SURGE ANALYSIS STUDY ON LIQUID PIPELINE USING "PIPELINESTUDIO"

A Project Report Submitted in Partial Fulfillment of the Requirement for the Degree of

MASTER OF TECHNOLOGY
IN
PIPELINE ENGINEERING

Under the Guidance of

Mr. Adarsh Kumar Arya

Submitted By

PRAFULL WAGH

(R150209027)

COLLEGE OF ENGINEERING STUDIES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

DEHRADUN

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Approved

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9.5.11

Head of Department

College of Engineering
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College of Engineering
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Dehradun

May, 2011

energysolutions

March 25, 2011.

CERTIFICATE

This is to certify that Mr. Prafull B. Wagh, student of M.Tech Pipeline Engineering from "University of Petroleum and Energy Studies, Dehradun" of 2009-11 batch, has worked as a Project Trainee with our organization during the period of 14th Feb to 25th March 2011.

He has submitted his Dissertation report entitled "Surge Analysis Study on a Liquid Pipeline using Pipelinestudio".

We wish him all the best for future endeavors.

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CERTIFICATE

This is to certify that the work contained in this thesis titled "Surge Analysis Study on Liquid Pipeline Using Pipelinestudio" has been carried out by Prafull Wagh under my supervision and has not been submitted elsewhere for a degree.

A.K. Arya 09/05/14

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At the end I would like to convey my regards to my parents whose blessings and boundless patience has kept my moral high during the course of my study. The chain of my gratitude would be definitely incomplete if I would forget to thank the first cause of this chain, using Aristotle's words- "The Prime Mover". I thank "The Almighty" for just one thing and that is "Everything".

Prafull B. Wagh

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ABSTRACT

The objective of this study is to:

- Determine the hydraulic parameters of a cross-country pipeline such as pressure, flow rate, temperature of pipeline and
- Study the effect of valve closure on pipeline to see whether the surge pressure exceeds the Maximum Allowable Operating Pressure (MAOP) and
- Model a surge relief valve if the surge pressure exceeds the value of MAOP.

The hydraulic and surge analysis is conducted by using **Pipelinestudio Liquid version 3.2.5.6.** By running the steady state simulation, steady state results are obtained. After getting MAOP from steady state results, the sectionalizing valves are closed one after the other from the delivery end to supply end by creating transient scenarios for the valve closure and putting the values of MAOP for the pipe in sectionalizing valves.

If the pipe upstream pressure will exceed the value of MAOP, the pipe will burst and leakage will occur. To overcome this problem relief valve at pressure below MAOP is being configured. It was found that the surge pressure in some instances of valve closure exceeds the MAOP of the pipeline and hence surge relief mechanism is required.

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NOMENCLATURE

Abbreviations:

ESD	Emergency Shutdown Valve
PLS	Pipeline studio
MAOP	Maximum Allowable Operating Pressure
LPG	Liquefied Petroleum Gas
BK	Block Valve
PL	Pipeline
PS	Pump Station

Chapter: 1

INTRODUCTION

1. INTRODUCTION

A liquid petroleum supply system is subjected to water hammer (surge) whenever there is a change in steady state condition such as pump stoppage. pump startup or valve closure. As a system changes from one steady state condition to another there is a transient change in flow and pressures as the system settles to the final steady state condition. The magnitude of transient pressures (or water hammer) and the time duration of the transient condition depends on the flow rate, velocity, pipeline material and the system boundary conditions such as tanks. pumps. air valves, control valves and changes in pipeline diameter.

The phenomenon of water hammer (surge) is generally poorly understood in the liquid petroleum industry. This is due to the difficulty in carrying out a comprehensive analysis, which considers all the system components and their interaction. It is not uncommon for designers to simply add a nominal pressure increase to allow for water hammer. This approach can be too conservative and unnecessarily costly and in some cases there have been system failures due to inadequate water hammer protection being provided which can causes dangerous problems and leads to major accidents.

The undertaking of a surge analysis, and selection of protection measures, should be an integral part during the design phase. There are now propriety water hammer programs available, which can assist designers in identifying potential water hammer problems and help in the selection protection measures. The use of these programs should be limited to experienced designers with intimate knowledge of water distribution systems.

The magnitude of the pressure surge depends on the fluid modulus (density and elasticity), the fluid velocity, and the speed of flow stoppage. In the case of a valve closure as the flow stoppage event, critical aspect of the speed of closure might not be the total time it takes to close the valve.

1.1 Scope

The scope of the surge analysis study can be divided in three distinctive parts:

1. Study about the hydraulic steady state analysis, to verify the operating capacities and operating scenarios as identified. A hydraulic steady state simulation calculates time invariant pressure, temperature and flow profile throughout a pipeline network using specified boundary conditions and network element set points that are specified.

In other words, the hydraulic steady state run calculates the hydraulic state of a pipeline system operating at equilibrium. This type of simulation can be done to obtain hydraulic steady state data or to provide the initial starting conditions for a transient simulation. This is carried out with the user supplied data.

2. Use the results of hydraulic steady state analysis as the basis for conducting the surge analysis under transient conditions (pump trip, restart and valve closure) to identify if a surge relief mechanism is required. A transient simulation models the dynamic response of the pipeline network to changes in one or more system variables, such as valve closure. Transient calculations are more complex and require more processing time than steady state calculation. Useful results can be obtained from a transient simulation only if changes occur in one or more of the parameters governing the pipeline network. In order to run a transient simulation, a scenario has to be created and the results of the transient simulation can be seen from transient report. Apart from this useful results can be obtained from the trend plots.

3. If a surge relief mechanism is required then it should be specified and tested by rerunning the simulation that caused surges. All scenarios will initially be run without a surge relief device included in the pipeline system. If surges that exceed the design pressure are obtained during the simulations then a surge relief device will be included in the pipeline model and all the surge analysis scenarios will re run to verify that the surge relief device is adequately specified.

Pipeline Studio Liquid version 3.2.5.6 is used for conducting the surge analysis under steady state and transient conditions.

1.2 Objectives of Surge Investigation

The objective for a water hammer investigation should be to suppress transient pressures to acceptable limit and avoid the following:

Pipeline Bursts and Leaks:

- Positive water hammer pressures should be limited to the pipe acceptable working pressure.
- Pipelines can fail by buckling resulting from excessive vacuum during transient conditions in the case of thin walled large diameter steel pipe, low pressure rating plastic pipe and plastic pipes exposed to high temperatures.
- Cement lining in steel pipes has spelled off the pipeline in situations where the pipeline is subjected to vacuum conditions accompanied by large pressure fluctuations. The exposed metal surface corrodes resulting in accelerated pipeline failure.
- Asbestos Cement rubber ring joints have failed from vacuum pressures resulting from pump stoppages. The vacuum pressures have allowed air to enter the pipeline via the rubber ring joints and the joints have failed with time exposure.

Damaged Equipment:

- This may occur due to the violent movement of mechanical parts. Examples of these are check valves slamming shut following pump stoppages at multiple pump stations and the sudden closure of large orifice air valves when filling pipelines.

1.3 Importance of Surge Relief

In many applications. such as pipelines, storage terminals and marine loading and unloading. it is necessary to include surge relief systems for the purpose of equipment and personnel protection. Surge pressures result from a sudden change in fluid velocity and, without surge relief. these surge pressures can damage pipes. other piping components, equipment and personnel.

These pressure surges can be generated by anything that causes the liquid velocity in a line to change quickly (e.g., valve closure, pump trip, Emergency Shutdown (ESD) closure occurs) and subsequently packing pressure. Total surge pressure may be significantly above the maximum allowable pressure of the system, leading to serious damage to your valuable assets.

The fundamental requirements of surge relief systems include the need for fast acting, high capacity valves which can open very quickly to remove surge pressures from the line and then return to the normal (closed) state quickly but without causing additional pressure surge during closure. These valves are often required to open fully in very short periods of time, so that they may pass the entire flowing stream if conditions dictate.

Chapter: 2

LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 Valve and Pump cavitations:

Cavitation:

Cavitation is the formation of vapor bubbles of a flowing liquid in a region where the pressure of the liquid falls below its vapor pressure. Cavitation is usually divided into two classes of behavior: inertial (or transient) Cavitation, and no inertial Cavitation. Inertial cavitation is the process where a void or bubble in a liquid rapidly collapses, producing a shock wave. Such cavitation often occurs in control valves, pumps, propellers, impellers, and in the vascular tissues of plants. Non inertial cavitation is the process in which a bubble in a fluid is forced to oscillate in size or shape due to some form of energy input, such as an acoustic field. Such cavitation is often employed in ultrasonic cleaning baths and can also be observed in pumps, propellers, etc.

Since the shock waves formed by cavitation are strong enough to significantly damage moving parts, cavitation is usually an undesirable phenomenon. It is specifically avoided in the design of machines such as turbines or propellers, and eliminating cavitation is a major field in the study of_fluid dynamics.

Avoiding Cavitation:

Cavitation_can in general be avoided by

Increasing the distance between the actual local static pressure in the fluid and the vapor pressure of the fluid at the actual temperature.

This can be done by:

- reengineering components initiating high speed velocities and low static pressures
- increasing the total or local static pressure in the system
- reducing the temperature of the fluid

Control valves:

Cavitation can occur in control valves .If the upstream pressure is just above the vapour pressure then it is possible that the pressure will drop below the vapour pressure as the fluid flows through the valve, if the pressure recovers after the valve to a pressure that is once again above the vapour pressure then cavitation will occur.

