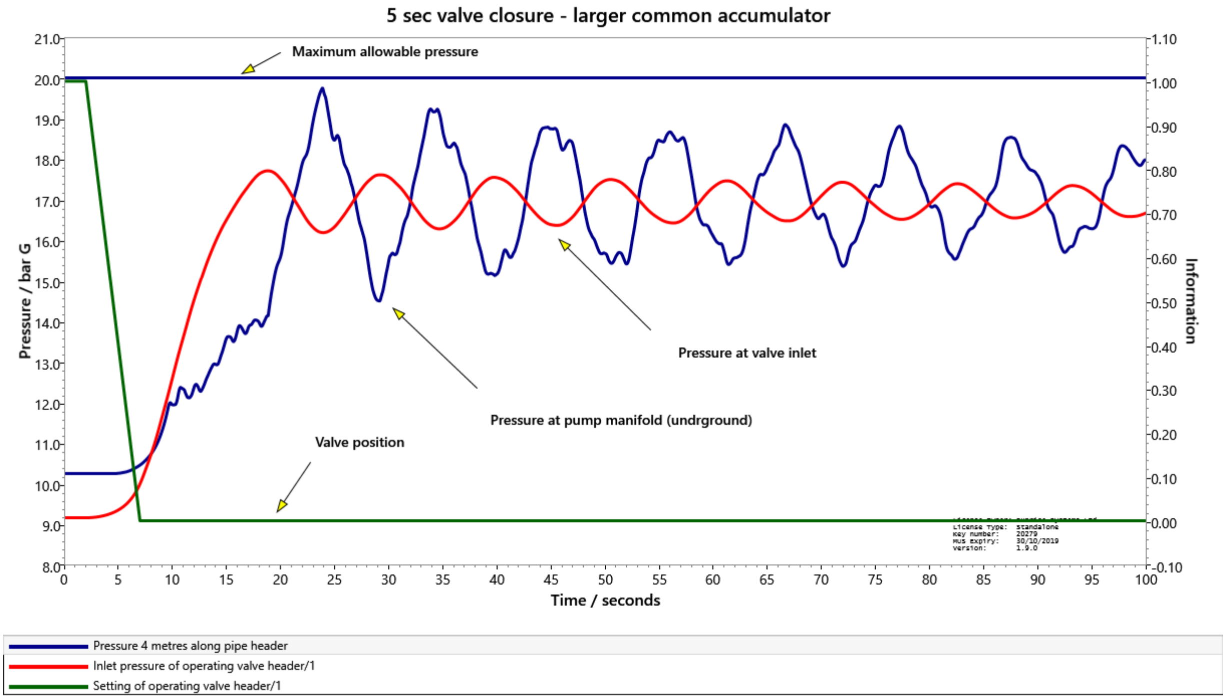
Alternatively, the network has one larger accumulator which is 100 inch diameter and 2.5 m tall.



Summary tabular output

```
PRESSURE EXTREMA
----------------

Maximum pressure is 19.7495 bar G
          on pipe header at the outlet
          at time 23.87000 seconds

Minimum pressure is 0.00000 bar G
          on pump Pump1 at the inlet
          at time 0.000000 seconds
```

Graphical result of pressure against time



3. International Airport Refuelling system – Control System Study

The salient parameters are the following:

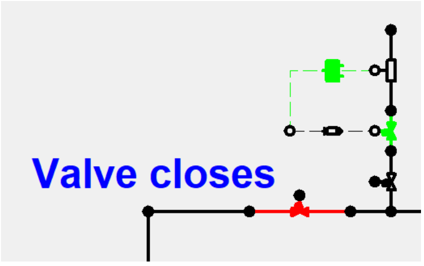
- Control valve Cv = 2000 (lit/min, bar)

