ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

TANKER LOADING AND FIRE-WATER RING-MAIN SYSTEMS DESIGN, BASED ON PIPENET VISION SOFTWARE APPLICATION

ENGR. SHADRACK OGONDA MBATA

PETROLEUM TECHNOLOGY DEVELOPMENT FUND
(PTDF)/NIGERIAN NATIONAL PETROLEUM CO-OPERATION (NNPC)

Abstract: **In this research project, a Tanker Loading and Simple offshore Fire-Water Ring-Main systems were studied using the Sunrise Pipe-net Application and three cases which comprehensively cover the cases that normally occur in Loading and Fire-Water Systems were considered.**

Tanker Loading and Fire-Water Ring-Main systems are usually located near the sea and in most cases offshore and therefore, are often susceptible to suffer from pressure surge problems; hence considerable care must be taken in their design. Subsequently, if there is a leak of hydrocarbon material, it could lead to a potential environmental disaster, such as fire and oil/gas pollution.

Tanker loading systems normally has two valves which could be the source of problems in the operation of the system. The Normal Shut-Off Valve (NSV), which operates on a daily basis as tankers need to be loaded or unloaded and the Emergency Relief Coupling (ERC) valve which is also of interest and operates when the system needs to be shut down in an emergency, such as storm or leakage. This valve which is usually located at the end of the jetty is designed to shut quickly and disconnect the hose going to the ship in an emergency situation.

Consequently, both closure of the NSV and ERC valve were considered for these design purposes. The operation of the NSV was considered because it operates on a daily basis. Even if the maximum pressure is acceptable, it could progressively weaken the connection and the system could start leaking. In anticipation of a loading system failure, there was need to design a Fire protection system on onshore/offshore platforms and process plant, since hydrocarbon materials are highly flammable.

In the end of the project, surge analyses were carried out based on the requisite force calculations and graphical results were generated to analyse the system design.

Keywords: **Tanker Loading System Design, Fire-Water Ring-Main System Design, Introduction, Methodology, Scope, Calculation/Results, Conclusion/Recommendations.**

1. TANKER LOADING SYSTEM DESIGN

Introduction:

This project on the tanker (Offshore/Onshore) loading system arouse basically from the fact that loading systems are often susceptible to suffer from pressure surge problems and the consequences of such problems which could lead to environmental disaster is given due consideration .In the design and analysis of the various problems highlighted below, a critical assessment of the component especially the valves that are employed in the network is brought to focus.

The normal shut-off valve (NSV) operates on a daily basis because tankers need it for loading and unloading. The emergency relief coupling valve (ERC) operates when the system needs to be shut down in the event of an emergency such as a storm and leakage. It is usually at the end of the jetty designed to shut quickly and disconnect the hose going to the ship.

At the end of the project, it is expected that the surge relief valve selection is fully optimized and the various forces acting on the pipes calculated and the results are generated graphically.

Scope:

It is intended that the operation of both valves, the NSV which works on a daily basis and is placed before the ERC which is a fast acting valve and its closure time cannot be exercised. The project is based on the Transient module application (standard) of the SUNRISE PIPENET VISION.

Other components worthy of mention here are the Glass Reinforced Epoxy (GRE) pipes, accumulators of various sizes, a non-return valve and a water pump.

GRE pipes are used because of the following qualities:

a. It is high corrosion resistant.

b. It has excellent flow characteristics.

c. 25 years service life.

d. Low maintenance and replacement cost.

However, GRE pipes have its constraints such as having a modulus of elasticity of 10% steel, shorter life span, and a weak adhesive joint. The constraints were however ignored.

Methodology:

The Simulations in Detail:

Main pipeline = 6km

Steel pipe = 10inch

Pipe type =AnsiB3610_S

Shut off valve (SOV) closes when the tanker is fully closed and there is an emergency relieve coupling valve (ERC) at the end of the jetty. ERC will close in an emergency such as storm. At this time, it will close very fast and disconnect the couplings to the tanker. The network schematic is shown on the SDF 1.

Initialization Stage.

From initialization menu, select transient option. Select simulation start 0 secs, simulation stops 120 secs. calculation time step 0.5 secs, click on user defined time step, select ambient pressure 0 bar G, ambient temperature of 15 degree Celsius, click on output total forces, set wave speed on 1260m/sec and click on no cavitation, vapor pressure (Pa G) = -97700, Bulk modulus (psi)=178400,

The units are user defined where length (m), diameter (mm), mass(kg), torque(nm), velocity(m/s) inertia(kg.m), force(N), temperature(Celsius), volume(liters), mass changing rate(kg/s), pressure(bar G), flowrate type(volumetric), density(kg/m),surface tension(N/m), viscosity (Cp).

Calculation/Results:

The tables shown below are used to input the valve characteristics curve data. (Table 1.)

Valve Position (s)	Cv (m3/hr,bar)
0	0
0.1	4.619708
0.2	29.932931
0.3	70.939274
0.4	124.576158
0.5	192.920061
0.7	383.244525
1	780.332237

ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

The pump performance data is given in the table below.

(Table 2.)

Flowrate, m3/hr	Head, Kg/cm2
0	12.39
100	11.706
240	11.023
320	9.371

Minimum flowrate = 0 m3/hr

Maximum flowrate = 320 m3/hr

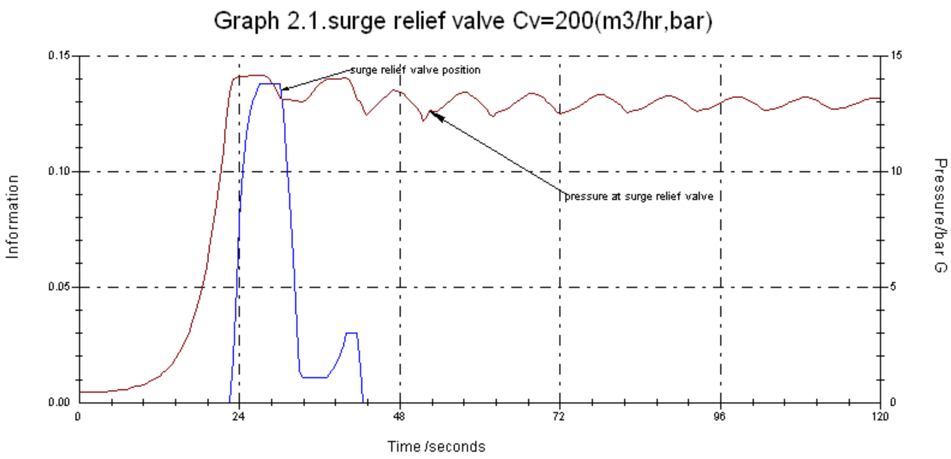
The scenarios here are combined into four groups.

The base case – the systems with no protection.

The system with protection – surge relief values.

The Scenarios 2.1

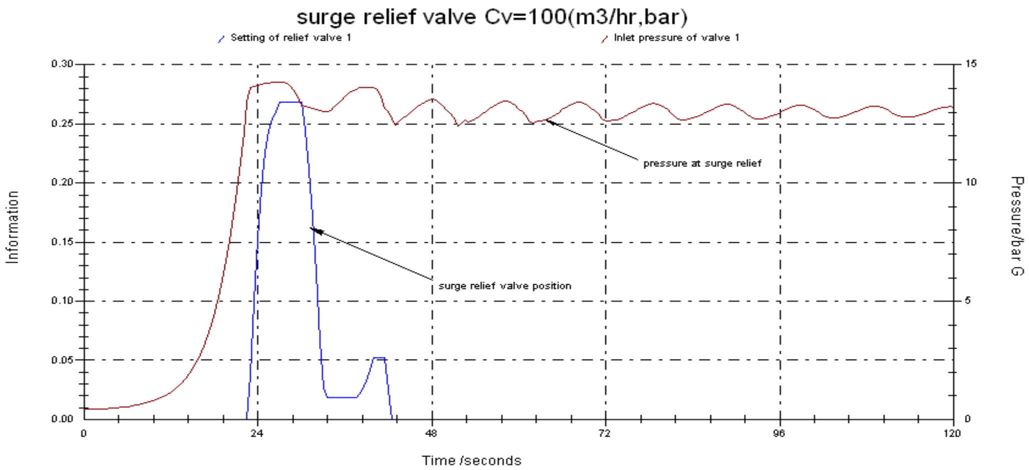
Surge relief valve with Cv = 200(m3/hr, bar)



The valve opens only around 15% of its fully opened position and so it is bigger than necessary.