Suction cavitation:

Suction_cavitation occurs when the pump suction is under a low-pressure/high-vacuum condition where the liquid turns into a vapor at the eye of the pump impeller. This vapor is carried over to the discharge side of the pump, where it no longer sees vacuum and is compressed back into a liquid by the discharge pressure. This imploding action occurs violently and attacks the face of the impeller. An impeller that has been operating under a suction cavitation condition can have large chunks of material removed from its face or very small bits of material removed, causing the impeller to look sponge like. Both cases will cause premature failure of the pump, often due to bearing failure. Suction cavitation is often identified by a sound like gravel or marbles in the pump casing.

Discharge cavitation:

Discharge cavitation occurs when the pump discharge pressure is extremely high, normally occurring in a pump that is running at less than 10% of its best efficiency point. The high discharge pressure causes the majority of the fluid to circulate inside the pump instead of being allowed to flow out the discharge. As the liquid flows around the impeller, it must pass through the small clearance between the impeller and the pump housing at extremely high_velocity. This velocity causes a vacuum to develop at the housing wall (similar to what occurs in a_venture), which turns the liquid into a vapor. A pump that has been operating under these conditions shows premature wear of the impeller vane tips and the pump housing. In addition, due to the high pressure conditions, premature failure of the pump's mechanical seal and bearings can be expected. Under extreme conditions, this can break the impeller shaft.

2.2 Water Hammer:

A water supply system is subjected to water hammer whenever there is a change in steady state condition such as pump stoppage, pump startup or valve closure. As a system changes from one steady state condition to another there is a transient change in flow and pressures as the system settles to the final steady state condition. The magnitude of transient pressures (or water hammer) and the time duration of the transient condition depends on the flow rate velocity, pipeline material and the system boundary conditions such as tanks, pumps, air valves, control valves and changes in pipeline diameter.

The phenomenon of water hammer is generally poorly understood in the water industry. This is due to the difficulty in carrying out a comprehensive analysis, which considers all the system components and their interaction. It is not uncommon for designers to simply add a nominal pressure increase to allow for water hammer. This approach can be too conservative and unnecessarily costly and in some cases there have been system failures due to inadequate water hammer protection being provided.

The undertaking of a water hammer analysis, and selection of protection measures, should be an integral part during the design phase. There are now propriety water hammer programs available, which can assist designers in identifying potential water hammer problems and help in the selection protection measures. The use of these programs should be limited to experienced designers with intimate knowledge of water distribution systems.

The magnitude of the pressure surge depends on the fluid modulus (density and elasticity), the fluid velocity, and the speed of flow stoppage. In the case of a valve closure as the flow stoppage event, critical aspect of the speed of closure might not be the total time it takes to close the valve.

2.3 Sudden Valve Closure:

The instantaneous valve closure calculation predicts the maximum increase in pressure that will occur due to a sudden valve closure. The valve closure time is considered to be instantaneous if the valve closes faster than (or equal to) the time required for a pressure wave to travel two pipe lengths (i.e. the time for the wave to travel upstream from the valve, reflect off the upstream boundary and return to the valve). The pressure wave travels two pipe lengths in a time of 2L/c. If the valve takes longer then 2L/c to close, then the water hammer pressures can be computed by our_other water hammer calculation_which predicts pressures for finite valve opening or closing times. The pressure predicted by the instantaneous valve closure calculation provides the engineer with the expected maximum pressure increase. The calculation can also be used in reverse - to compute the pipe velocity - if a maximum pressure rise is input.

2.4 Pump Trip:

As a pump fails, flowing into the pipeline drops rapidly, but the column of liquid in the pipeline continues under its own momentum leaving behind a low pressure region eventually, the momentum is overcome by the opposing force of a static head, which in turn accelerates the liquid column back towards the pumping station. The pump discharge non return check valve closes in this interim period and hence a rapid pressure rise occurs when the pipeline fluid impinges on the closed valve. The magnitude of the initial pressure drop and subsequent pressure rise is influenced by the initial pipeline velocity, the static head, the pipe length, material and friction.

2.5 PROTECTION DEVICES TO RELIEVE SURGE PRESSURE:

Every water supply system is unique in relation to water hammer effects. The most effective solution to a potential water hammer problem may be a single or combination of protection devices. The relative merits of various devices should be compared and the best solution evaluated during the design phase of a new project.

A number of commonly used protection devices are described:

Flywheel

An effective device attached to pumps for generally shorter pipeline lengths. They help to dampen surges by slowly decelerating the pump speed on pump stoppage.

Air Vessel

A pressure vessel containing air and water. It is a very effective device for controlling both positive and negative pressure surges and is often used as a last resort because of high capital costs.

One Way Surge Tower

An open ended device which is connected to the pipeline by a check valve. It allows water to enter the pipeline when the pipeline is subjected to vacuum pressures.

Non Return Valves

These are often used on steeply rising pumping mains. They help to prevent the pipeline length of water falling back on the pump's check valve following pump stoppage.

Standpipe

Can be used in low pumping head systems where the height of the standpipe does not become excessive. They are often used on gravity systems.

Control Valves

They are often fitted on pump discharges. They are opened and closed slowly to minimize water during pump stoppage and startup. They are not effective during a sudden pump stoppage.

Surge Anticipator Valves

They are fitted to a pump delivery. They are hydraulically activated control valves which open when a pump stops and start to close as the pressure starts to build up when down surge reaches the pump. The slow closure of the valve minimizes water hammer pressures.

ESD Valves

By definition emergency shutdown valves are designed to take the process to a safe state if certain, pre-specified operating limits are exceeded. The major problem with these valves relates to the fact that they typically operate in one static position for long periods of time and only move in an emergency situation.

Variations in demand

Change in demand to a specific user, controlled by a valve directly link to the supply, can result in transient pressures.

Unintentional changes in the operational positions of Valves

In cases where valves are controlled electrically or pneumatically, care should be taken to avoid transients due to unintentional triggering or failure of the control system.

Chapter: 3

THEORETICAL DEVELOPMENT

3. THEORETICAL DEVELOPMENT

3.1 PipelineStudio Description:

PipelineStudio (PLS) is the industry leading pipeline design and engineering solution that combines graphical configuration and reporting tools with industry proven simulation engines. It offers a unique combination of steady-state and transient simulation capabilities to design facilities and plan operations from a single product. PipelineStudio is currently used by over 300 customers worldwide, by both pipeline operators and consulting engineering firms. It provides fast, accurate, robust and reliable answers to a wide range of steady-state and transient analysis challenges.

PipelineStudio (PLS) delivers rapid and accurate offline design, planning and hydraulic analysis for natural gas and liquid pipelines through advanced state-of-the-art simulation techniques. The combination of both steady-state and transient hydraulic simulation within a feature rich Windows graphical interface enables better understanding of even the most demanding problems by providing appropriate analysis of the process. PipelineStudio (PLS) has been proven to be an effective decision support tool that really can deliver financial benefit to your organization.

Its familiar Windows look and feel makes it easy to use right out of the box. Work flow enhancing techniques such as templates and complexity management along with a comprehensive set of pipes and pipeline equipment enable rapid configuration of robust and accurate models of your whole pipeline network. And once PipelineStudio has constructed an engineering model of your pipeline network, the same model can be integrated into custom applications, or other Energy Solutions products, to enhance specific business processes and your financial performance. PipelineStudio has comprehensive online help, supports multiple languages and is easy to learn.

3.2 PipelineStudio Benefits:

With PipelineStudio, engineers and planners are able to use reliable, accurate information to make decisions leading to improvements in pipeline design, performance and throughput. Engineers can achieve optimum system performance and create emergency plans without interrupting online production.

PipelineStudio can reduce the costs of pipeline operation by supplying effective and innovative engineering solutions to your most challenging issues. Updates to operational strategy for efficiency gains are quick and easy to implement. Pipeline companies, engineering firms and government agencies have all used PipelineStudio to directly impact bottom line results.

- Reduce capital expenditures by maximizing use of existing infrastructure
- Improve productivity and efficiency with fast and accurate pipeline design/modeling
- Promote health and safety through offline operator training and analysis of transient operating conditions
- Identify ideal operational parameters during both low and high demand periods

3.3 PipelineStudio Applications:

Use Pipeline Studio for:

- Flow assurance
- Designing, routing, sizing of pipeline networks
- Upset, leak and survival time analysis
- Rapid assessment of unscheduled changes in operation
- Compressor requirements
- Fuel consumption calculations
- Assessment of storage requirements
- Surge Analysis

With over 30 years in the market place, Pipeline Studio has been tried, tested, proven and relied upon by many hundreds of companies throughout the world.

3.4 Simulations and simulation options:

You can run steady-state and transient simulations, as well as setting various options on how those simulations are run.

Steady-state simulations are the starting points for transient simulations. Most of the time, you want to make sure you can run a successful basic, steady-state simulation before setting different options (such as tracking and simulation controls) or creating a transient simulation.

General steps for running a simulation:

- Run a steady-state simulation to get a steady-state result.
- Run a transient simulation to get a dynamic result.
- (Optionally) Run a transient re-start from the last transient simulation state.