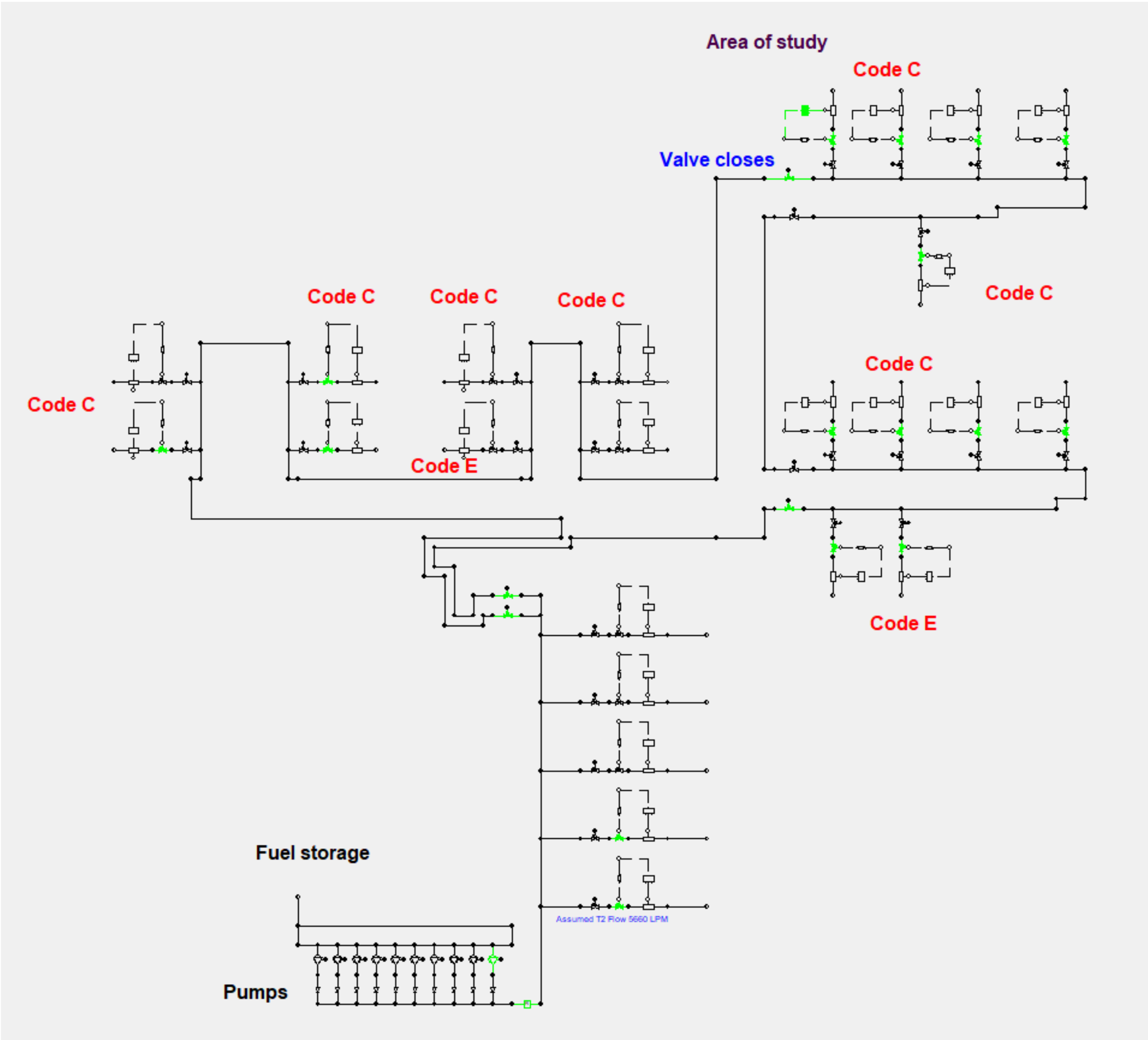
Controller parameters:

- Gain = -0.001 (lt/min, bar)
- Set point = 1176 (lt/min) flowrate
- Output set point = Anti-windup tracking time = 1 sec

