Application Bulletin
PIPENET® LNG Applications

MODELLING LNG LOADING SYSTEMS

BACKGROUND

In this application bulletin we illustrate the use and benefits of PIPENET Transient module in mitigating potential pressure surges and cavitation in LNG loading systems. A number of scenarios are considered before arriving at the optimum philosophy of operation.

In particular we consider the following two aspects of the normal shut down of the system. The simulations pinpoint the strategy for eliminating pressure surge problems.

1. The pressure surge upstream of the shut off valve.
2. Cavitation in the loading arm.

The table below shows the scenarios which were considered. In all cases the shut off valve closes.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Pump stops	No	Yes	Yes	Yes	Yes
Bypass valve opens	No	Yes	Yes	Yes	Yes
Back pressure at tank	No	No	Yes	Yes	Yes
Tank valve closes	No	No	No	Yes	Yes
Higher elevation of loading arm	No	No	No	No	Yes

LNG properties:

Density = 444 kg/m3

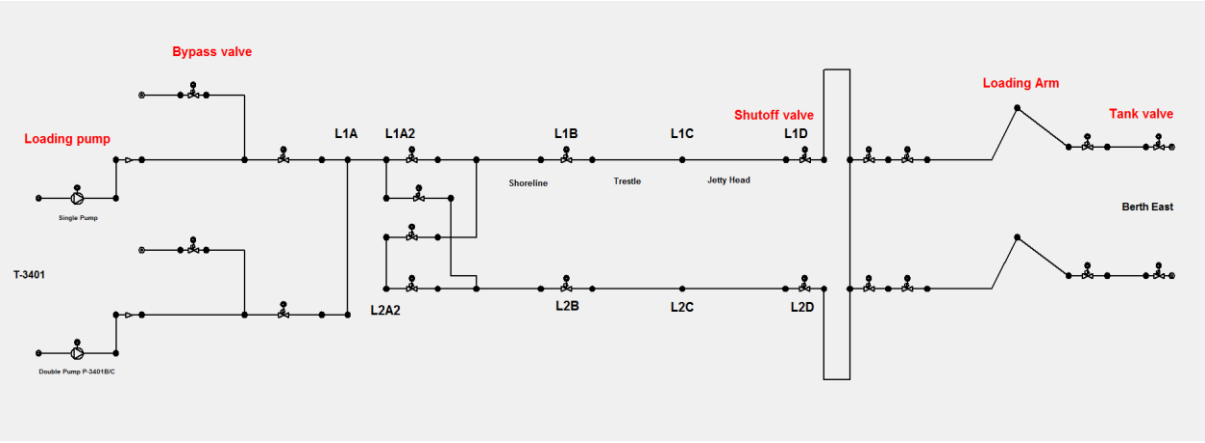
Viscosity = 0.128 cP

Bulk modulus = 1.17x 10^9 Pa

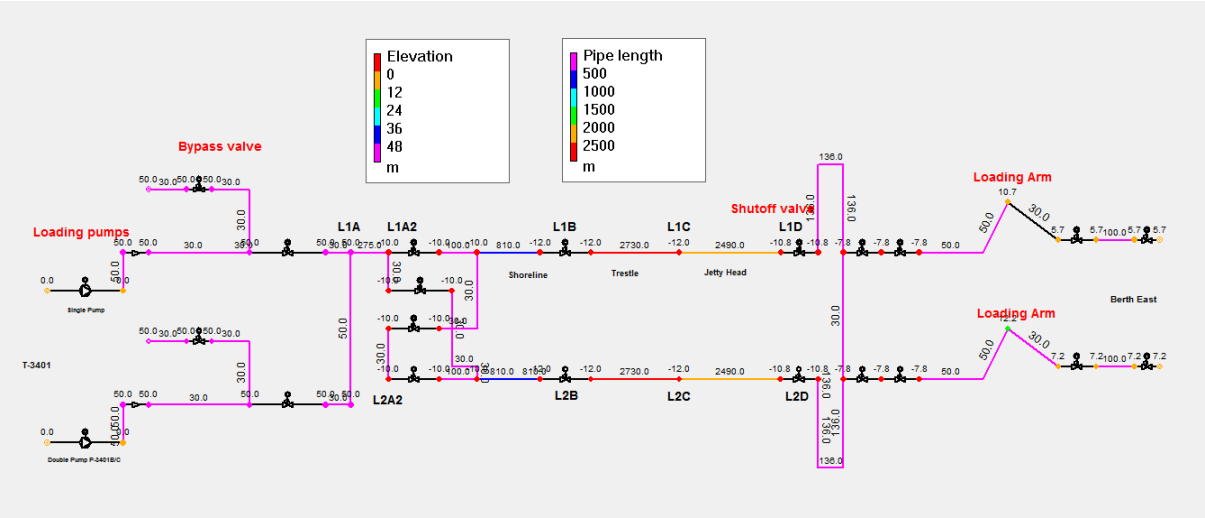
Vapour pressure = 0 barg

The apex of the loading arm is 21.5 m above the shut-off valve in Scenarios 1 – 4. In Scenario 5 it is increased to 46.5 m.

The schematic drawing of the network:



The schematic drawing with colour coding:



THE RESULTS:

Both graphical and numerical results are presented for the 5 scenarios outlined above.