Simulation options:

For simulation options, you can set:

- **General**: standard pressure and temperature reference conditions, tracking, etc.
- **Controls**: run type, transient controls (time step, trends), steady-state controls (iterations, initial values), etc.
- **Fluid**: Equation of state, system wide temperature, etc.
- **Batch**: liquid defaults, batch creation tolerances, etc.
- **Report**: input, steady-state options, dynamic options, etc.
- **Pipe/network element reports**: hydraulic, component, type (summary and detailed), etc.
- **Alarm**: default alarm limits for pressure and flow, etc.
- **Volume**: volume accumulation period and offset

3.5 Simulation Types:

Steady-state simulations

A steady-state simulation calculates time-invariant pressure, temperature and flow profiles throughout a pipeline network using specified boundary conditions and network element set points that you enter. In other words, the steady-state run calculates the hydraulic state of a pipeline system operating at equilibrium. This type of simulation can be done to obtain steady-state data or to provide the initial starting conditions for a transient simulation.

When you request a steady-state simulation, Pipeline Studio validates the network, exports a keyword file and runs the steady-state simulation. Steady-state results can be viewed using a variety of formats. For example, you can view results using data blocks (on a network view), a table view, formatted text output reports (the Keyword Processor Report and Steady State Report) or a profile chart.

Transient simulations

A transient simulation models the dynamic response of the pipeline network to changes in one or more system variables, such as source/delivery rates or network element set points. Transient calculations are more complex and require more processing time than steady-state calculations. Useful results can be obtained from a transient simulation only if changes occur in one or more of the parameters governing the pipeline network. In fact, to run a transient simulation, you must enter a scenario (open the Simulation menu and choose Scenario). Once a steady-state simulation has been performed, you run various transient simulations, all using the same steady-state results as the starting point for the transient simulations. However, certain changes (such as a change in pipe diameter) require that the steady-state is re-run before running a transient simulation. When you request a transient simulation after making this type of change, Pipeline Studio should detect the change and automatically re-run a steady-state simulation before running the transient simulation. You can also run a transient re-start to simulate another transient scenario, starting from the previous transient simulation's final results.

Steady-state diagnostics

There is a display to show the steady-state iterations and any mode changes made during the steady-state run. There is also a built-in graph showing the convergence of the steady-state simulation, which helps you to detect cycling during the steady-state solution.

When you get a steady-state solution, the program checks all devices to see that the control mode at steady-state matches the mode which you requested. If not, an alarm is raised for the device.

Alarms for requested modes

When you get a steady-state solution, Pipeline Studio checks all devices to see that the control mode at steady-state matches the mode which you requested. If not, an alarm is raised for the device. This helps you to see whether the steady-state solution that you obtained matched your requested set points.

Batch transient simulations

During batch (non-interactive) transient simulation runs, a message box indicates the starting, current and final times.

To interrupt non-interactive transient simulation runs, press the Escape key.

Simulation output file archiving

Because binary file names are re-used every simulation, you need to establish a way of archiving data files if the generated binary files are to be used more than once. Moreover, a great deal of time and computer savings can be realized if some of the produced files can be re-used. For example, in the case of systems that only require occasional modeling, data sets (and the corresponding binary files) can be created in advance and then re-used as needed.

Chapter: 4

EXPERIMENTAL

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LIQUID NETWORK TRAINING

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4. PROJECT DETAILS

4.1 PipelineStudio Training: Module Surge

The Module

The module contains a series of cases; starting with a case that will be used as starting point to generate additional cases.

The cases will illustrate the importance of doing a surge analysis by closing a valve to determine any possible over pressure in the pipeline under certain operating conditions.

The User

This pipelinestudio Training Class is intended to the users of the product or someone who wants to become more productive using pipelinestudio.

The goal of the pipelinestudio training class is to provide a pipeline engineer, technician or professional with all of the skills and familiarity with the product needed to allow them to begin making productive and efficient use of the product.

The Training

Pipelinestudio Training is being provided in a laboratory-type environment with the intent to provide the trainee with an interactive and high-ratio of hands on experience. The purpose of this is to keep things interesting and provide better overall retention by the student.

Pipelinestudio training is divided into ordered and methodical labs or modules to allow the user to build on skills obtained from the previous module or lab and maximize the retention of knowledge associated with this training. Lecture and discussion will be incorporated into the labs themselves.

SURGE

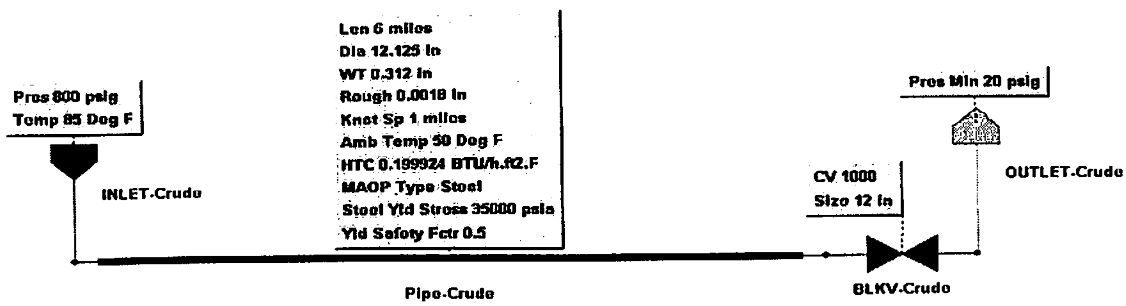
Purpose

This case demonstrates the hydraulic behavior when a block valve is close how this affects the upstream pressure of the block valve.

Pressure surges (water hammer) developed during startup and shutdown, and/or under accident conditions such as loss of power to the pumps or inadvertent valve closure, can easily exceed steady state values. Cavitations or excessive pressure surging during transient operation can lead to pipeline or component failure. Pipelinestudio permits the simulation of the scenario in order to have an idea about the surge pressures generated in the pipelines and whether they would exceed the MAOP of the pipelines or not

Case1 (Surge)
Instructions

Use the configuration layout as a reference to configure the network and use the configuration name: "Case1"



Supply INLET-Crude details:

Fluid Temperature	85	Deg F
Maximum Pressure	800	Psig

Delivery OUTLET-Crude details:

Minimum Pressure	20	Psig

Fluid Properties (Table Type = Auto-generated Class = Crude):

Fluid Name	API Range	Temperature Range (Deg F)	Pressure Range (Psig)
Crude-1	20	200	1500
	17	50	1

Viscosity Curve:

Fluid Name	Temperature	Viscosity
Crude-1	70	690
	80	479.8
	100	326.7
	120	158.3
	140	85.5

Pipes details:

Pipe Name	Length (Miles)	In Dia. (inch)	Wall Thickness	Roughness
Pipe-Crude	6	12.125	0.312	0.0018

Pipe Name	MAOP Type	Yield Stress	Yield Safety Factor	Ambient Temperature	Heat Transfer Coeff.
Pipe-Crude	Steel	35000	0.5	50	

Elevation details: (User line from Supply INLET-Crude to Delivery OUTLET-Crude)

Mile Post Miles	Elevation Ft.
0	0
6	0

Block Valve details:

Valve Name	CV	Size in Inches
Blkv-Crude	1000	12

Transient Scenario details (Time Unit = Seconds):

Device Type	Name	Set Point	Units	Initial	10	40	250
Block Valve	BLKV-Crude	% open	percent	100	100	0	0

Valve closing in 30 seconds

Case Study 1:

INSTRUCTOR'S SOLUTION

1) Create a new case based on the schematic shown and the information given for CASE1
2) Create a transient scenario table to match the scheduled for the valve closure.
3) Select the appropriate trend categories to answer the questions.
4) Make additional data files and modifications as required.

OBSERVATIONS AND QUESTIONS

After entering and executing the model described above, answer the following questions:

1) What is the MAOP calculated?

856.538 psig

2) How long does it take to reach the MAOP (856.538) ?

Time = 42 seconds = 2 seconds after the valve closure

Case 1A and 1B (Surge)
Instructions

Use the configuration name: "Case1" and generate additional cases using the fluids properties: Kerosene, Diesel, NGL, Propane and Aviation Gas. Run surge case for each product and compare the trends.

Kerosene

Fluid Properties (Table Type = Correlation Class = Kerosene):

Fluid Name	API Range
Kerosene-1	47
	41

Viscosity Curve:

Fluid Name	Temperature (Deg F)	Viscosity (cS)
Kerosene-1	82.4	1.95
	104	1.5

Diesel

Fluid Properties (Table Type = Auto-generated Class = Diesel):

Fluid Name	API Range	Temperature Range (Deg F)	Pressure Range (Psig)
Diesel	39	100	1000
	29	60	100

Viscosity Curve

Fluid Name	Temperature (Deg F)	Viscosity (cS)
	60	4.2
	80	3.3
	100	2.9

NGL

Fluid Properties (Table Type = Correlation Class = NGL):

Fluid Name	API Range
NGL	163.292
	145.951

Viscosity Curve

Fluid Name	Temperature (Deg F)	Viscosity (cS)
NGL	20	0.33
	40	0.32
	60	0.31
	80	0.3
	100	0.29
	120	0.28

LPG

Fluid Properties (Table Type = Correlation Class = LPG):

Fluid Name	API Range
Propane	10
	10

Viscosity Curve:

Fluid Name	Temperature (Deg F)	Viscosity (cS)
Propane	40	0.25
	80	0.2

Aviation Gas

Fluid Properties (Table Type = Correlation Class = LPG):