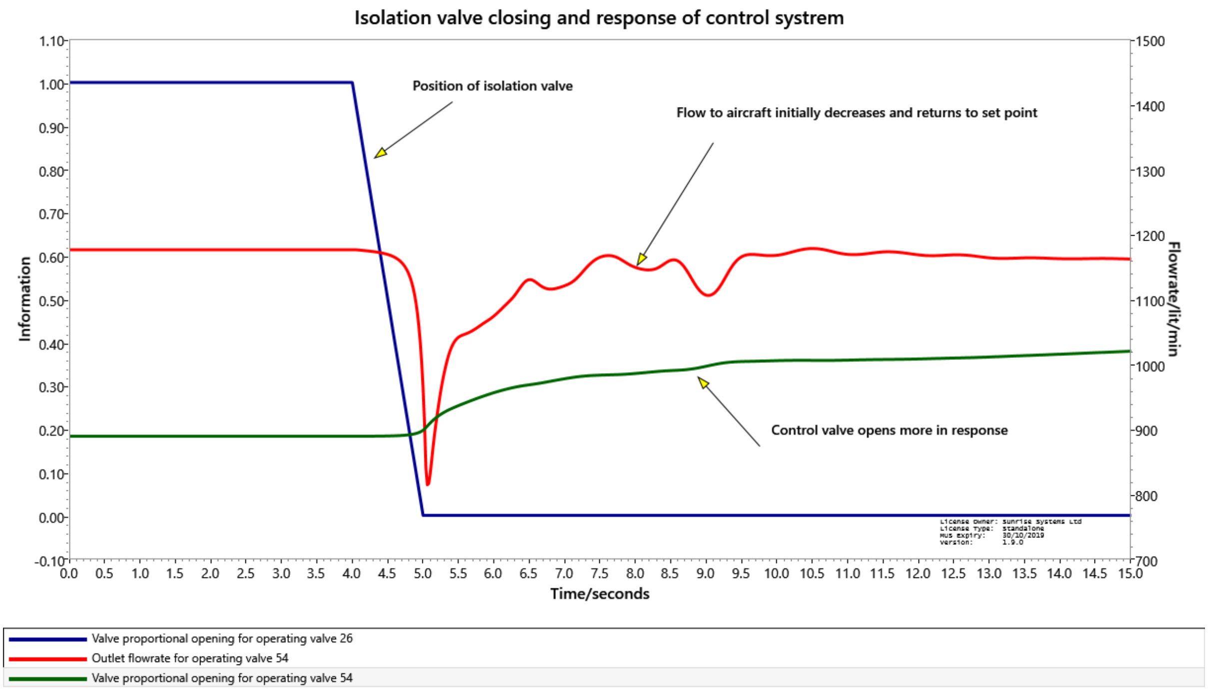
Event to be modelled:

- The isolation valve shown below closes in 1 sec.


Valve closes


Area of study
Code C
Valve closes
Code C
Code C
Code C
Code C
Code C
Code C
Code E
Code E
Fuel storage
Pumps
Assumed T2 Flow 5660 LPM