The scenario 2.2

Surge relief valve with CV = 100(m3/hr, bar)

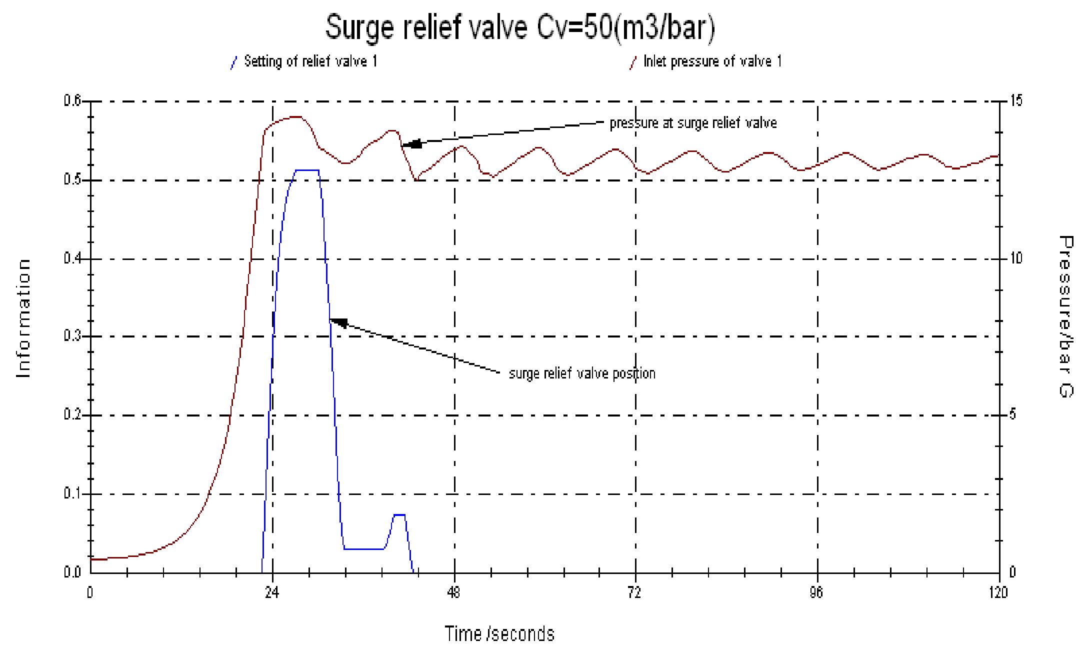


The valve opens around 28% and so it is a bigger size for the duty. This could be a good choice.

ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

Scenario 2.3.

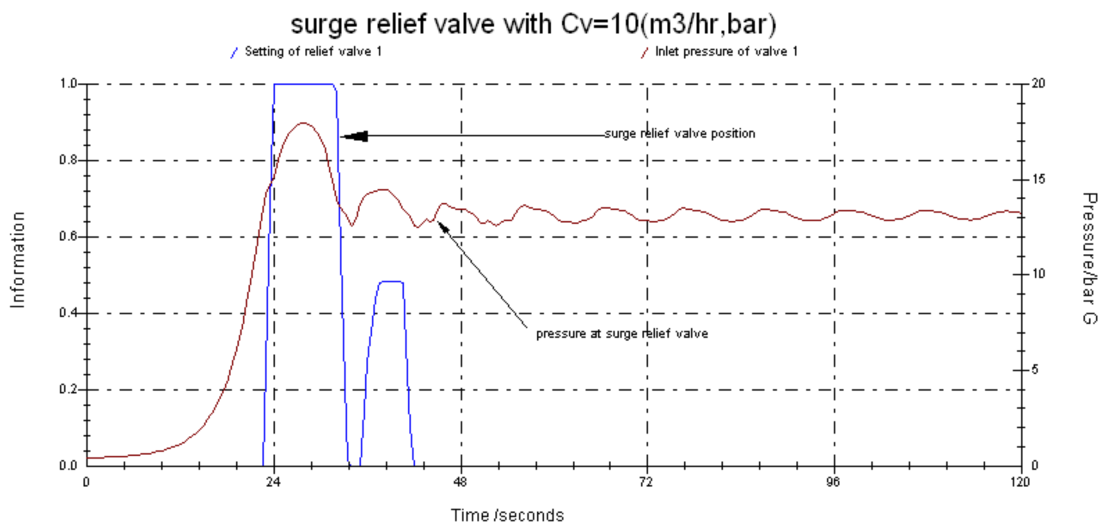
Surge relief valve with Cv=50(m3/bar)



The valve opens around 54% of the fully open position. This is a good choice for the choice of valve.

Scenario 2.4

Surge relief valve with Cv =10(m3/hr, bar).



The valve fully opens here and in spite of that it is not able to contain the pressure below 15bar G. The valve is probably too small.

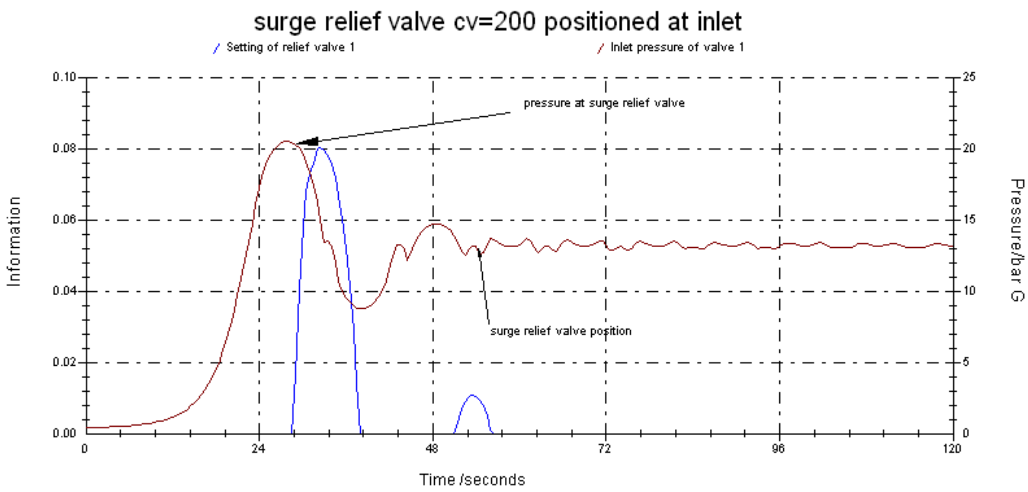
Scenario 2.5.

Surge relief valve with Cv =200(m3/hr, bar) Positioned at inlet.

