Application Bulletin – Process Industry
PIPENET® Transient Module Case Study

SUBSEA PIPELINE SYSTEM

BACKGROUND

This project was based on a location in the Arabian Gulf, where oil was transported via a 35 Km pipeline from an oil platform to a tank farm. The lowest point of the pipeline is 80 m below the level of the platform. Oil is pumped by a booster/transfer pump and there is an isolation valve at the end of the pipeline.

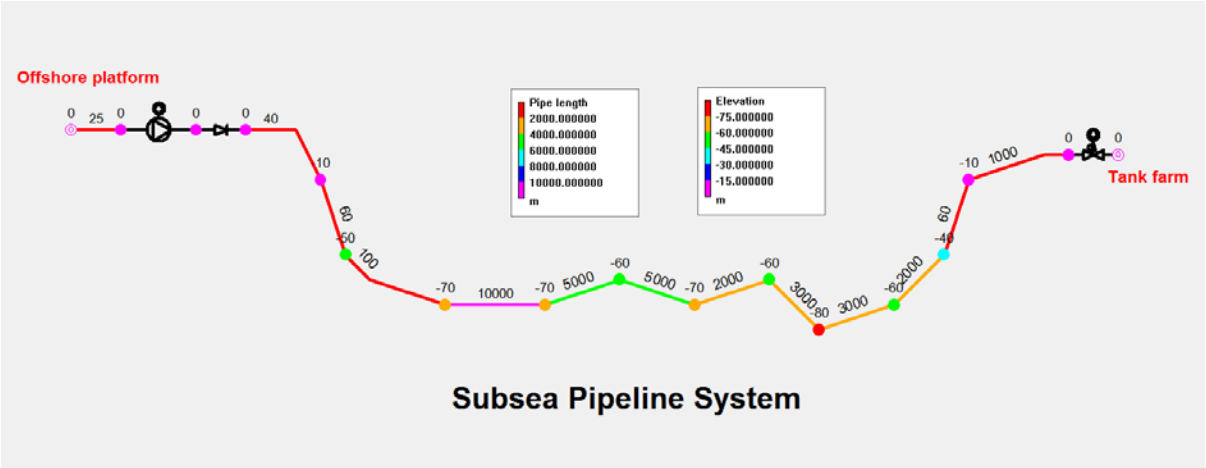
The engineers needed to investigate what transient pressures might occur when the valve was closed. In this project there were two circumstances that caused particular concern:

The pipeline was 25 years old and had suffered some corrosion

There was a high water cut in the oil. This made the fluid less compressible, which in turn would tend to increase the pressure surge.

PIPENET MODEL

PIPENET Transient was chosen to perform the analysis and help to choose a closure strategy for the valve that would yield acceptable results. It was a straightforward task to model the network, which is shown below as a PIPENET Schematic view.



Pipes have been colour coded to show length, and nodes have been colour coded to show elevation.

PIPENET was asked to analyse the following four valve closure cases.

- 60 sec
- 120 sec
- 240 sec

- 600 sec (quadratic valve closure)

The wave speed is 1159 m/sec.