Case 1: Proportional and integral terms

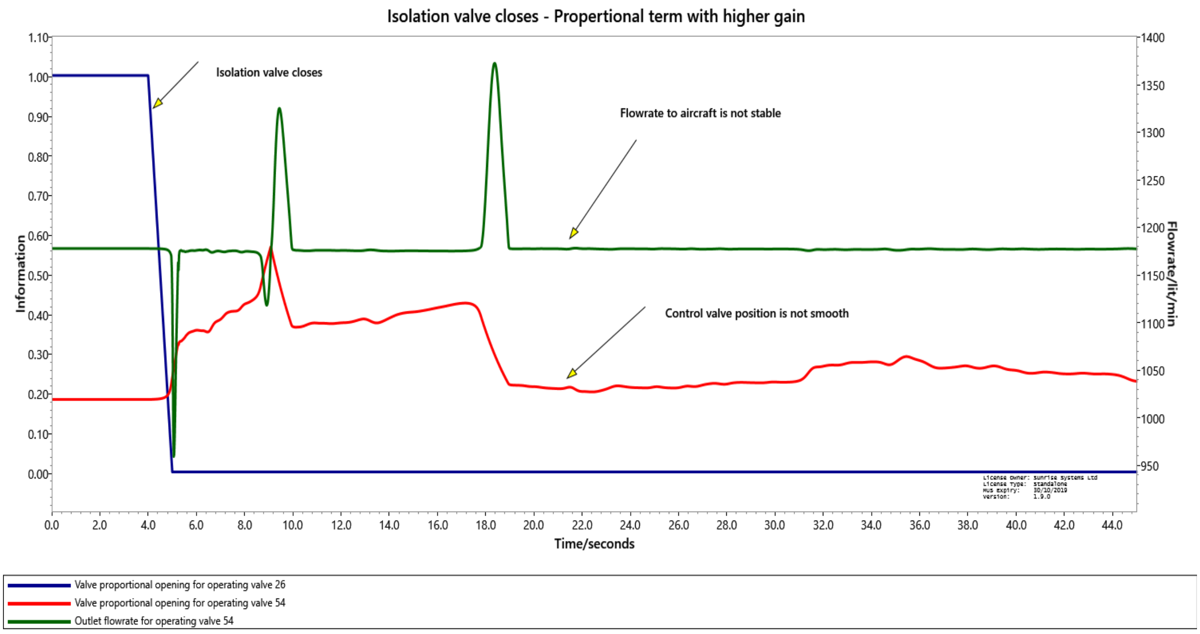


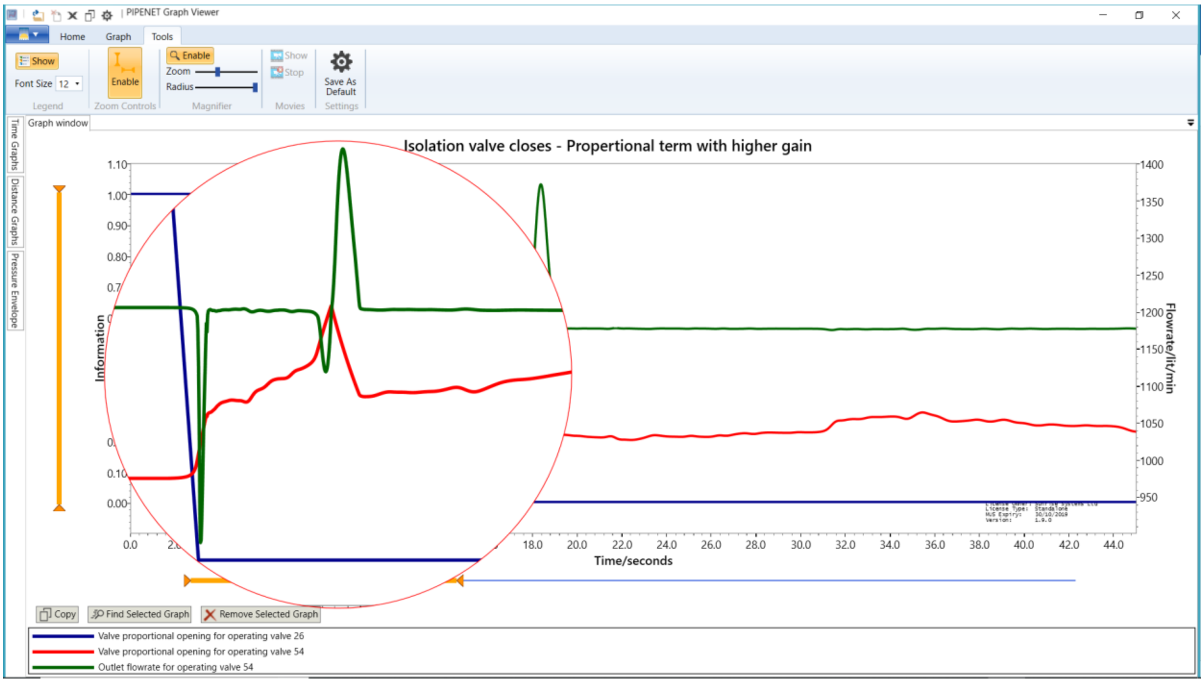
Case 2: Proportional term only with increased gain

The integral term is removed.