Max pressure at valve inlet = 20.9 bar G

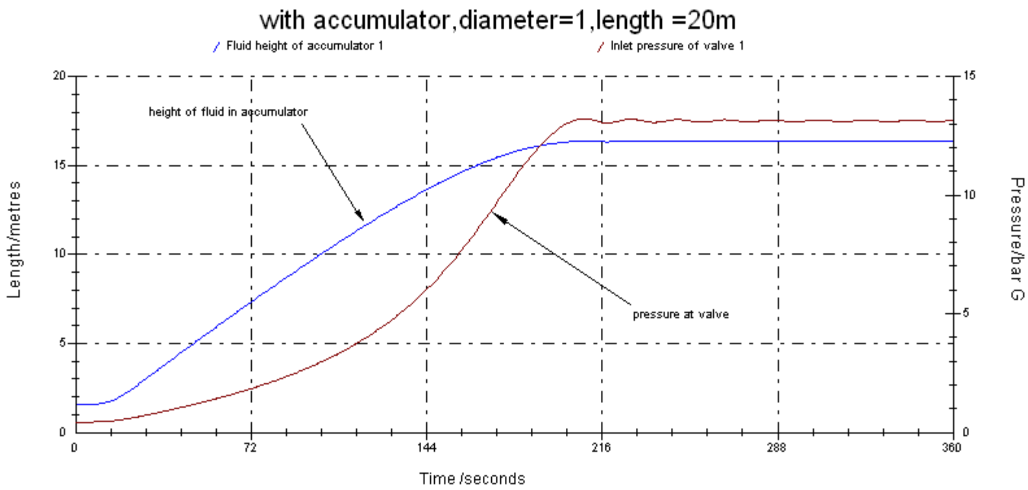
Max pressure at pipeline inlet =14.1 bar G.

ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com



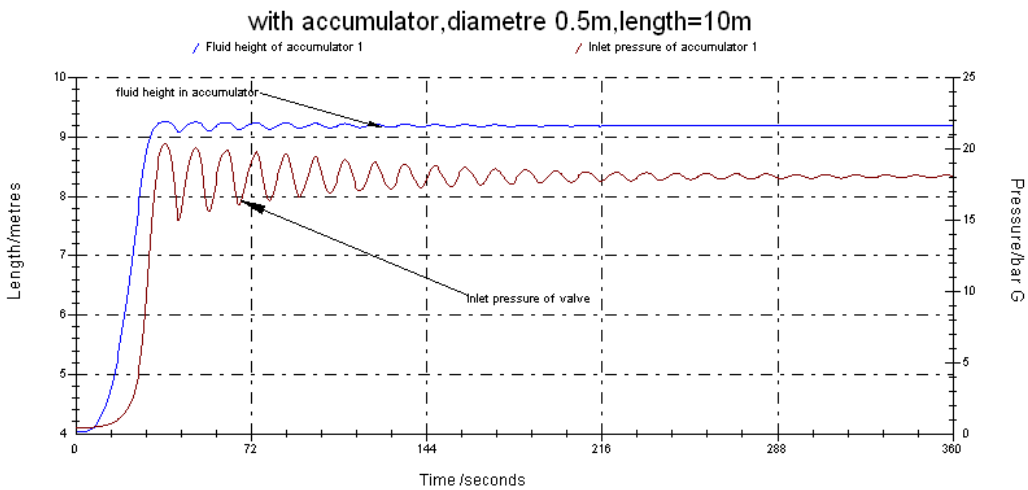
Scenario 3.1

With accumulator, Diameter = 1m, length =20m.



Scenario 3.2.

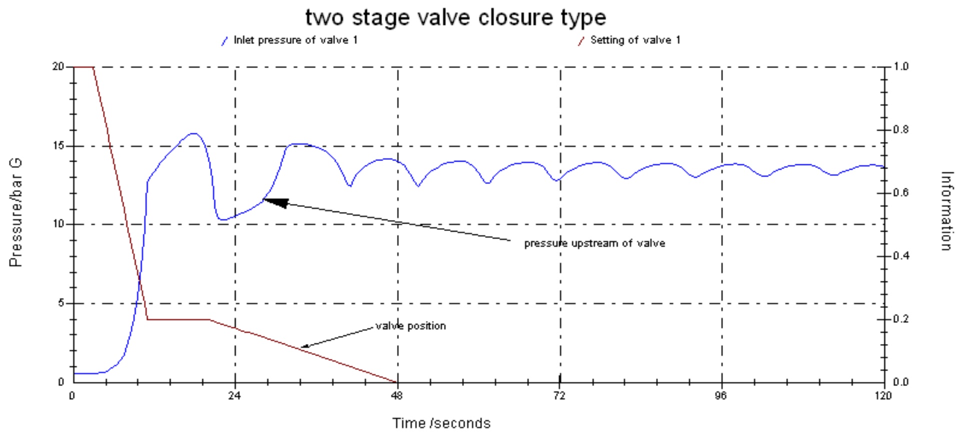
With accumulator, diameter = 0.5m, length =10m



ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

Scenario 4.1.

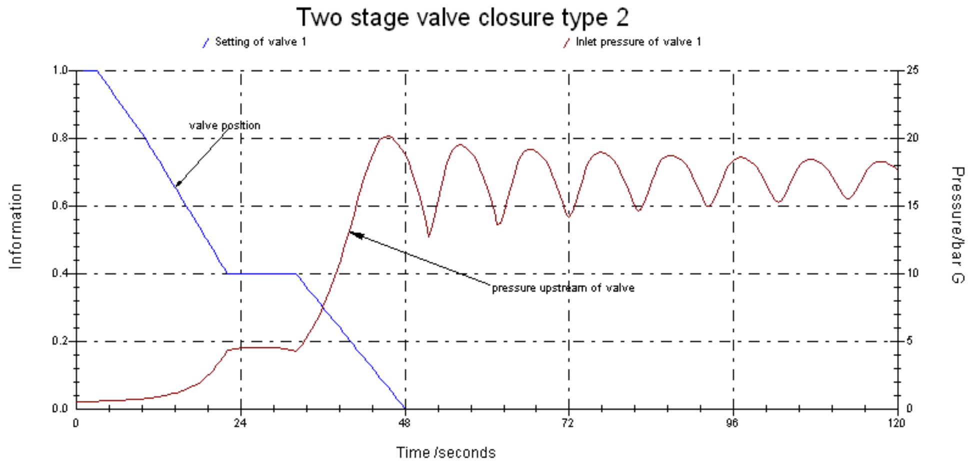
Two Stage valve closure type 1.



Max pressure at valve =14.7bar g.

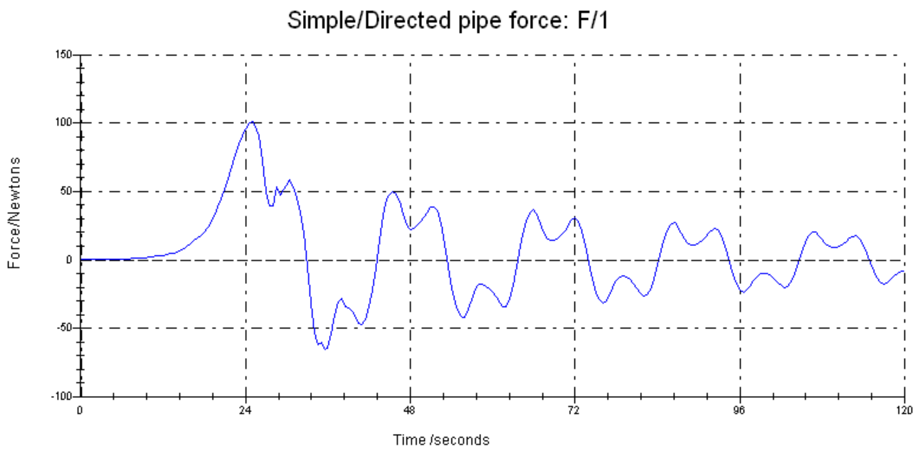
Scenario 4.2.

Two stage valve closure type 2.