SCENARIO 1 – Linear closure in 60 seconds

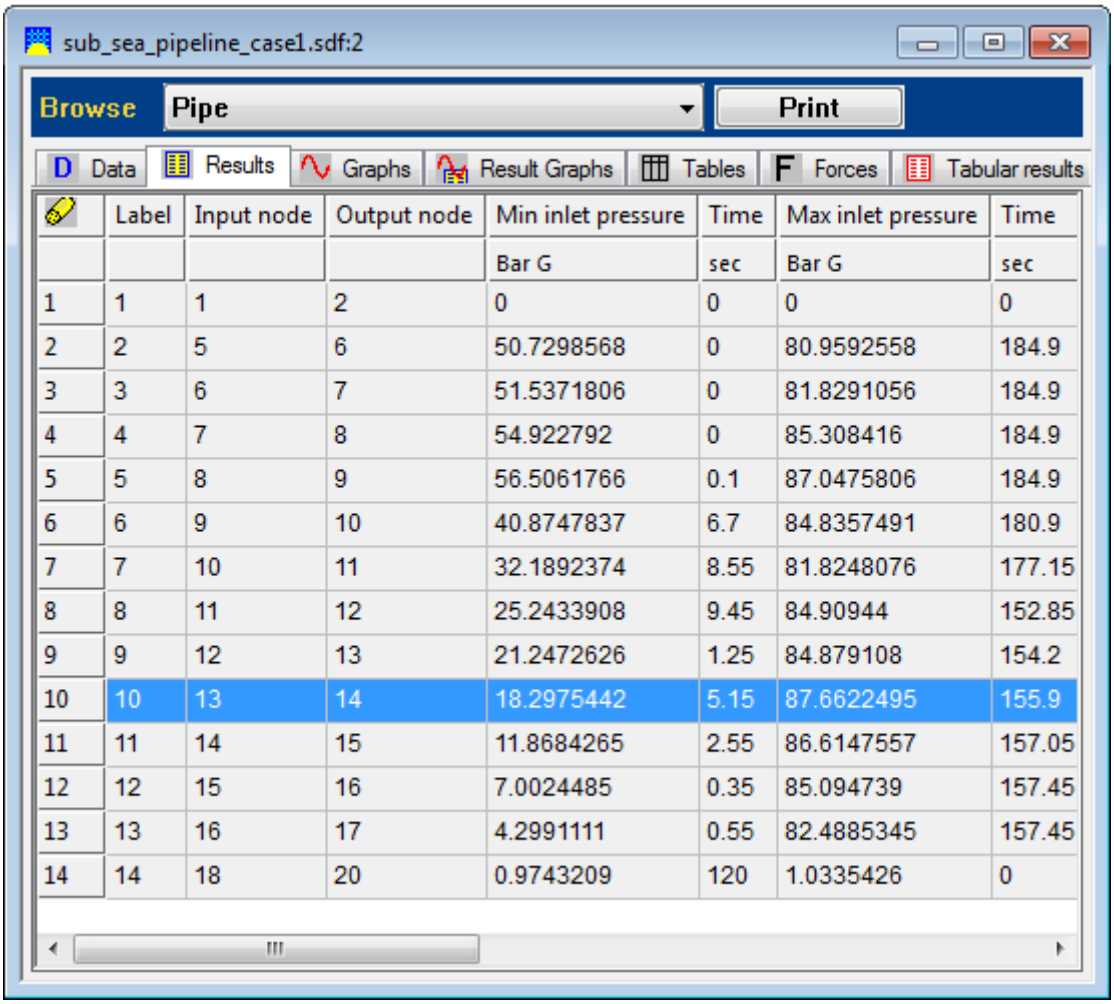
The period for the pressure wave to return to the valve after traversing the length of the pipe is approximately 60.4 sec. As this time (which is sometimes referred to as the critical time) is longer than the valve closure time, this scenario is likely to generate the maximum surge pressure.

As expected the maximum pressure occurs at the lowest point in the system. It reaches a value of 90 bar, which is unacceptably high.

SCENARIO 2 – Linear closure in 120 seconds

In the second scenario the valve closure time is increased to 120 sec. One would expect the pressure surge to decrease a little but not very significantly. This is because in a system of this type, the pressure surge can be expected to decrease significantly only after the valve closure time is many times the critical time.