Fluid Name	API Range
Aviation Gas	68
	68

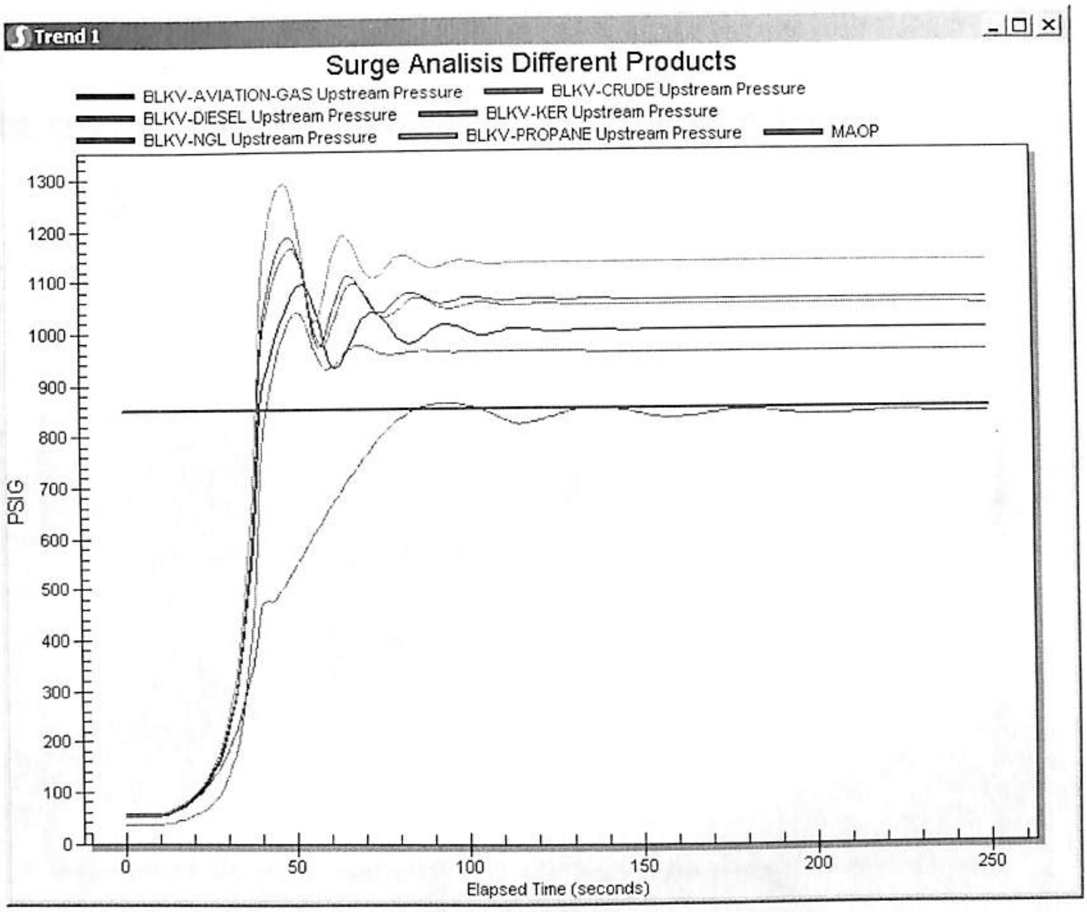
Viscosity Curve:

Fluid Name	Temperature (Deg F)	Viscosity (cS)
Aviation Gas	40	0.76
	80	0.53

Case Study 1A (continued)

INSTRUCTOR'S SOLUTION
OBSERVATIONS AND QUESTIONS

1) Generate additional cases using the fluids properties: Kerosene, Diesel, NGL, Propane and Aviation Gas. Run surge case for each product and compare the trends.



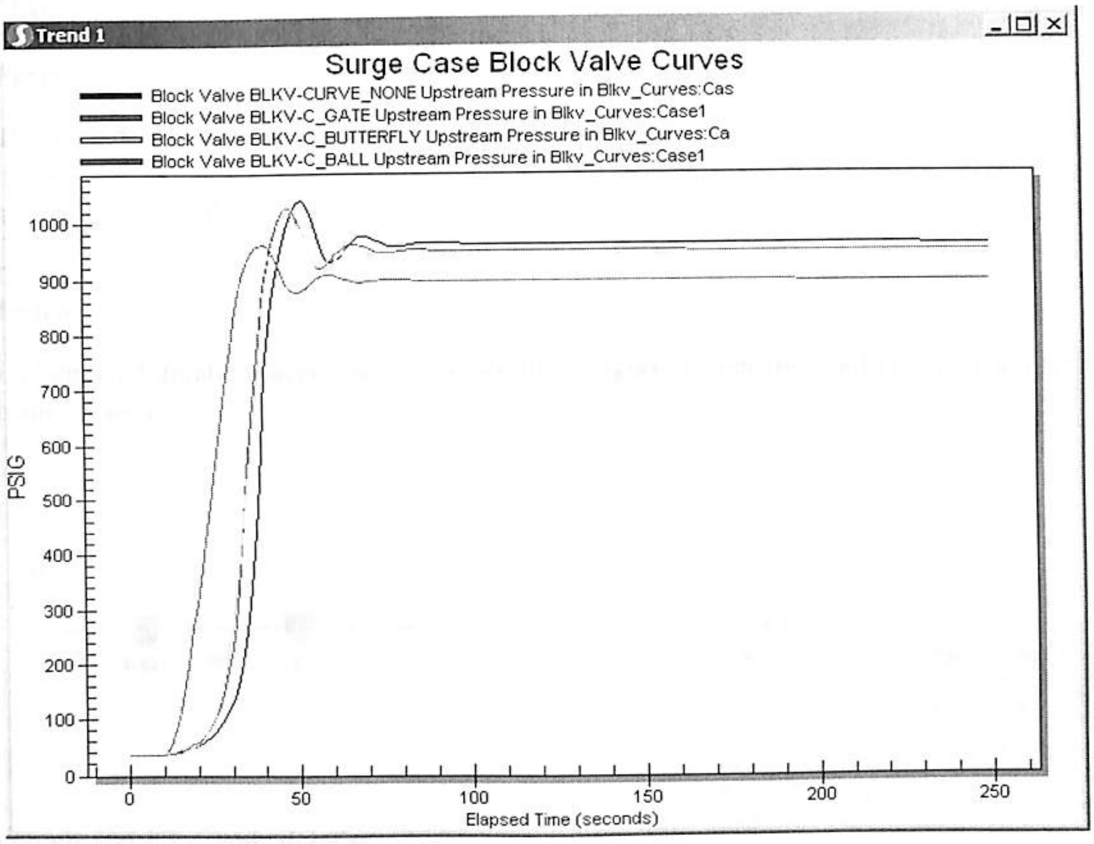
Case Study 1B (continued)

INSTRUCTOR'S SOLUTION
OBSERVATIONS AND QUESTIONS

Instructions

Use the configuration name: "Case1" (fluid "Crude-1") and generate additional cases using the CV curves: None for the default values, Ball Valve, Butterfly Valve and Gate Valve.

Run surge case for each configuration and compare the trends



4.2 PipelineStudio Training: Module Relief Valve

The Module

The module contains a series of case: starting with a case that will be used as a starting point to generate additional cases.

The cases will illustrate the importance of having a device that can release products and avoid over pressure in the pipeline.

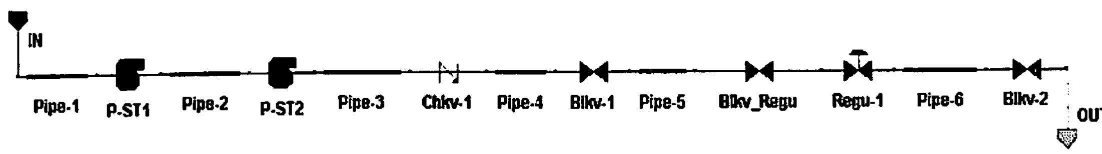
MAOP

Purpose

This case demonstrate the hydraulic behavior when a delivery suddenly change from the normal operation to "0" flow. The pressure upstream of the delivery will increase to the level that goes above of the MAOP established.