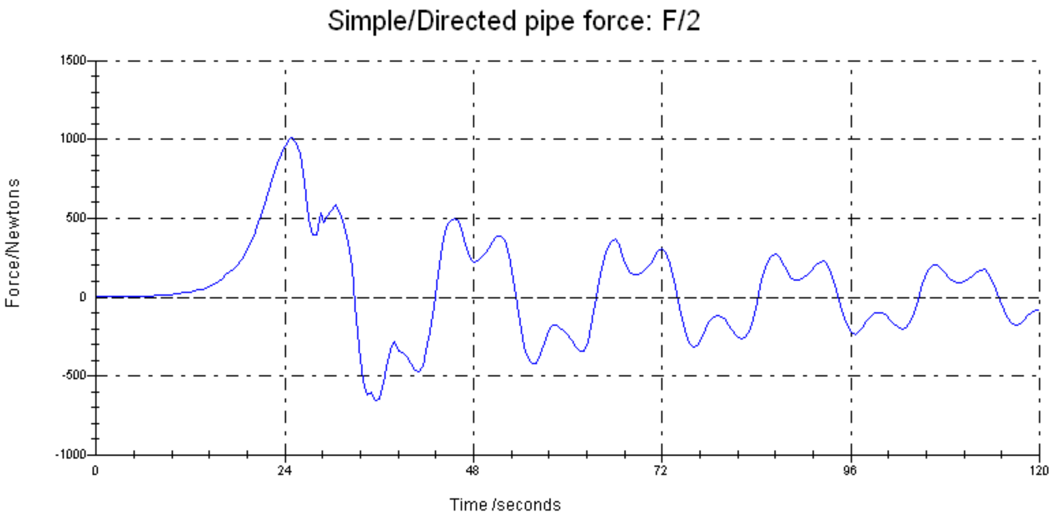
The Calculated force are shown on the chart below.

For F/1.

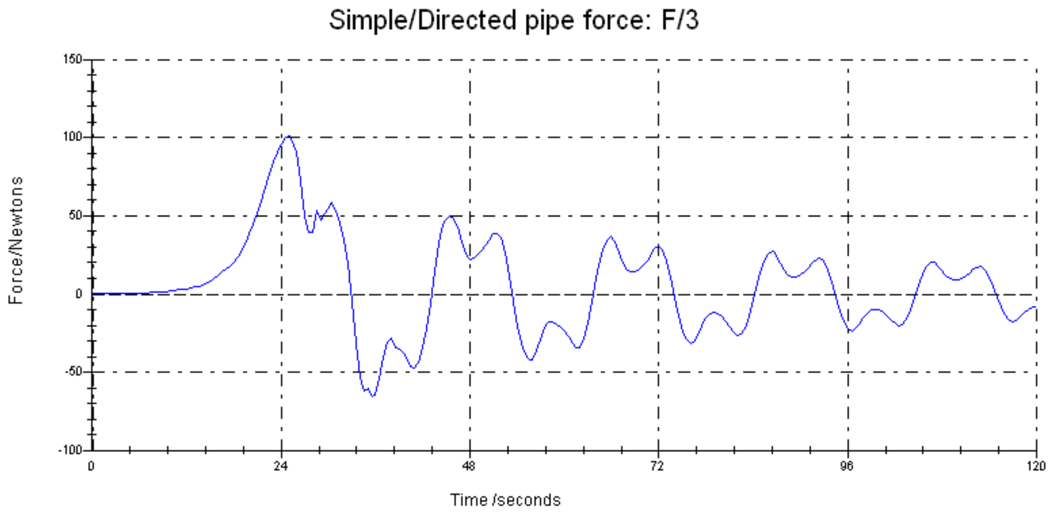


ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

For F/2.



For F/3



Conclusion/Recommendation:

The biggest problem with the approach in scenarios 4.1 and 4.2 is the fact that it does not protect the system in the event of ERC valve closing. This is so since the closure of the ERC valve can still produce a high pressure surge. Since there are no surge protection devices, this pressure can find its way all through the system. The accumulator and the surge relief valve usage on the other hand can protect the system irrespective of whether the NSV or the ERC valve which opens.

It can be concluded that pressure surge analysis is very crucial to avoid damage to the equipments such as pumps, valves and pipes in the petroleum and petrochemical industries and also to avoid environmental disaster if pipeline network rupture. In this project, the correct size for the surge relief valve is decided to be Cv = 50(cu.m/hr) and is positioned at the inlet of shut off valve rather than at the outlet of the non return valve.

2. FIRE-WATER RING-MAIN SYSTEM DESIGN

Introduction:

The design of fire water systems, especially those found on offshore platforms should be well planed for and managed, as they are susceptible to surge problems. All fire protection systems on process plant are susceptible to pressure surges, not just offshore platforms, and considerable care must be taken in their design.

ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

In this project a simple offshore firewater system was studied and three cases which might be of general interest were considered. These three cases comprehensively cover the cases which normally occur in firewater systems.

- Pump start-up with no system running. This is often the case during pump start-up for weekly test purposes.
- Pump start-up with systems running. Problems can be caused by the fact that cavity separation can form. When this cavity collapses, very large pressure surges can be setup.
- Valve closure during normal running.

The engineering solution to these problems is very simple. Installing an overboard dump valve, just upstream of the non-return valve. This is held open during pump start up. After the end of priming the riser pipe, this valve is slowly closed. So the fire pump reaches an equilibrium pressure with stationary water down stream of the non-return valve over a period of time, rather than stop almost instantaneously.

At the end of the project, it is expected that this overboard dump valve should bring the pressure surge down to a manageable level.

Scope:

It is intended that the operation of the two node caisson type 1, the overboard dump valve, jockey pump which works on a daily basis is placed alongside with the Copper/Nickel (90/10) 20 bar pipe schedule. The project is based on the Transient module application (spray) of the SUNRISE PIPENET VISION.

Other components worthy of mention here are the Copper/Nickel (90/10) 20 bar pipe schedule, a non-return valve and a water pump. Two node caisson type-1 is preferable for this project since it has an in-built non-return valve.

Methodology:

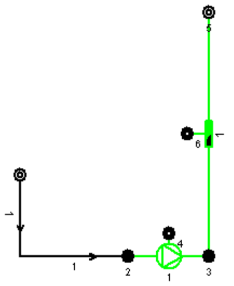
The simulations in detail: the complete project was started by completing the title and unit dialog boxes as necessary. A pipe schedule of Copper/Nickel (90/10) 20 bar was used. The pump data were inserted; taking note that flow rate of 0 lit/min must be one of the data points for satisfactory simulation, because the fire pump starts from stand still. So, unless 0 lit/min flow rate is one of the data points, PIPENET has to extrapolate the pump curve and this can lead to misleading results.

Secondly, the caisson and pipe data's were entered respectively, after which specifications were made at boundary conditions. The simulation time was set to 30 sec, the graphical output time step set to be 0.01 sec and graphical results for all the variables of the pump, the pipe and the two node caissons fully selected.

Initialization Stage

From initialization menu, select transient option. Select simulation start 0 secs, simulation stops 30 secs. calculation time step 0.01 secs, click on user defined time step, select ambient pressure 0 bar G, ambient temperature of 26.85 degree Celsius, set wave speed on 1260m/sec and click on no cavitation, vapor pressure (Pa G) = -97700, Bulk modulus (psi) =178400,

The units are user defined: length(m), diameter(mm), mass(kg), torque(nm), velocity(m/s), inertia(kg.m), force(N), temperature(Celsius), volume(liters), mass changing rate(kg/s), pressure(bar G), flow rate type(volumetric), density(kg/m), surface tension(N/m), viscosity (Cp).



ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

Calculation/Results:

The tables shown below were used to input the pump characteristics curve data: (Table 1.)

Flowrate, Lit/min	Pressure, bar G
0	20.5
15000	18.5
25000	16.5
35000	14.0

Valves Equivalent Cvs Data is shown below: (Table 2.)

Item	Valve label	Equivalent Cv (lit/min, bar)
Deluge System	2	8000
Helideck monitors	3, 4	1200

Piping Data is Shown Below: (Table 3.)

PIPE LABEL	LENGTH, M	ELEVATION, M	DIAMETER,MM
01	10	-5	600
02	22	3	600
03	26	0	500
04	46	0	500
05	32	0	500
06	24	0	500
07	25	15	250
08	10	0	250
09	25	-15	250
10	05	0	250
11	05	0	250
12	05	0	250

Minimum flow rate = 0

Maximum flow rate = 35000

The cases here are combined into 6 groups.

Case 1a: pump start-up with no system running

Case 1b: with overboard dump valve.