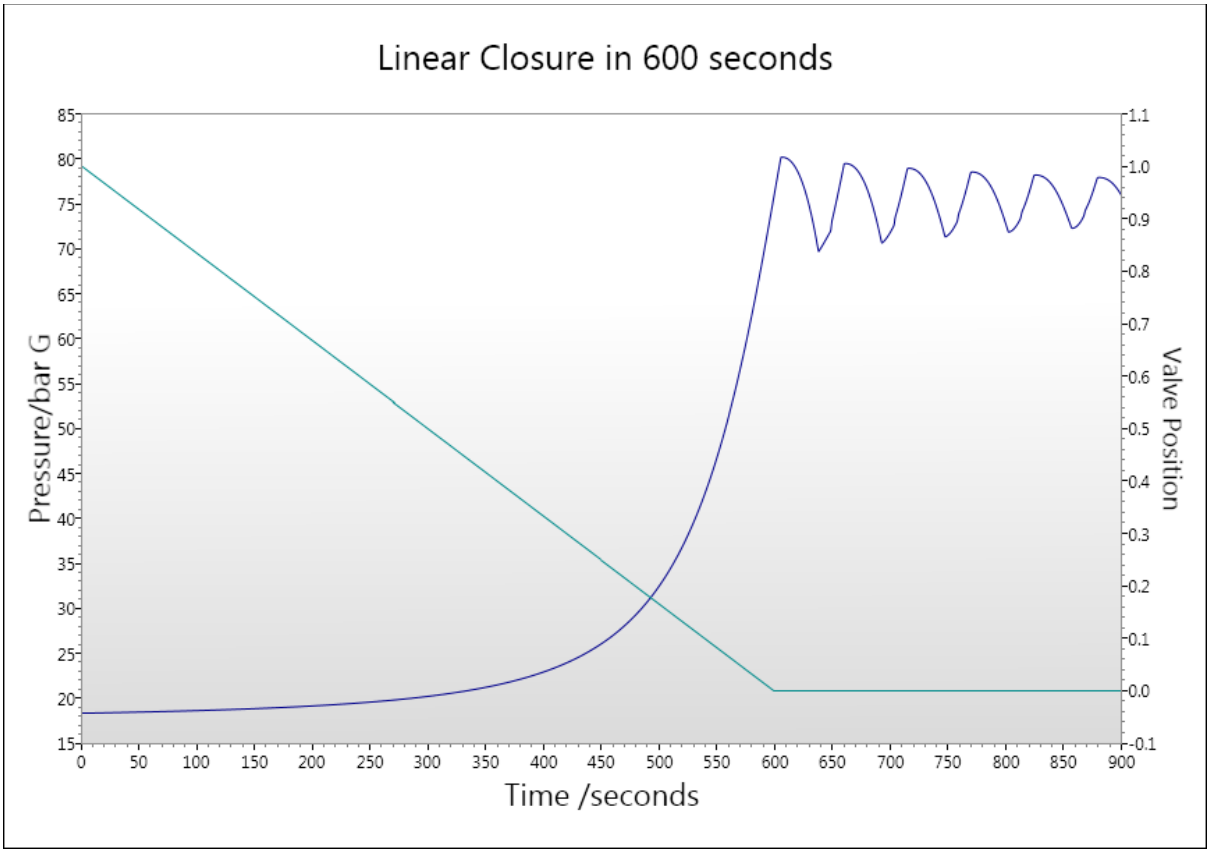
As expected, the maximum pressure drops only slightly, to 87.7 barg. We can show this using a graph as above, or by a detailed inspection of the pipes in the network:



	Label	Input node	Output node	Min inlet pressure	Time	Max inlet pressure	Time
				Bar G	sec	Bar G	sec
1	1	1	2	0	0	0	0
2	2	5	6	50.7298568	0	80.9592558	184.9
3	3	6	7	51.5371806	0	81.8291056	184.9
4	4	7	8	54.922792	0	85.308416	184.9
5	5	8	9	56.5061766	0.1	87.0475806	184.9
6	6	9	10	40.8747837	6.7	84.8357491	180.9
7	7	10	11	32.1892374	8.55	81.8248076	177.15
8	8	11	12	25.2433908	9.45	84.90944	152.85
9	9	12	13	21.2472626	1.25	84.879108	154.2
10	10	13	14	18.2975442	5.15	87.6622495	155.9
11	11	14	15	11.8684265	2.55	86.6147557	157.05
12	12	15	16	7.0024485	0.35	85.094739	157.45
13	13	16	17	4.2991111	0.55	82.4885345	157.45
14	14	18	20	0.9743209	120	1.0335426	0

The maximum pressure again occurs at lowest point in the system and reaches 92.5 barg. As expected this is a little less than the maximum pressure with 60 sec valve closure time but not greatly.