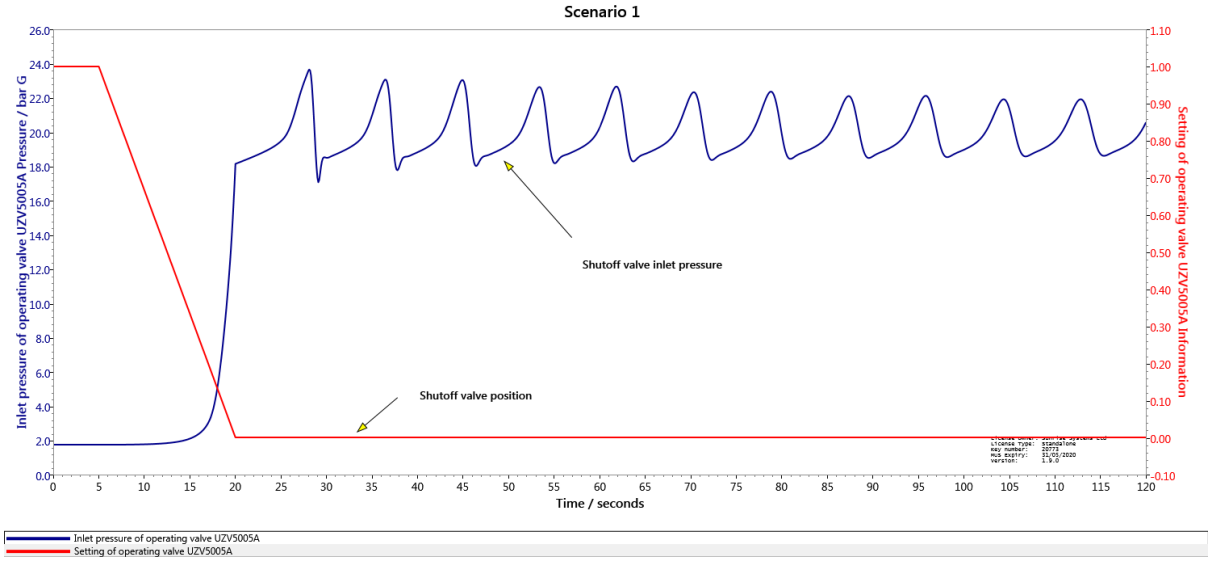
Scenario 1

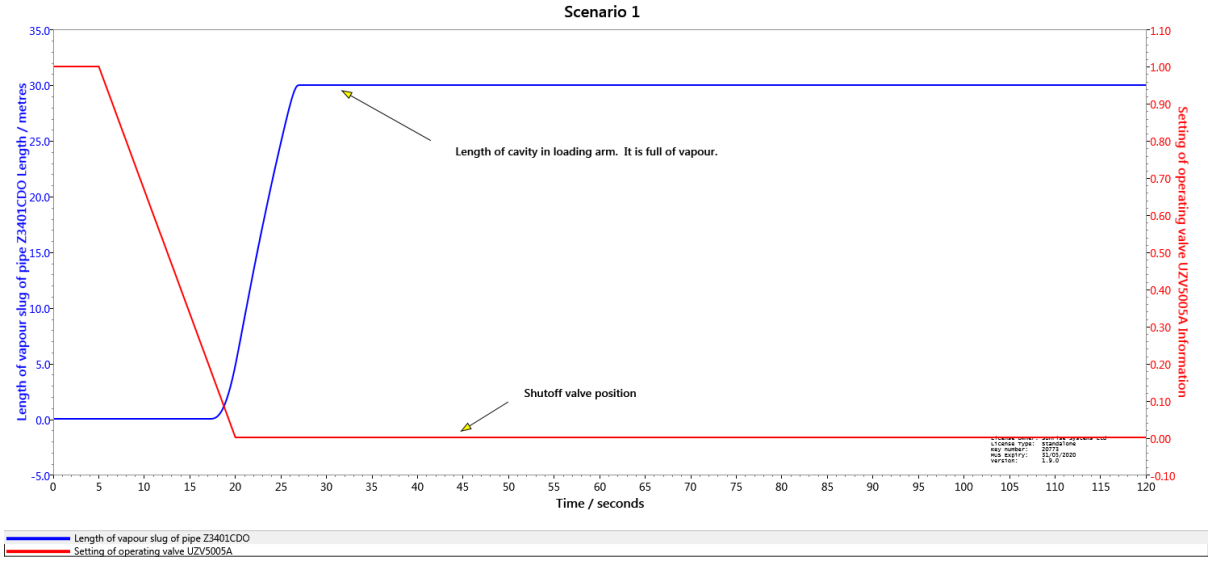
In this scenario the shutoff valve closes and no other transient phenomena take place.

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

Maximum pressure is 23.6586 bar G
          on pipe 25 at the outlet
          at time 28.10000 seconds