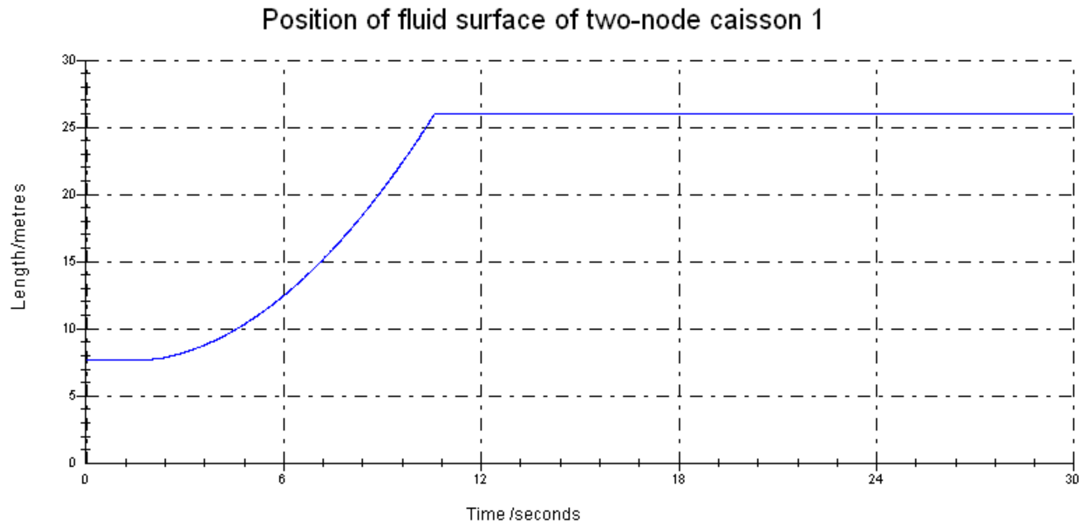
Case 2a: pump start-up with system running.

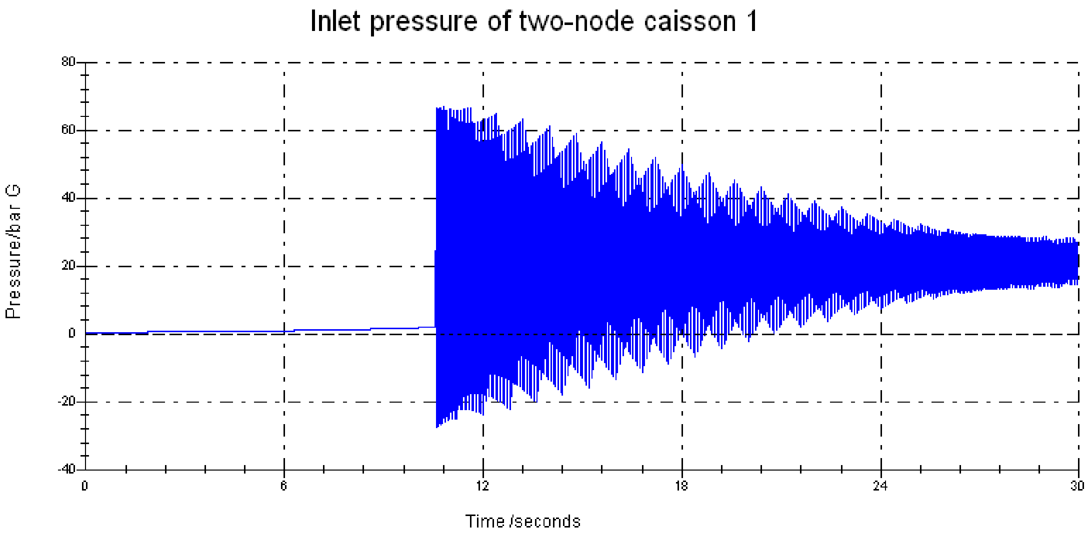
Case 2b: with vacuum breaker.

Case 3a: valve closure

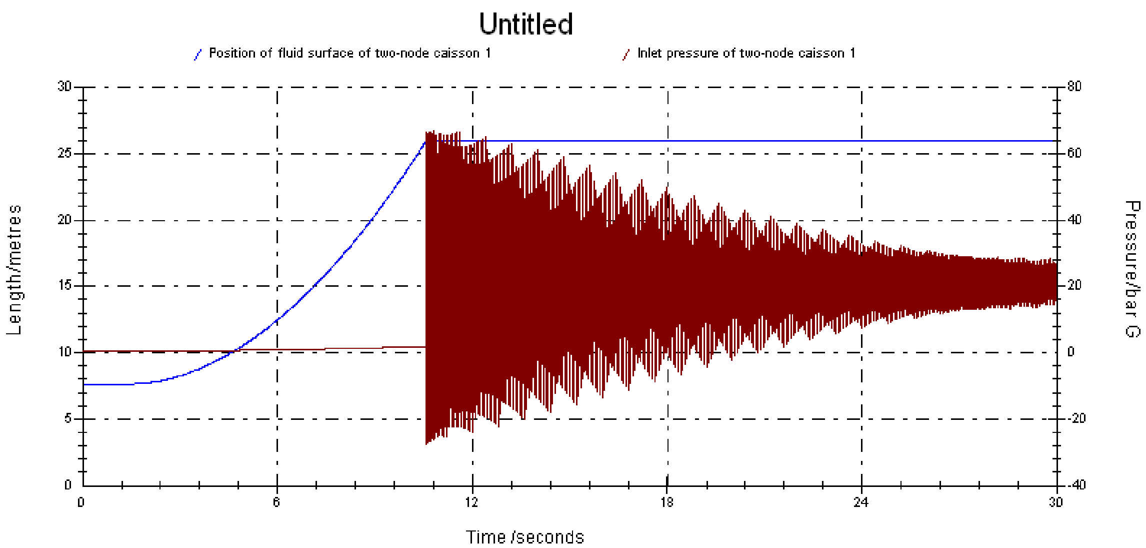
Case 3b: deluge valve closure case.

Case 1a (pump start- up with no system running)