SCENARIO 3 – Linear closure in 600 seconds

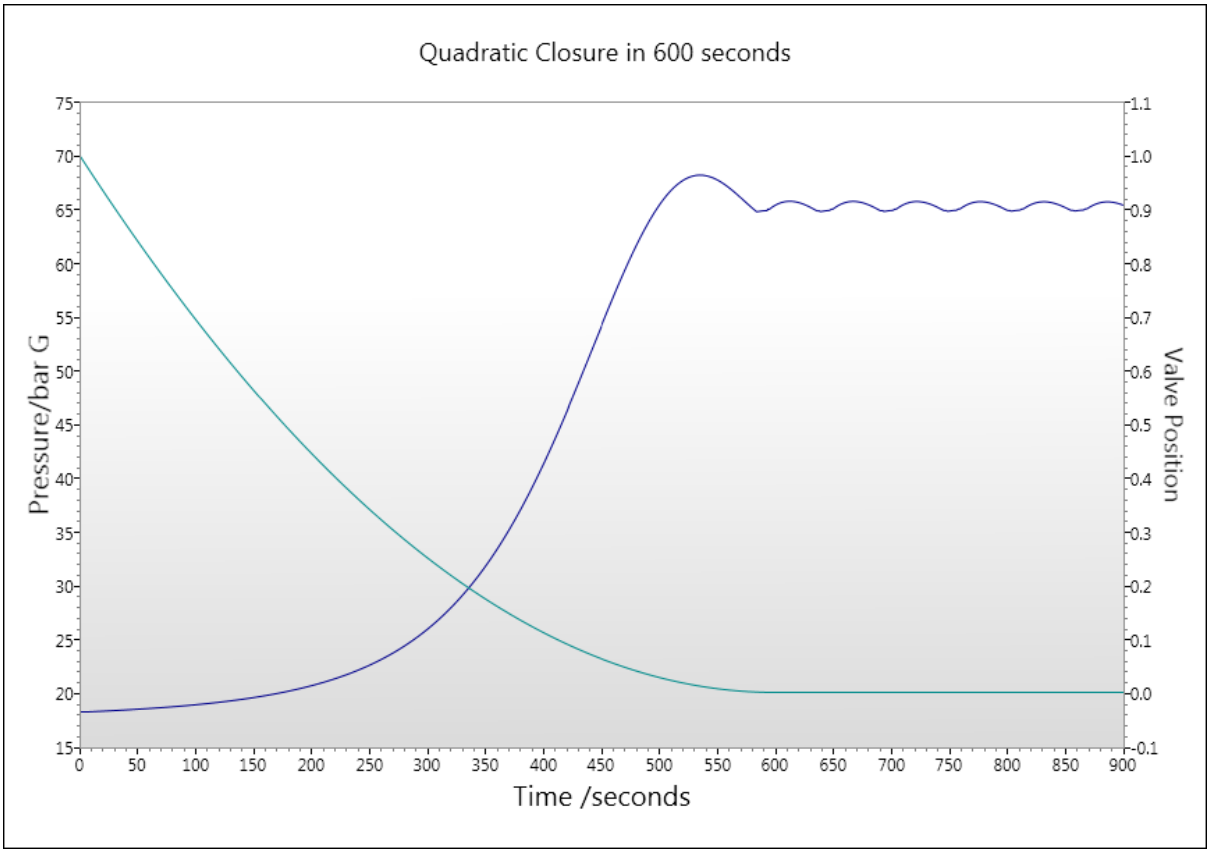


The extra increase in the closure time has decreased the maximum pressure to 80 barg. However we would still like to reduce it further.

SCENARIO 4 – Quadratic closure in 600 seconds

In this scenario we consider a valve closure time of 600 sec with a quadratic closure pattern.

Generally, the biggest pressure surge is created during the final stages of valve closure. With quadratic valve closure the valve closes quickly to begin with and slowly during the final moments. So, within a given valve closure time, the effective rate of closure during the critical period is slower.



The effect is to reduce the maximum pressure at the lowest point of the system to 68 barg. It is difficult to reduce this significantly. The closed head of the pump is 57 bar. The additional pressure due to static head is approximately 7 barg. The pressure at the lowest point would therefore be 64 barg even without any pressure surge.

CONCLUSION

We have presented here a small number of scenarios used to measure pressures at the valve inlet, and determine an optimum valve closure strategy. PIPENET was also used successfully on the project to:

Identify where in the network the maximum pressures occurred (as expected, this is at the lowest point of the network)

Analyse the effects of a rupture in the system, including the amount of oil lost, and thence quantify the benefits of installing an automatic leak detection system.

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

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