Minimum pressure is 0.00000 bar G
          on pipe 4 at the inlet
          at time 0.000000 seconds
```





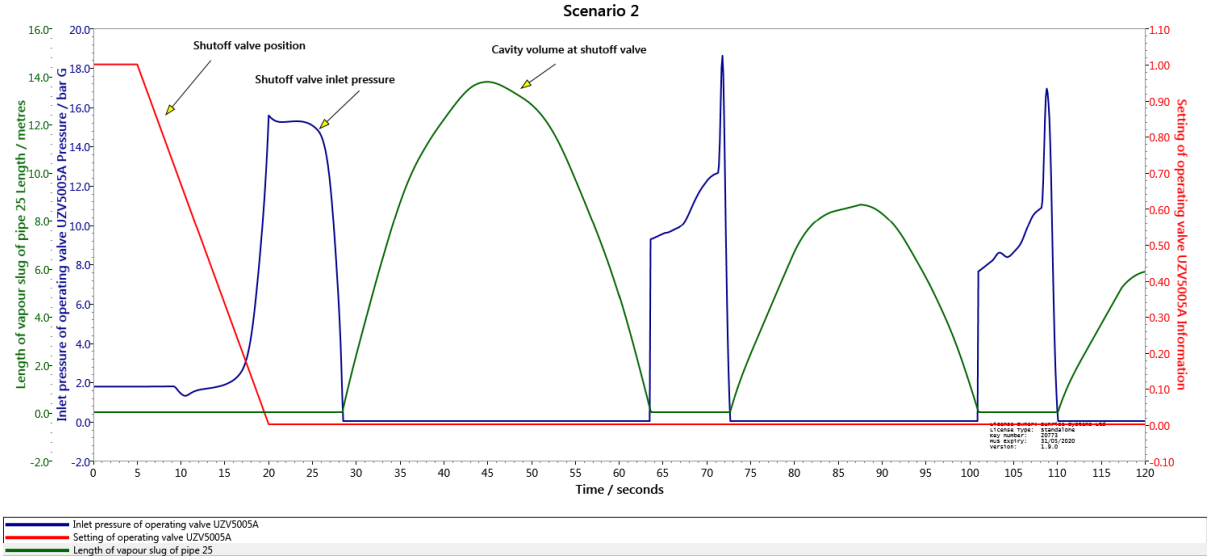
Scenario 2

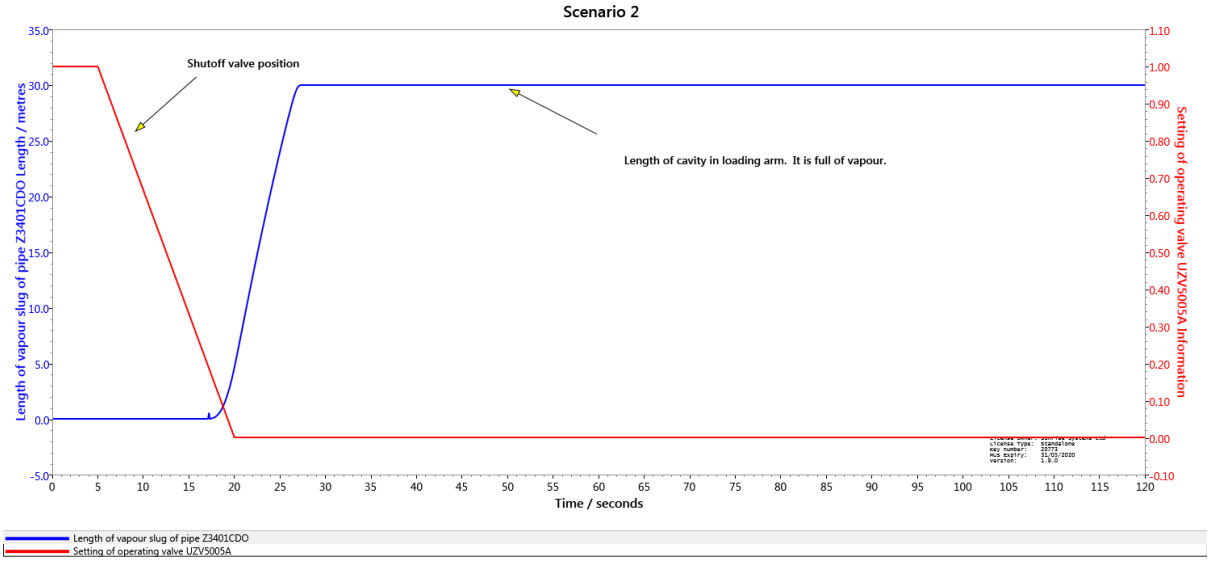
In this scenario the shutoff valve closes, the loading pump stops and the bypass valve opens.

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

Maximum pressure is 18.6108 bar G
          on pipe 25 at the outlet
          at time 71.80000 seconds

Minimum pressure is 0.00000 bar G
          on pipe 4 at the inlet
          at time 0.000000 seconds
```