Case 1 (MAOP)
Instructions

Use the configuration layout as a reference to configure the network and use the configuration name: "Case1"



Supply INLET-Crude details:

Fluid Temperature	**60**	**Deg F**
Maximum Pressure	**1200**	**Psig**

Delivery OUTLET-Crude details:

Minimum Pressure	**3333**	**Psig**

Fluid Properties (Table Type = Auto-generated Class = Crude):

Fluid Name	API Range	Temperature Range (Deg F)	Pressure Range (Psig)
Crude-1	50	200	2000
	40	1	1

Viscosity Curve:

Fluid Name	Temperature	Viscosity
Crude-1	60	2.2
	80	1.9
	100	1.4

Pipes details:

Pipe Name	Length (Miles)	In Dia. (inch)	Wall Thickness	Roughness
Pipe-1	29	12.126	0.312	0.001
Pipe-2	32	12	0.375	0.001
Pipe-3	15	15.25	0.375	0.001
Pipe-4	12	12.5	0.5	0.001
Pipe-5	12	12.5	0.5	0.001
Pipe-6	52	12.5	0.5	0.001

Pipe Name	MAOP Type	Yield Stress	Yield Safety Factor	Ambient Temperature	Heat Transfer Coeff.
Pipe-1	Steel	35000	0.72	50	1
Pipe-2	Steel	35000	0.72	50	1
Pipe-3	Steel	42000	0.72	50	1
Pipe-4	Steel	35000	0.72	50	1
Pipe-5	Steel	35000	0.72	50	1
Pipe-6	Steel	35000	0.72	50	1

Elevation details: (User line from Supply INLET-Crude to Delivery OUTLET-Crude)

Mile Post Miles	Elevation Ft.
0	820
29	2460
62	3937
77	4265
102	3280
152	328

Pump details (Generic)

P-ST1

Adiabatic Efficiency	100	%
Mechanical Efficiency	100	%
Max Down Pressure	1180	
Mode	Max Down Pressure	

P-ST2

Adiabatic Efficiency	100	%
Mechanical Efficiency	100	%
Max Down Pressure	1170	
Mode	Max Down Pressure	

Block Valve details:

Valve Name	CV	Size in Inches
Blkv-1	50000	12
Blkv Regu	50000	12
Blkv-2	50000	12

Regulator details:

Regulator Name	Cv	Size in Inches	Down Max. Press. (Psig)
Regu-1	50000	12	1000

Case Study 1 (continued)

INSTRUCTOR'S SOLUTION
OBSERVATIONS AND QUESTIONS

After the network has been configured, add the trends accordingly and continue with the following instructions:

A) Turn "On" the temperature tracking
B) Using the Network View Properties color the devices by "Status"
C) Add data blocks to verify pressures and flows
D) Run steady state
E) Enable the Alarms, select the block valve Blkv-2 and input the MAOP value calculated for HiHi alarm
F) Select the pressure and MAOP profile,
G) Split the Network View and the profile window (Tile Horizontally)
H) Activate the Interactive Transient simulation
I) Select the delivery "OUT" and change the flow to "0"
J) Start the Interactive Transient simulation
K) Verify the time when the pressure reach the MAOP
L) Run the simulation enough time to review the trends and the alarm window

After 2 min. 23 secs the pressure reached is 1870.97 psig (MAOP=1866.67 psig)

RELIEF VALVE

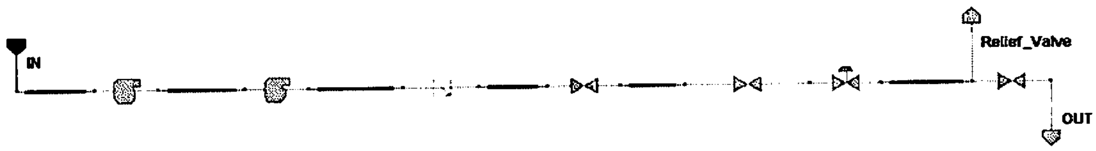
Purpose

This case demonstrate the hydraulic behavior when a delivery suddenly change from the normal operation to "0" flow. The pressure upstream of the delivery will increase to the level that is necessary to use a relief valve to avoid violation to the MAOP. This case study is designed to help identify the requirements for a relief valve in order to protect any specific location in the network.

Case1A (Relief Valve)

Instructions

Open the Case1 and use the configuration layout as a reference to configure the location of the relief valve and use the configuration name: "Case1A"



Since the Maximum Allowable Operating Pressure (MAOP) for the last segment of the pipeline has been established = 1866.67 psig the set point for the relief valve is 1860 psig.

Delivery **Relief-Valve** details:

Maximum Pressure	1860	**Psig**
Minimum Pressure	1860	**Psig**
Check Valve	Yes	
Mode	Check	

After the network has been configured add the trends accordingly; continue with the instructions

Case Study 1A (continued)

INSTRUCTOR'S SOLUTION

OBSERVATIONS AND QUESTIONS

After the network has been configured, add the trends accordingly and continue with the following instructions:

A) Turn "On" the temperature tracking

B) Select the block valve Blkv-2 and input 1859 psig for HiHi alarm

C) Select the delivery "Relief-Valve" and enable the trends Accumulate Volume, pressure and flow

D) Run steady state

E) Select pressure and MAOP profile,

F) Split the Network View and the profile window (Tile Horizontally)

G) Activate the Interactive Transient simulation

H) Select the delivery "OUT" and change the flow to "0"

I) Start the Interactive Transient simulation

J) Verify the time when the pressure reach 1859 psig (MAOP = 1866.67 psig)

K) Run the simulation enough time to review the trends and the alarm window

After 2 minutes and 21 seconds the pressure reached is 1859 psig

Verify the amount of product that needs to exit the pipeline to keep the pressure around 1860 psig after five hours?

Accumulated Volume = 8.159 BBL/H after 5 hours

4.3 NETWORK DESCRIPTION

This system network represents a pipeline system consisting of one input (supply) i.e source station and product is being delivered to 6 delivery stations through pipeline. It consist of 20 pipes.17 block valves and 7generic pumps.

For delivering product to delivery station *D1*, total pipeline length is 205.579km for delivering product, pump station P1 is there at a length of 54.275km.Product is being delivered at D1 at flow rate of $216m^3/hr$ and at a pressure of $8.2795kg/cm^2$.

At the diversion point there is one more pump station P2 to deliver the product further. When pump station P2 increases pressure from $15.5445kg/cm^2$ to $75kg/cm^2$ and at distance of 147.484 km from supply another Pump station P3 is there.

At a distance of 182.597km from supply two branches are there to deliver product to delivery stations D2 and D3. For delivering product to delivery station D3 two pump stations P4 and P5 are there. For delivering product from delivery station D3 to D4 one more pump station is P6 installed.

After that, looking straight in the network from supply, next branching is done at 292km from the supply. From one branch of diversion, the product is delivered to delivery station D5 and other to D6 for product delivery to D6 the pump station P7 is installed at the distance of 292km from supply.