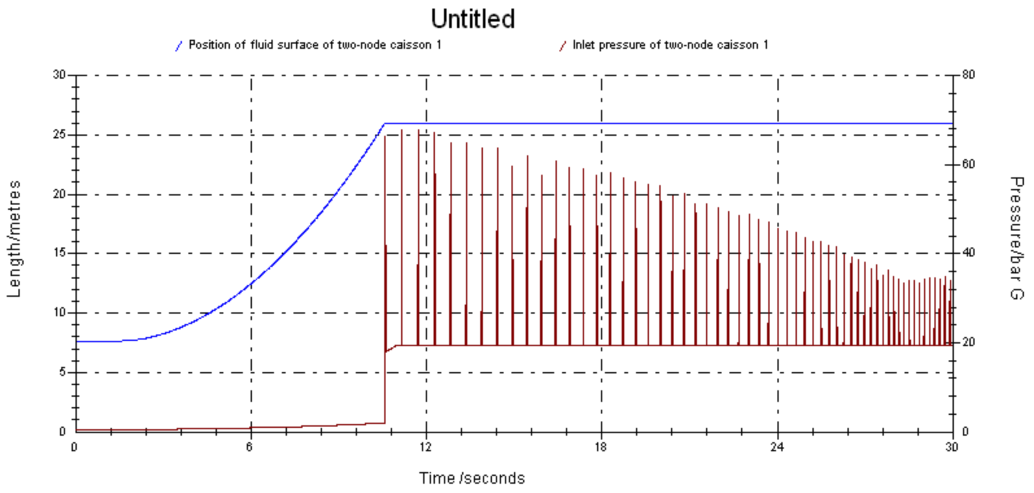




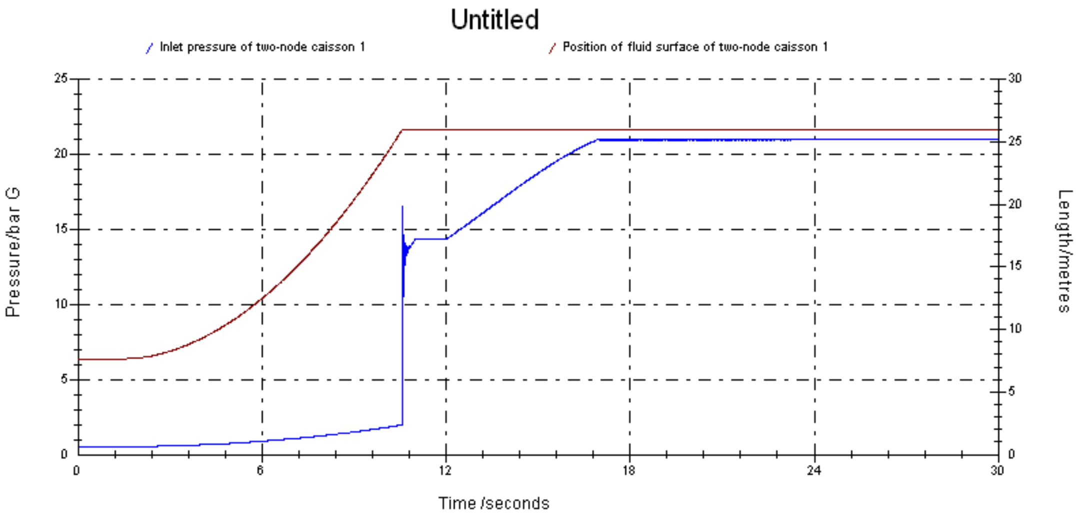
Case 1a (pump start- up with no system running), overlay of graph.



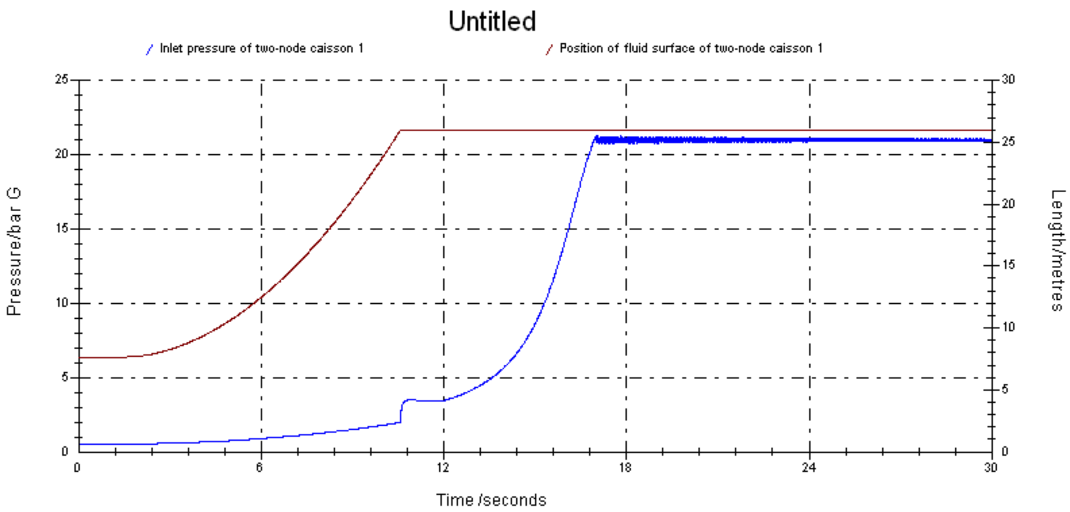
Case 1a (pump start- up with no system running, with cavitation.), overlay of graph.



Case 1b: with overboard dump valve. Cv = 10,000 (lit/min, bar).

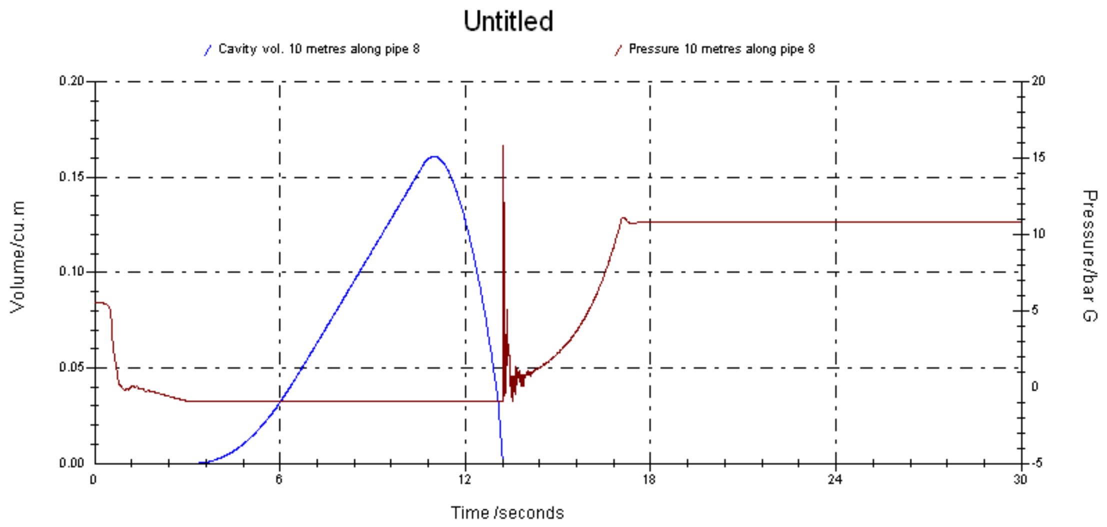


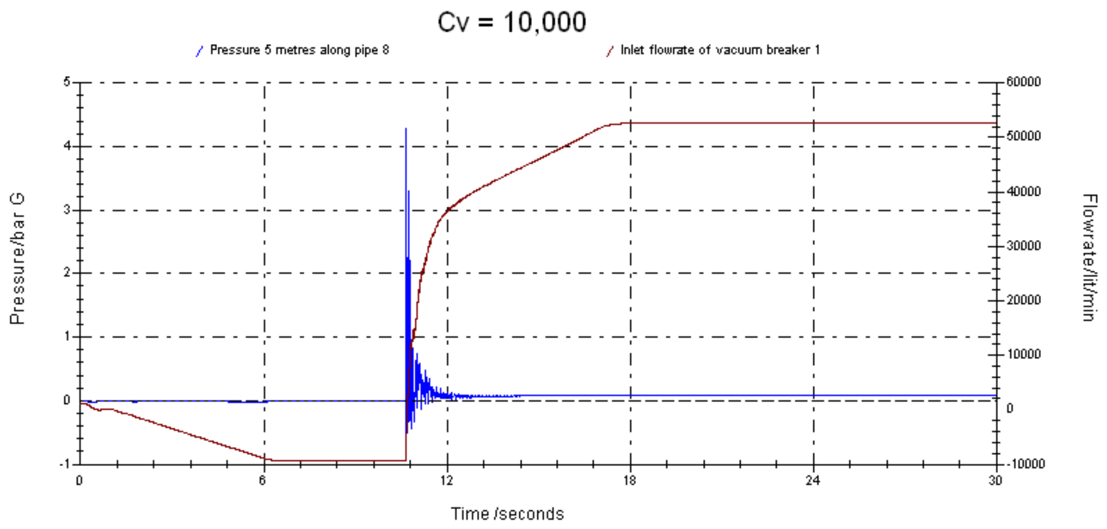
Case 1b: with overboard dump valve. Cv = 50,000 (lit/min, bar)