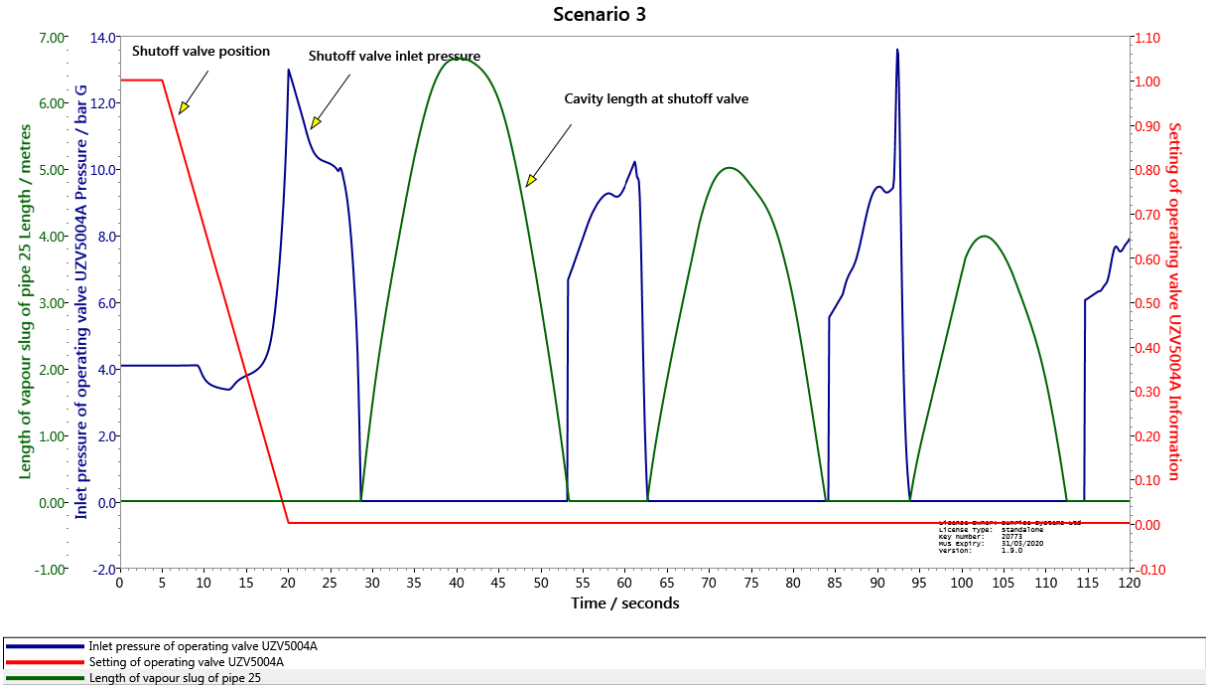
Scenario 3

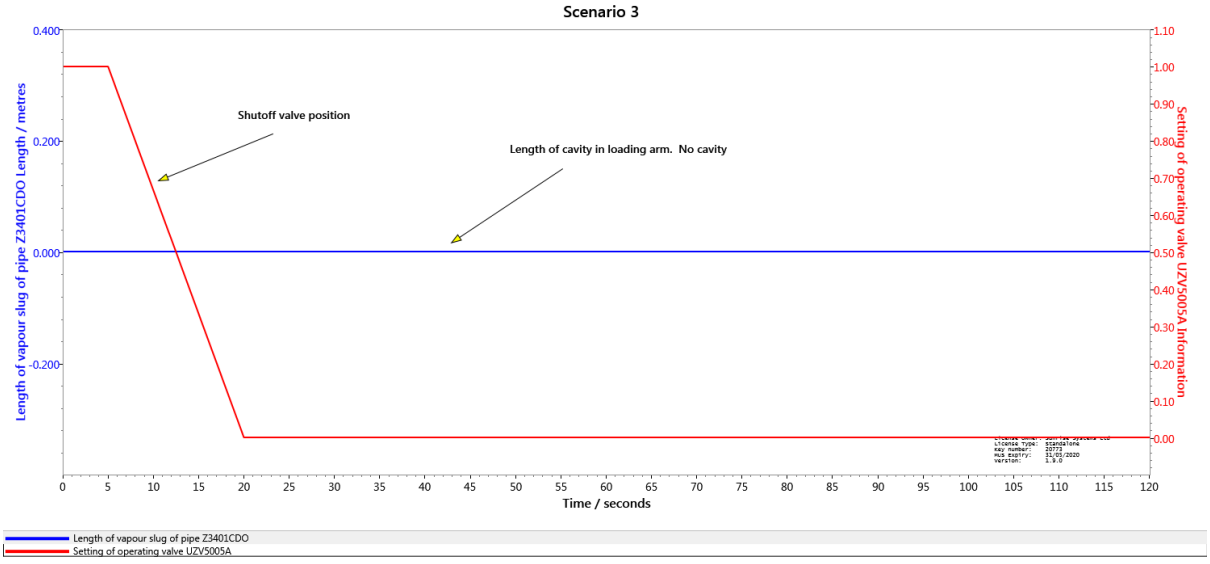
In this scenario the shutoff valve closes, the loading pump stops, the bypass valve opens and the cargo tank has a back pressure of 2.5 barg.