Pipeline network layout

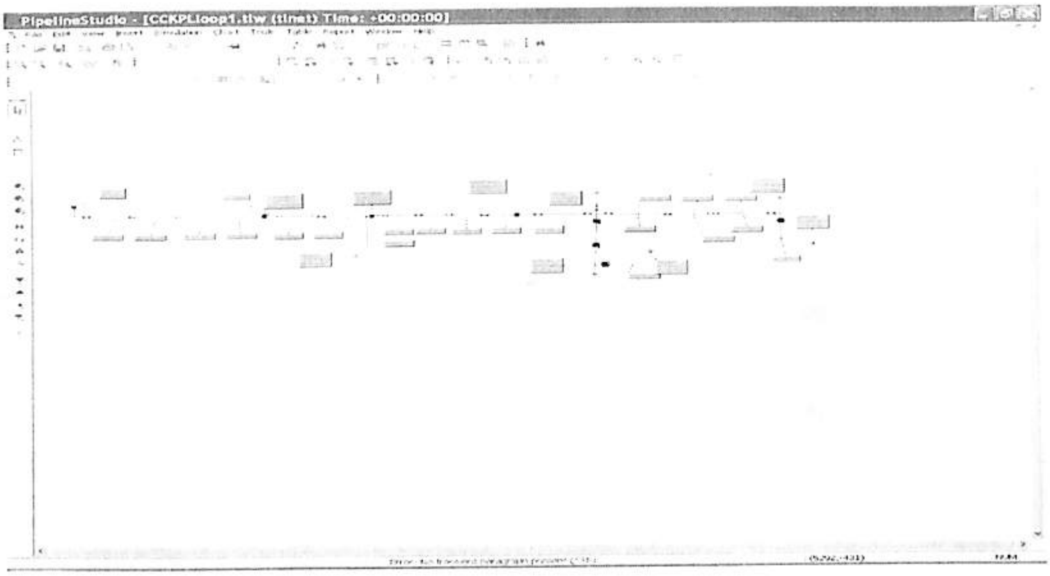


Fig 06: ENTIRE NETWORK LAYOUT

SECTION LAYOUT

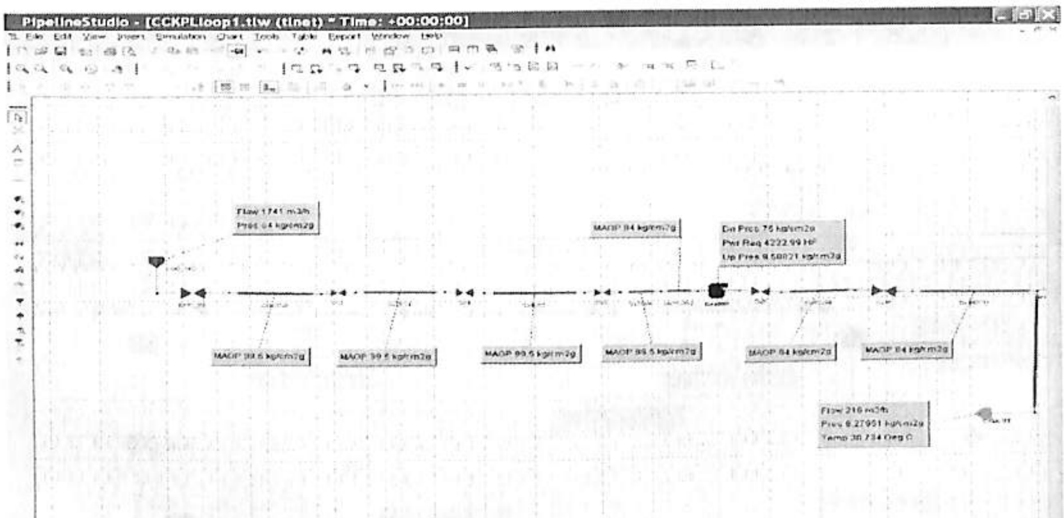


Fig 07: SECTION FROM SUPPLY TO DELIVERY D1

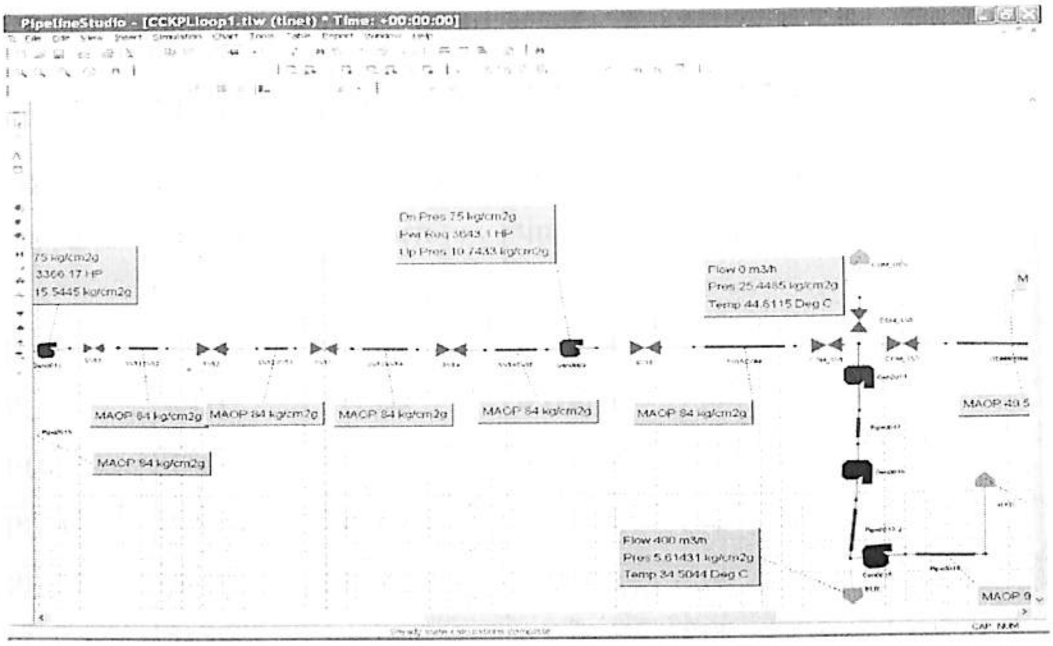


Fig 08: SECTION FROM D1 to D2, D3 AND D4

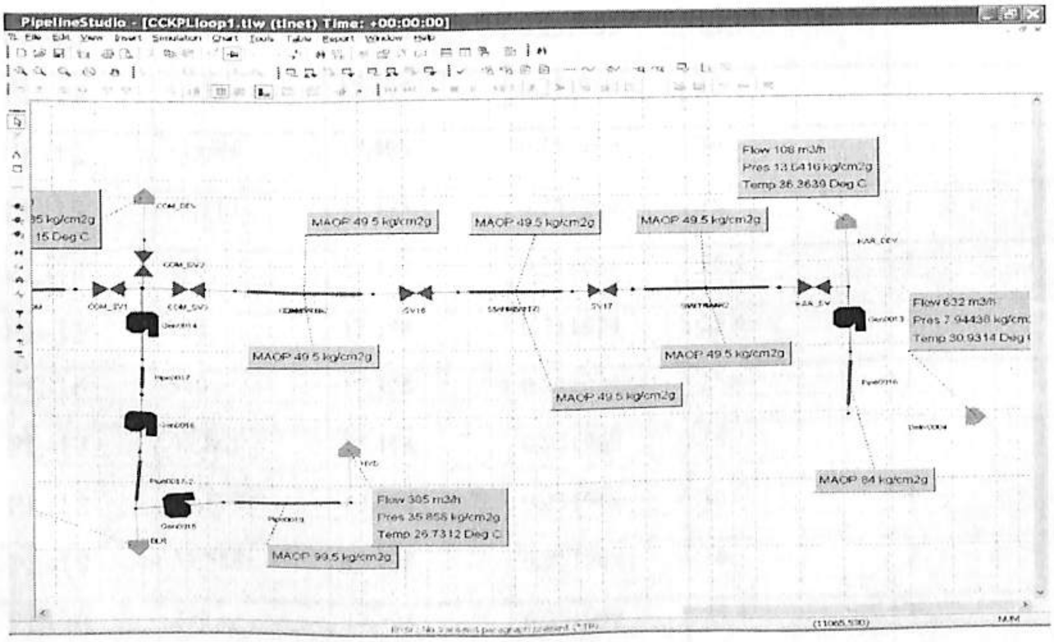


Fig 09: SECTION CONSISTING D2, D3, D4, D5 AND D6

4.4 INPUT DATA:

PIPE SPECIFICATION DATA:

Pipe name	Length In Km	Diameter In inch	Wall thickness In inch	Roughness In microns	Knot space In inch
PL-1	12.117	17.378	0.311024	16	1
PL-2	8.453	17.378	0.311024	16	1
PL-3	17.624	17.378	0.311024	16	1
PL-4	5.206	17.378	0.311024	16	1
PL-5	10.875	17.498	0.251969	16	1
PL-6	21.710	17.498	0.251969	16	1
PL-7	19.594	17.498	0.251969	16	1
PL-8	110	17.498	0.251969	25.4	1
PL-9	9.764	17.498	0.251969	16	1
PL-10	18.473	17.498	0.251969	16	1
PL-11	12.584	17.498	0.251969	16	1
PL-12	11.084	17.498	0.251969	16	1
PL-13	35.113	17.498	0.251969	16	1
PL-14	170	17.378	0.311024	25.4	1
PL-15	120	17.378	0.311024	25.4	1
PL-16	510	17.378	0.311024	25.4	1
PL-17	33.861	17.498	0.251969	16	1
PL-18	40.173	17.498	0.251969	16	1
PL-19	35.558	17.498	0.251969	16	1
PL-20	208	17.498	0.251969	25.4	1

Table 01

PUMP SPECIFICATION DATA

Pump name	Adia.Eff. (%)	Mech. eff. (%)	Max D.P. (kg/cm^2 g)	Mode
P-1	100	100	75	Max D.P.
P-2	100	100	75	Max D.P.
P-3	100	100	75	Max D.P.
P-4	100	100	89	Max D.P.
P-5	100	100	89	Max D.P.
P-6	100	100	50	Max D.P.
P-7	100	100	45	Max D.P.

Table 02

SUPPLY DATA

Fluid temp = 38^0C

Max pressure = 84 kg/cm^2 g

4.5 ELEVATION PROFILES:

FROM SUPPLY TO D-1:

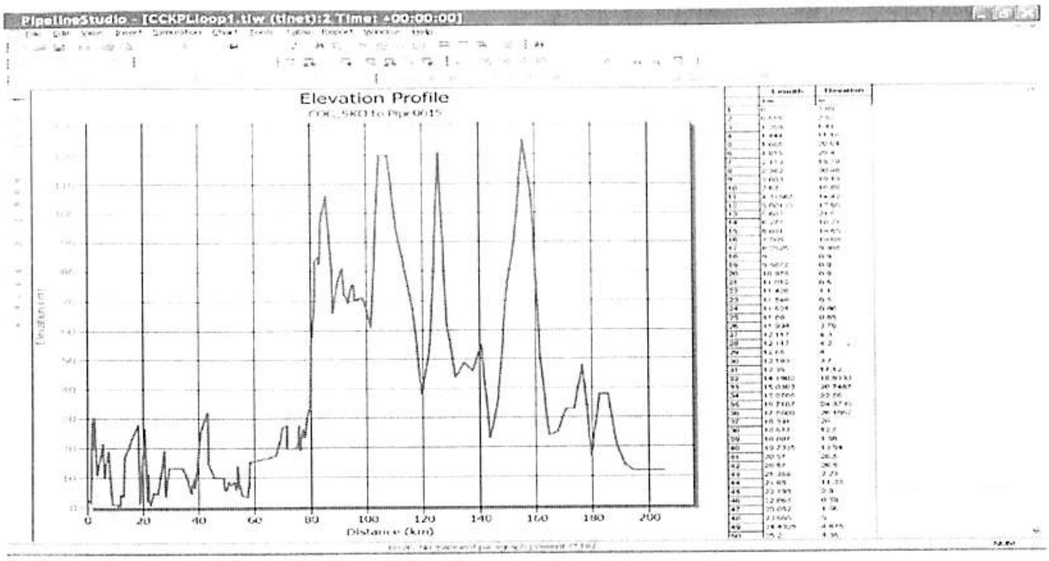


Fig 10

From supply to D-2

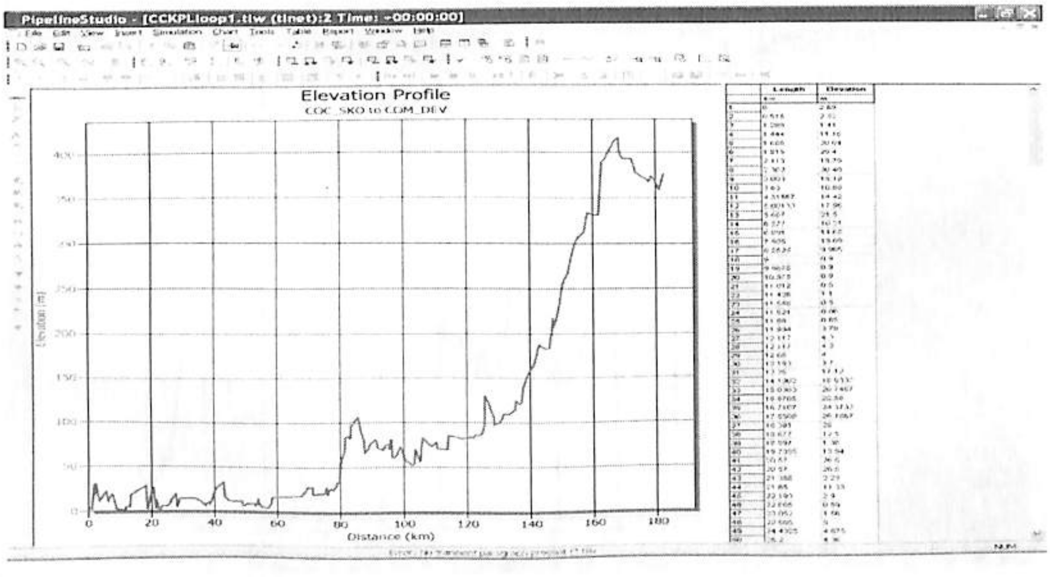


Fig 11

From supply to D-3

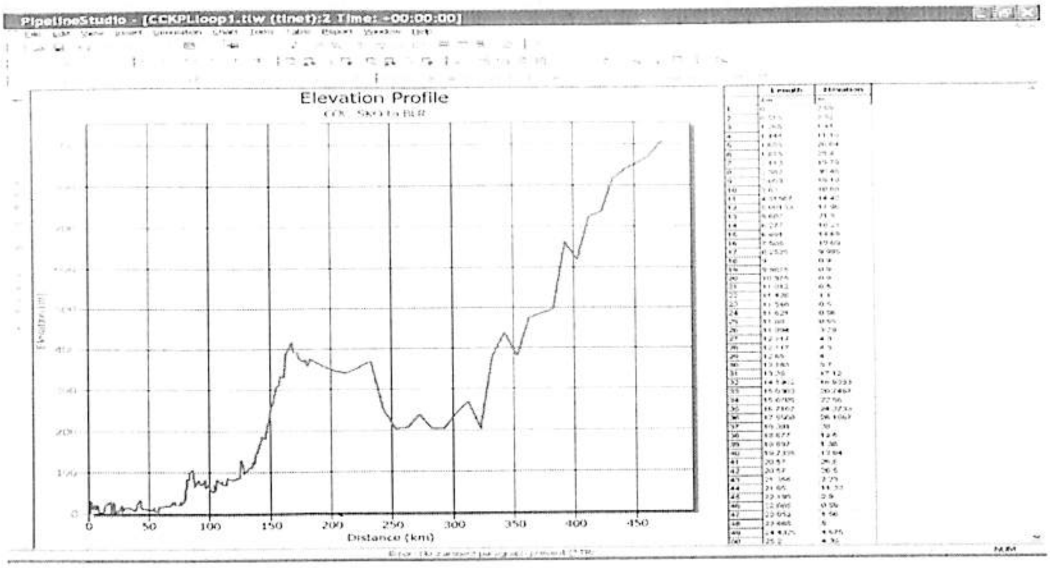


Fig 12

From supply to D-4

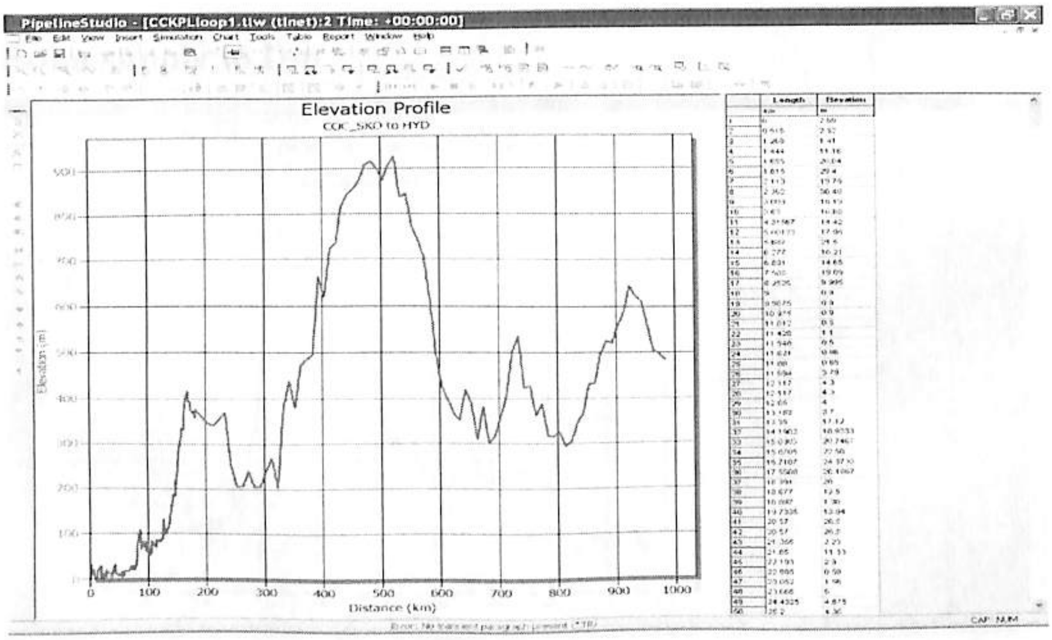


Fig 13

From supply to D-5

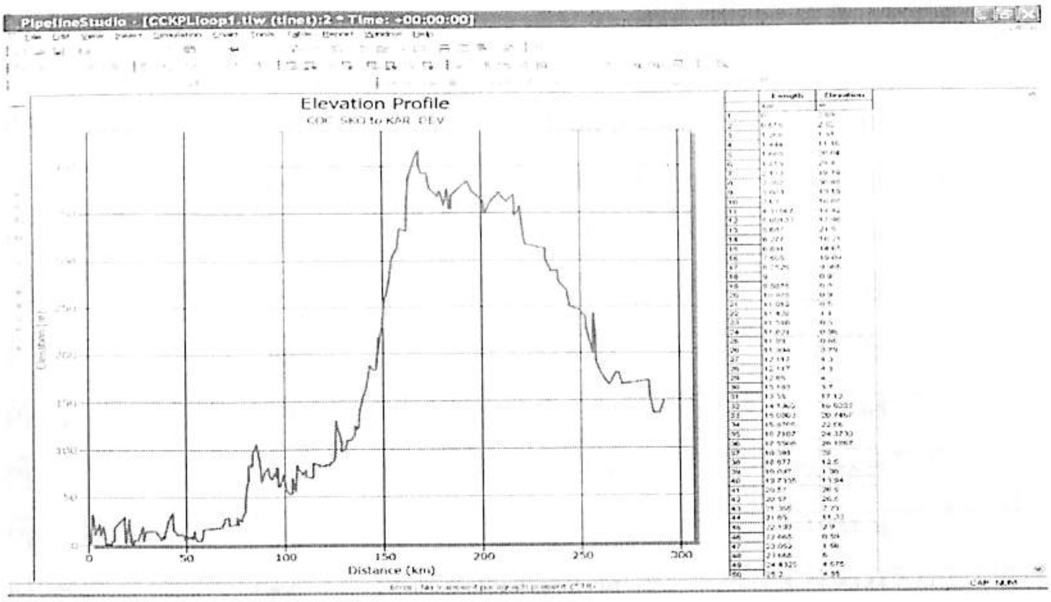


Fig 14

From supply to D-6

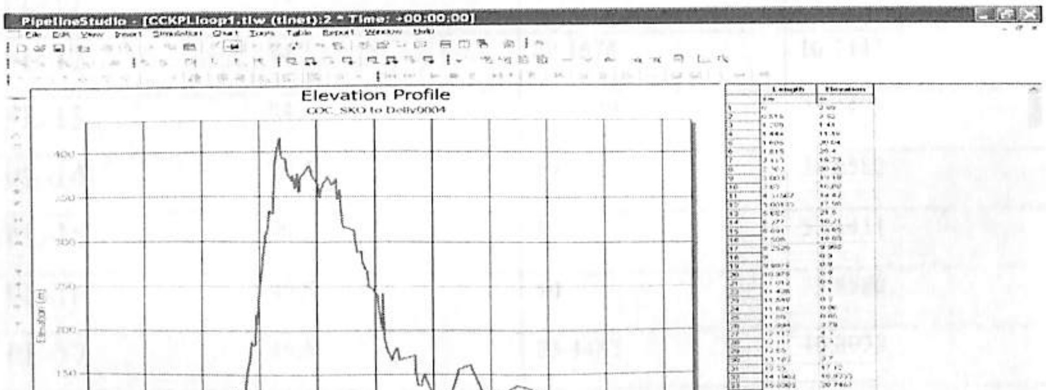


Fig 15

4.6 STEADY STATE RESULTS

PIPE RESULTS

Pipe name	MAOP (kg/cm^2 g)	Head pressure (kg/cm^2 g)	Tail pressure (kg/cm^2 g)
PL-1	99.5	83.9986	67.1654
PL-2	99.5	67.164	53.6945
PL-3	99.5	53.6931	30.9335
PL-4	99.5	30.9335	23.3105
PL-5	84	23.3106	9.58821
PL-6	84	74.9986	45.4126
PL-7	84	45.4112	15.5445
PL-8	84	15.5445	8.27951
PL-9	84	74.9989	66.2029
PL-10	84	66.2019	44.8913
PL-11	84	44.8902	29.1685
PL-12	84	29.1674	10.7443
PL-13	84	74.9989	25.4495
PL-14	99.5	89	34.0582
PL-15	99.5	89	5.61431
PL-16	99.5	50	35.8580
PL-17	49.5	25.4482	16.8038
PL-18	49.5	16.8038	16.0158
PL-19	49.5	16.0156	13.6419
PL-20	84	45	7.94438