The gain was set to -0.1 (lt/min,bar).

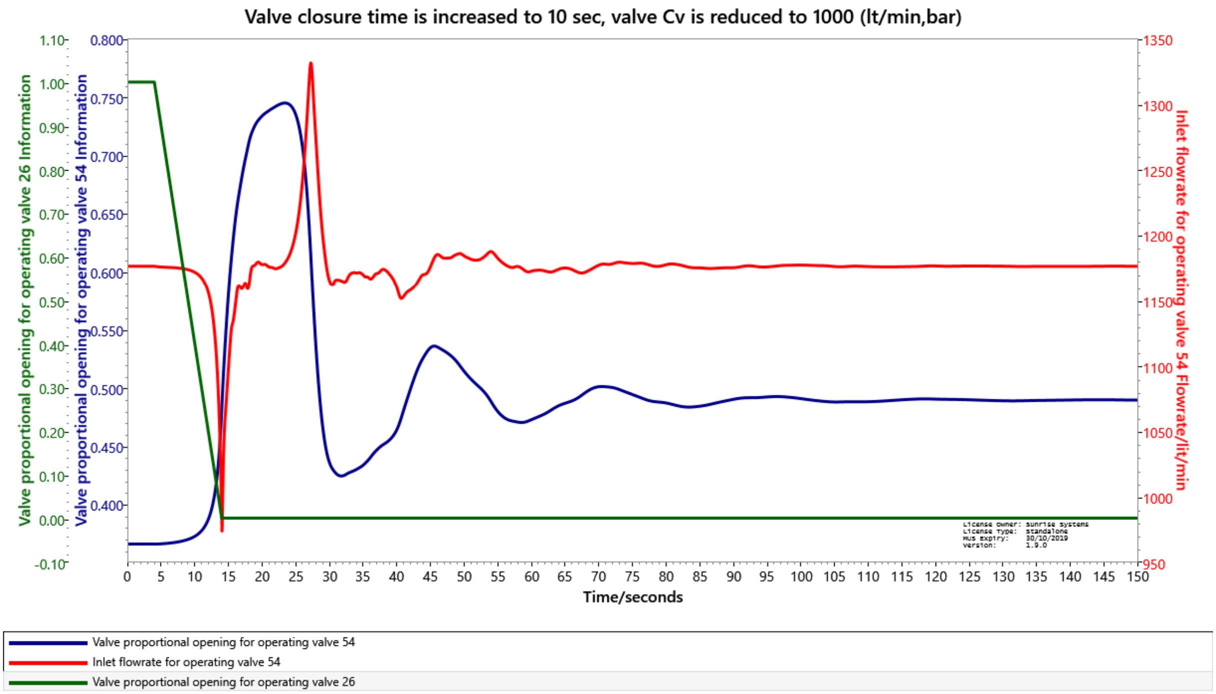
We can see that the flowrate of jet fuel to the aircraft has significant peaks and troughs.





Case 3: Fine tuning

The isolation valve closure time is increased to 10 sec and the control valve Cv is decreased to 1000 (lt/min, bar). It is clear that case 1 is well behaved and is difficult to improve upon.



CONCLUSIONS

This Application Bulletin considers three different aircraft refuelling systems. The studies had different aims and objectives.

Example 1: The aim was to bring the pressure below the maximum allowable pressure of 20 barg by changing the size of the accumulator.

Example 2: The aim was to reduce the cost of the system by reducing the number of accumulators, while still not exceeding the maximum allowable pressure of 20 barg.

Example 3: The aim here was to analyse the stability of the control system.

This document shows the versatility of PIPENET in optimising the design of aircraft refuelling systems.

If you have any questions about this case study, or any other of PIPENET's capabilities, please email us at pipenet@sunrise-sys.com.