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

Maximum pressure is 14.8745 bar G
          on pipe 25 at the outlet
          at time 61.60000 seconds

Minimum pressure is 0.00000 bar G
          on pipe 4 at the inlet
          at time 0.000000 seconds
```





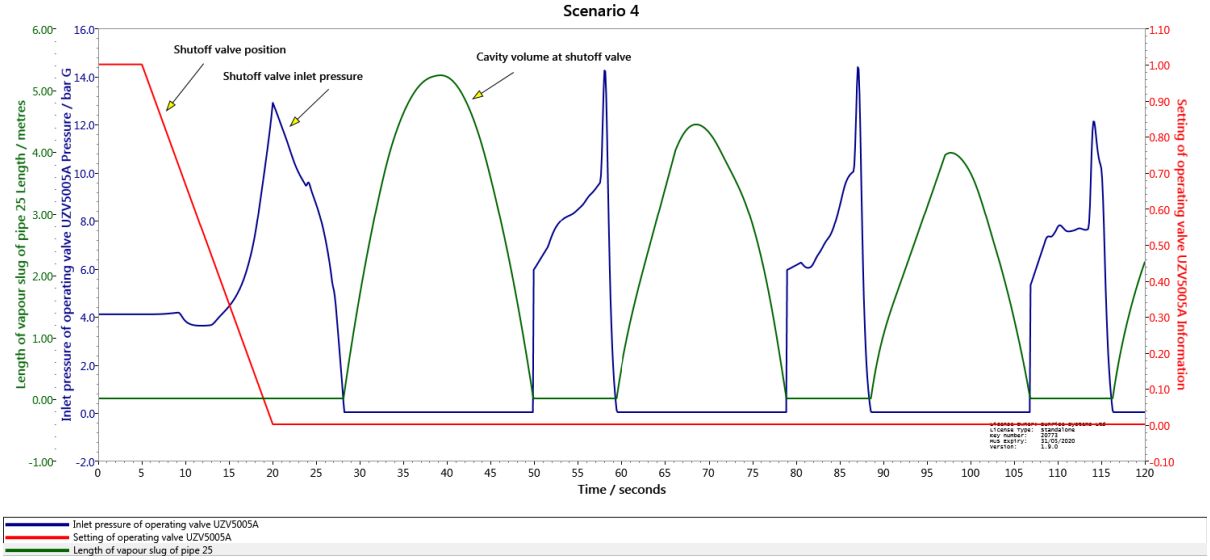
Scenario 4

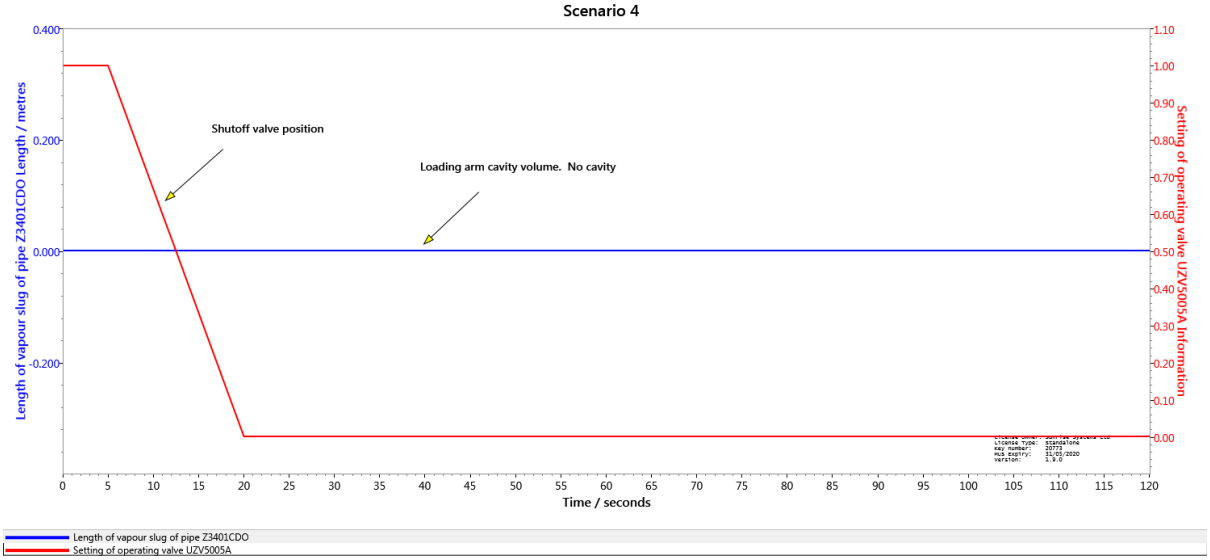
In this scenario the shutoff valve closes, the loading pump stops, the bypass valve opens, the cargo tank has a back pressure of 2.5 barg and the tank valve closes.

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

Maximum pressure is 14.3922 bar G
          on pipe 25 at the outlet
          at time 87.10000 seconds

Minimum pressure is 0.00000 bar G
          on pipe 4 at the inlet
          at time 0.000000 seconds
```