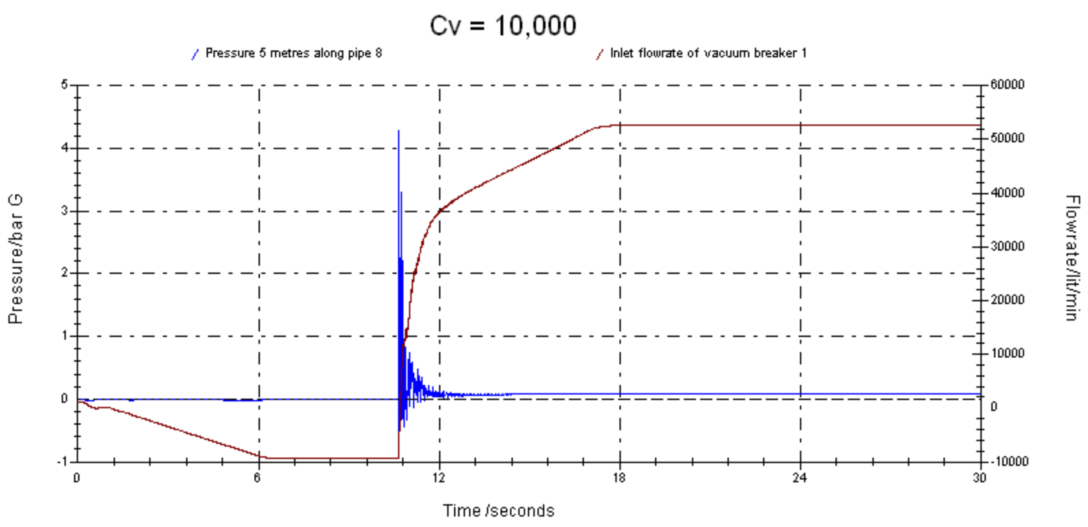
ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

Case 2a: pump start-up with system running (for Cv = 50,000 lit/min, bar)



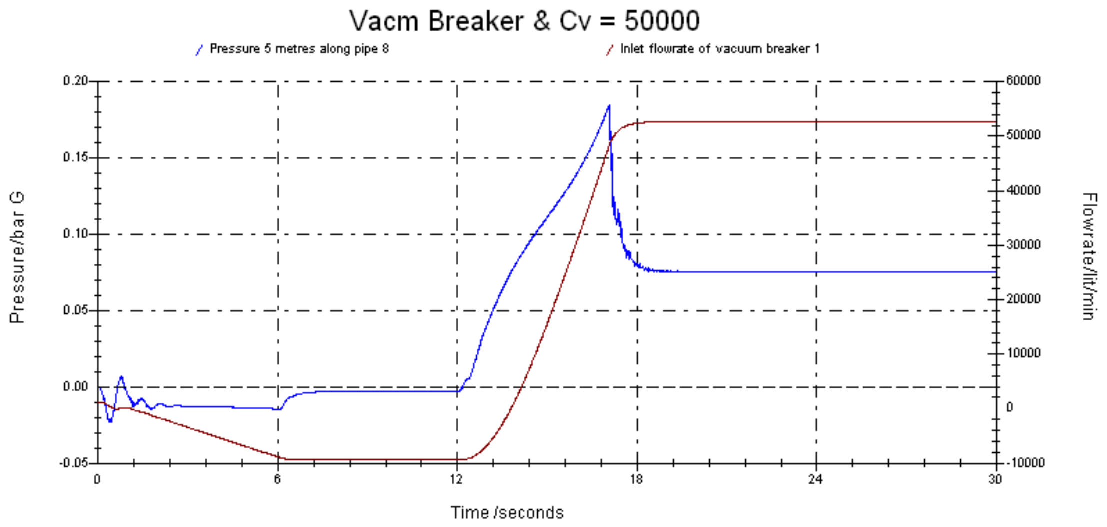


Case 2b: pump start-up with system running, with vacuum breaker. (for Cv = 10,000)

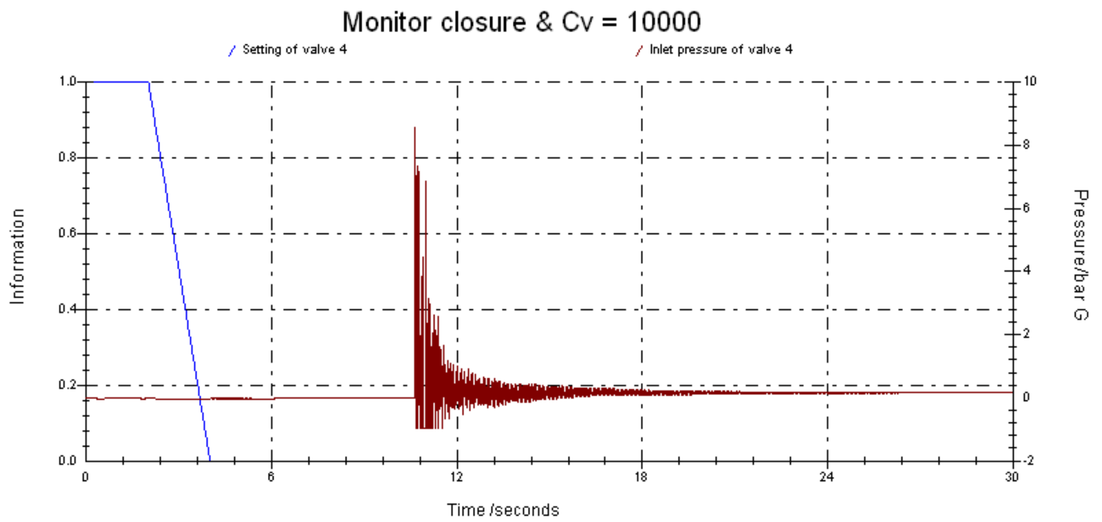


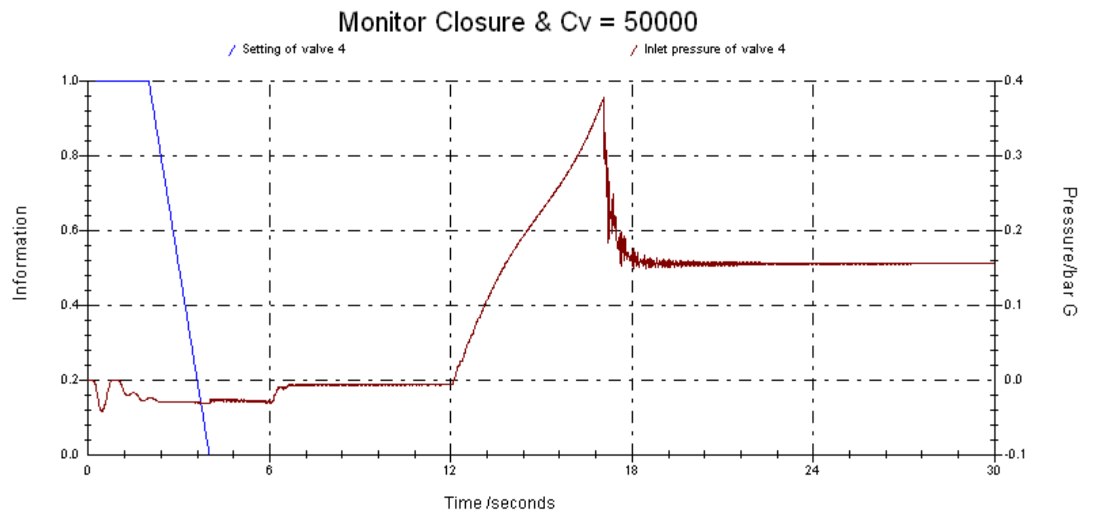
ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 1, pp: (269-283), Month: January - March 2019, Available at: www.researchpublish.com

Case 2b: pump start-up with system running, with vacuum breaker. (for Cv = 50,000)