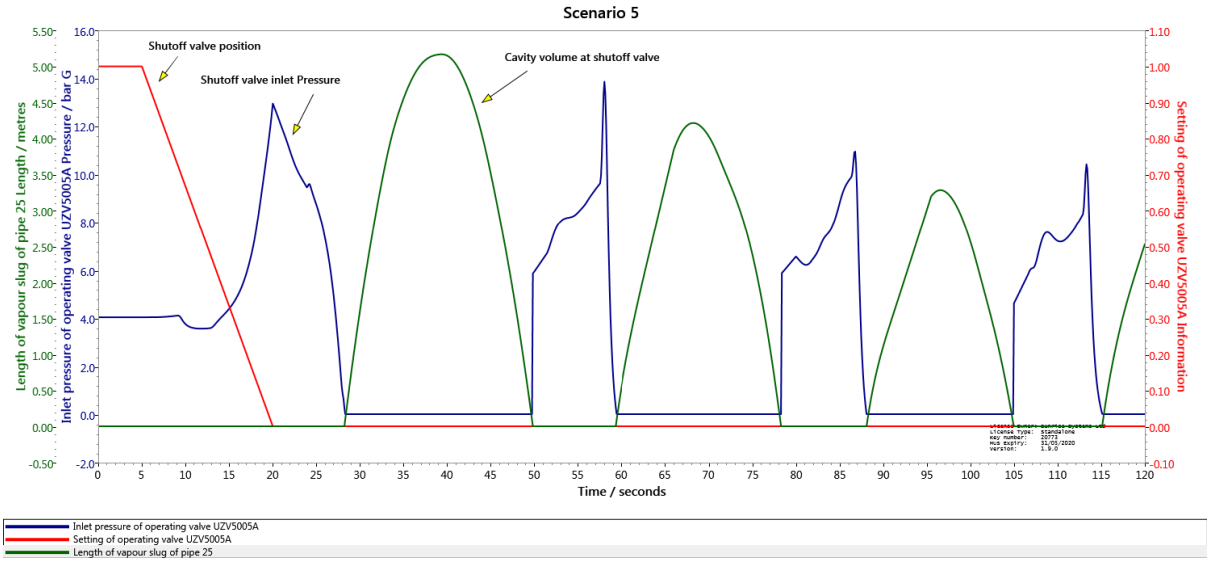
Scenario 5

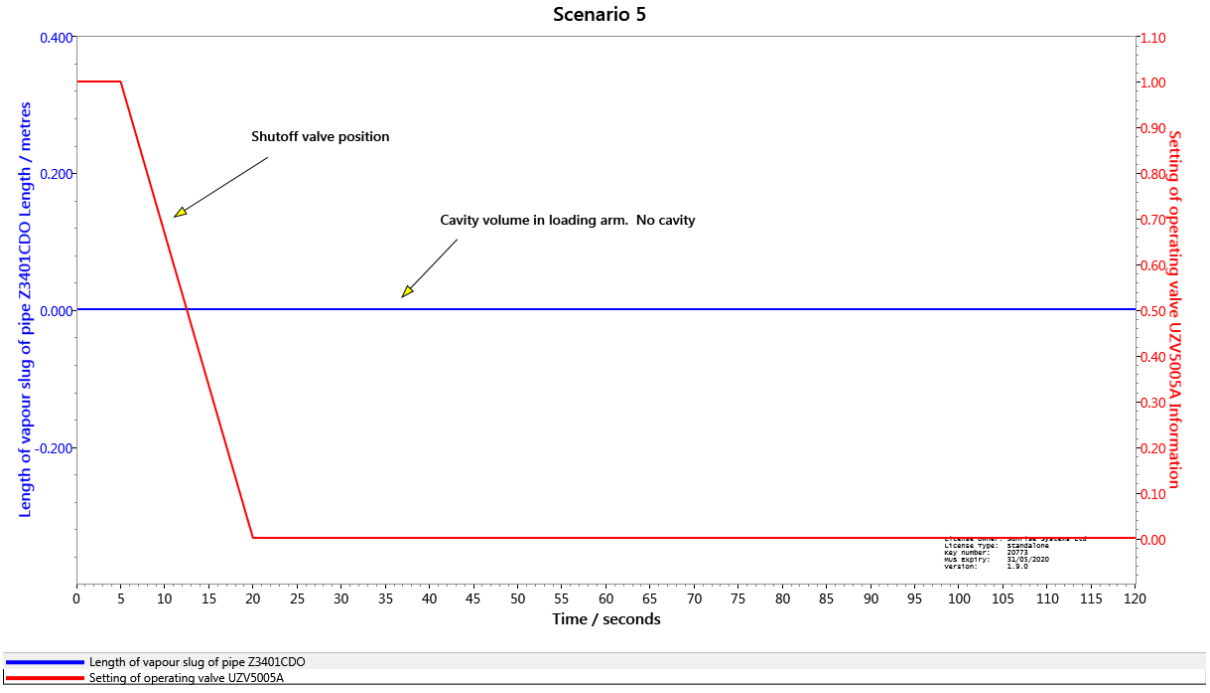
In this scenario the shutoff valve closes, the loading pump stops, the bypass valve opens, the cargo tank has a back pressure of 2.5 barg, the tank valve closes and the apex of the loading arm is increased to 46.5 m above the shutoff valve.

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

Maximum pressure is 13.8637 bar G
          on pipe 25 at the outlet
          at time 58.00000 seconds

Minimum pressure is 0.00000 bar G
          on pipe 4 at the inlet
          at time 0.000000 seconds
```





CONCLUSIONS

This document shows why it is essential to perform pressure surge analysis when designing LNG loading systems. The simulations suggest that it is important to shut down the loading pumps and open the bypass valves. It is also important to have a back pressure at the end of the system. However, depending on the design and layout of the system it may be necessary to take other surge alleviating measures.

On the basis that the maximum allowable pressure in the systems is 15 barg, the following table summarises the results of the simulation.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Maximum pressure	23.66 barg	18.61 barg	14.87 barg	14.39 barg	13.86 barg
Acceptability	Not acceptable	Not acceptable	Acceptable	Acceptable	Acceptable

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

Sunrise Systems Limited • Sunrise Business Park
Ely Road • Waterbeach • Cambridge CB25 9QZ • United Kingdom
Email: Pipenet@sunrise-sys.com • Web Site: www.sunrise-sys.com