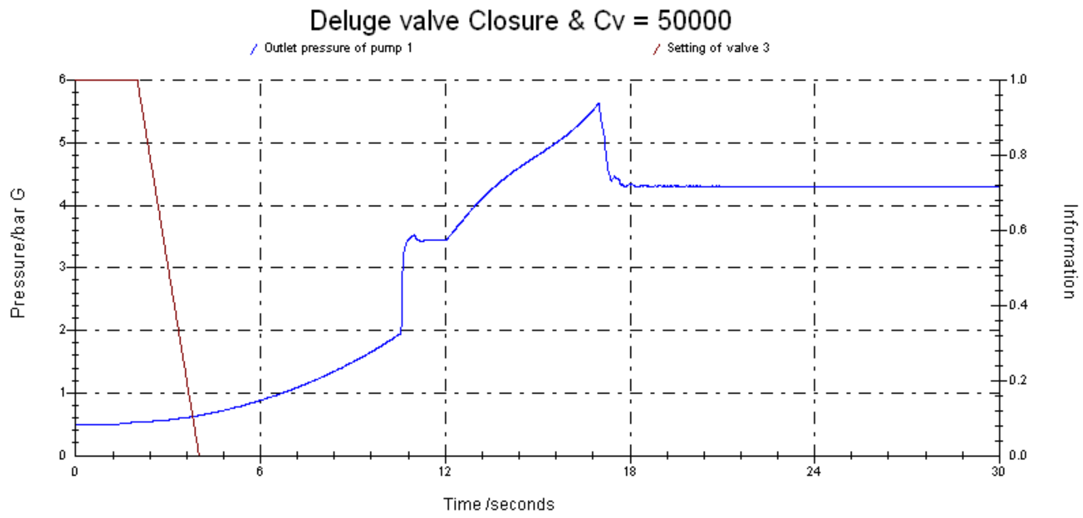


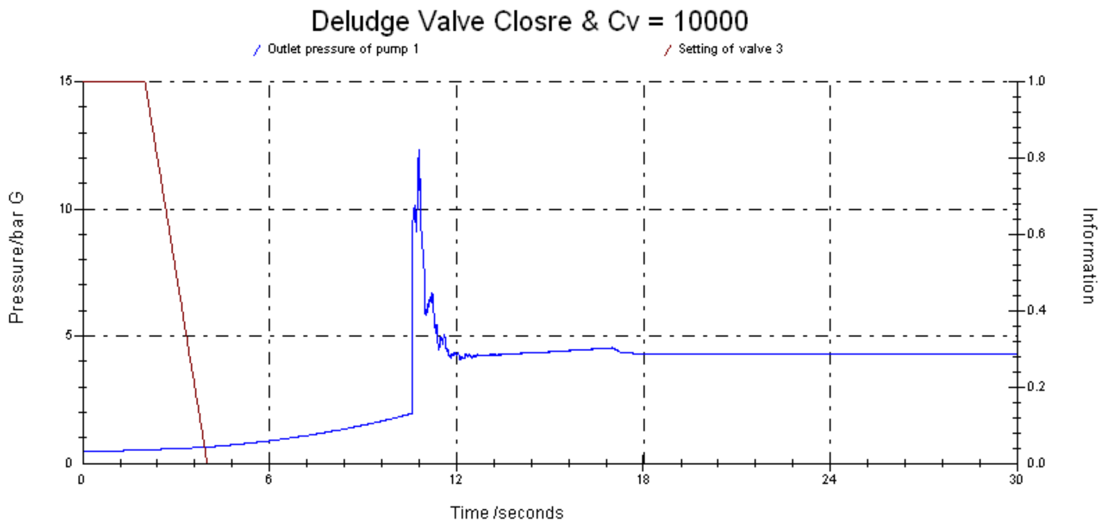
Case 3a: valve closure, (Cv = 10,000)





Case 3b: deluge valve closure case





Conclusion/Recommendation:

Various cases were tried in a bid to reduce the pressure surge.

In the first case with pump start-up with no system running, it was observed that the system would exhibit cavity formation because of the negative pressure at the caisson inlet, so vapor cavity formation was introduced, which invariably made no difference.

In the case of over board dump valve, with different flow rates (10,000 and 50,000), it was observed that the difference the valve size makes is remarkable. This gives a procedure of optimizing the valve size.

When the pump started with the system running, the sole purpose was to set the initial pressure to 7 bar G. In order to reduce the pressure surge, a vacuum breaker assembly was introduced. And deluge and monitor valves were closed for both flow rates (10,000 and 50,000), it was realized that the flow rate of 50,000 lit/min bar gave the required output pressure target of 7 bar G.

Hence the following recommendations were made:

In the foregone project, I tried as much as possible to keep the system simple, and also to reduce the number of pipes to less than 50, input the network in stages. I avoided inputting a large network in one attempt and also tried avoiding short pipes.

ACKNOWLEDGEMENT

I wish to express my profound gratitude to Almighty God, the all generous and merciful king, who offered me the power and opportunity to accomplish this project.

My sincere gratitude goes to the Managements of the Petroleum Technology Development Fund (PTDF) for funding my Engineering Design Training Program. I would also want to extend my gratitude to the Managements of the Port Harcourt Refining Company (PHRC) Nigeria, which is a subsidiary of the Nigerian National Petroleum Co-operation, Sunrise Systems Cambridge, United Kingdom and Weams & Company Nigeria Limited, for their valuable contributions towards the successful completion of this project by providing me with the enabling environment, software applications, Design Models, thesis and journals.

Lest I forget the Deputy Manager, General Engineering and Project Management, Engineering and Technical Services Department, Port Harcourt Refining Company (PHRC) Nigeria, Engineer Hamid Jalo Abubakar and to many other people whose names could not be mentioned due to limited space, for their valuable assistance before and during this design project, I would humbly and respectfully register my appreciation and gratitude.

REFERENCES

[1] Bartlett L.M, Andrews J.D, (2003): “Genetic Algorithm Optimisation of a Firewater Deluge System”. Loughborough University, Quality and Reliability Engineering International, 19 (1), pp. 39-52.

[2] Cudina P, (2008): “Design Procedure and Mathematical Models the Concept Design of Tankers and Bulk Carriers”. Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb.

[3] El-Oun Z, Stephens P, (1995): “Pressure Surge Analysis in Tanker Loading/Unloading Systems”. The Proceedings of the Fifth (1995) International offshore and polar engineering conference PI995-I8 Volume 1, The Hague, The Netherland.

[4] Fagerland S, (2013): “A Computerised System for Loading and Discharging oil Tankers”. Thesis in partial fulfilment of the requirement for the award of Masters Degree at the Auckland University of Technology.

[5] Flite Software, (2018): “Fluid Flow Fire Protection System Design”.

[6] Kick-Othmer, (1984): “An Encyclopaedia of Chemical Technology”, Volume 7, 3rd Edition.

[7] Kochadze T, Tsetskhladze A, (2012): “Certain Features of the Cargo plan for Oil Tankers”. Faculty of Engineering, Akaki Tsereteli state University, Kutaisi, Georgia

[8] Kshitiz V, (2017): “Piping Lay-out for Fire Sprinkler System: An Overview”, International Journal of Engineering and Applied Sciences (IJEAS), ISSN: 2394 – 3661, Volume -4, Issue – 3, March edition.

[9] Mousavi M, (2013): “A Mechanism for Determining Tanker Truck Transport Rates: A Case of Oil Products Supply Chain”. P-ISSN: 2162-9374, e-ISSN: 2162- 8416, 2013; 3(4): 206-217, doi:10.5923/j.mm.20130304.03.

[10] Plessas T, Boulougouris E, Papanikolaou A, Adamopoulos N, Pytharoulis M, (2013): “Simulation of Loading and Discharging of Tankers”. National Technical University of Athens, Greece, (Annex VI)

[11] Razeen J, Venkata V, Krishnakanth K, Ejaz S, (2018): “Design and Analysis of Fire-Water Network for a typical Onshore Gas Processing Plant”. Trainee Engineers-HSE Design, Technip India Ltd.

[12] Sunrise Systems, (2008): “Modelling Pipelines and Engineering Utility Systems”, Sunrise Pipe-net Vision, Cambridge United Kingdom.

[13] Weam & Company LTD, (2008): “Engineering Design Training and Services Manual”.