Table 03

PUMP RESULTS

Pump name	Power req. (HP)	Up pressure (kg/cm^2 g)	Dn pressure (kg/cm^2 g)	Head (m)
P-1	4222.99	9.58821	75	790.588
P-2	3366.17	15.5445	75	719.442
P-3	3643.10	10.7433	75	778.629
P-4	1851.13	25.4485	89	768.594
P-5	1589.01	34.0582	89	659.760
P-6	631.663	5.61431	50	534.754
P-7	733.568	13.6416	45	378.314

Table 04

DELIVERY RESULTS

Name	D-1	D-2	D-3	D-4	D-5	D-6
Flow (m3/hr)	216	0	400	385	108	632
Pressure (kg/cm^2 g)	8.27951	25.4485	5.61431	35.8580	13.6416	7.94438
Temp. (Deg.C)	30.7340	44.8115	34.5044	26.7312	36.3639	30.9314

Table 05

4.7 SIMULATION METHODOLOGY FOR SURGE ANALYSIS

The following steps and explanation are followed for conducting the surge (transient) simulations:

1. The results of steady state simulation are taken as basis for conducting surge analysis.
2. The surge analysis is carried out by closing the ESD valves.
3. Simulation period is divided into ramp intervals corresponding to the start and finish of each system change that occurs during a transient scenario. Each interval establishes a time increment for valve closure changes in the pipeline network.
4. Time unit for all scenarios under consideration is seconds. The valve closure time is considered to be 60 seconds. Once closed the valve will remain closed for 3600 seconds (one hour). The results of the transient simulation are for one hour.

4.8 SURGE ANALYSIS RESULTS USING TRANSIENT SIMULATION

Surge analysis scenario for ESD at block valve BK-17 :

The surge analysis scenario is used for running the transient simulation is given below:

	Device type	Name	Set point	Units	Initial	60	3600
1.	Block valve	BK-17	% open	percent	100	0	0

Surge scenario for ESD valve closure.

The ESD valve BK-17 at delivery end is closed after 60 seconds and it continues to remain close till 1 hour.

SURGE RESULTS

Device	Up pressure (kg/cm^2 g)	Up pressure time(sec)	Dn pressure (kg/cm^2 g)	Dn pressure Time(sec)
PL-19	49.468	471.02	49.732	332.48
BK-17	49.567	332.49	14.119	60

Upstream pressure Vs Time graph for PL-19:

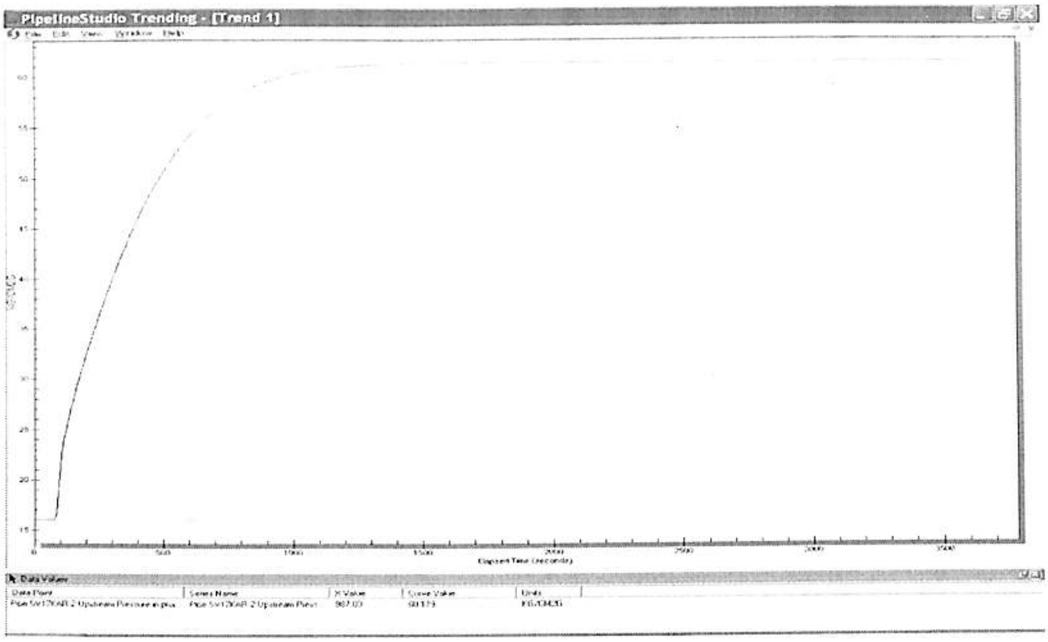


Fig 16

Downstream pressure Vs Time graph for PL-19:

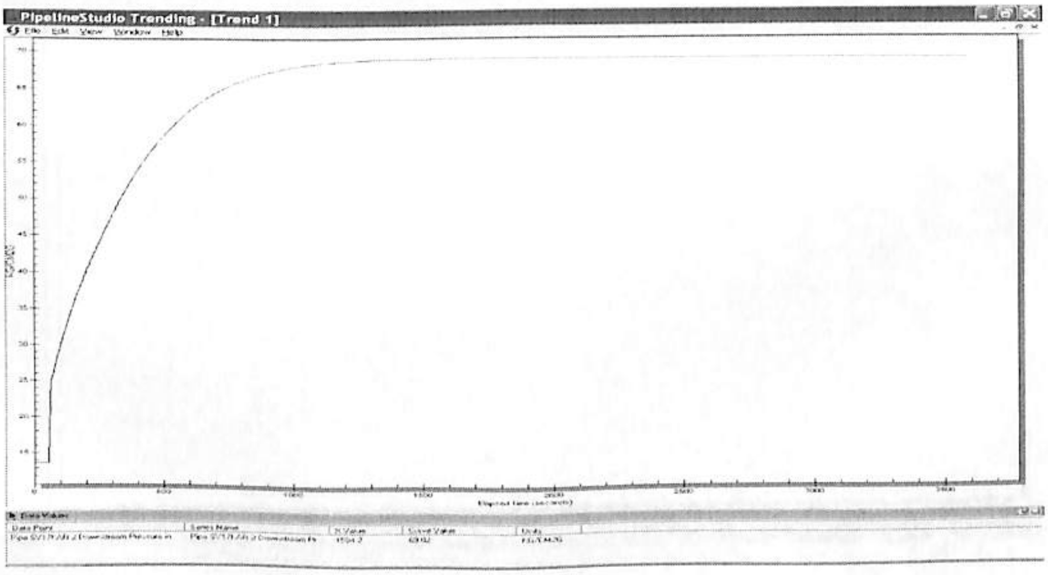


Fig 17

Upstream pressure Vs Time graph for BK-17:

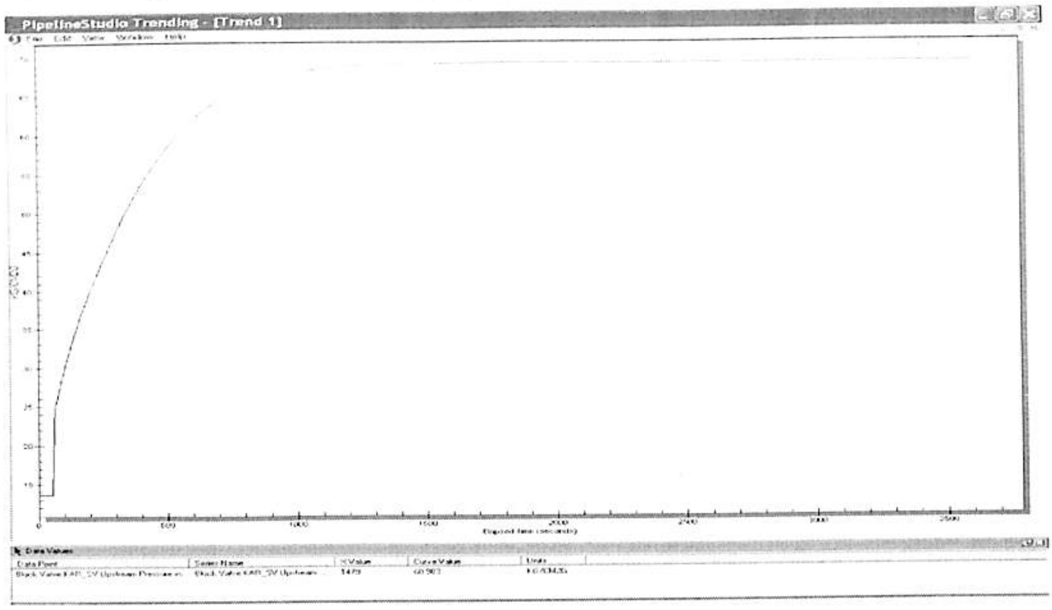


Fig 18

Downstream pressure Vs time graph for BK-17:

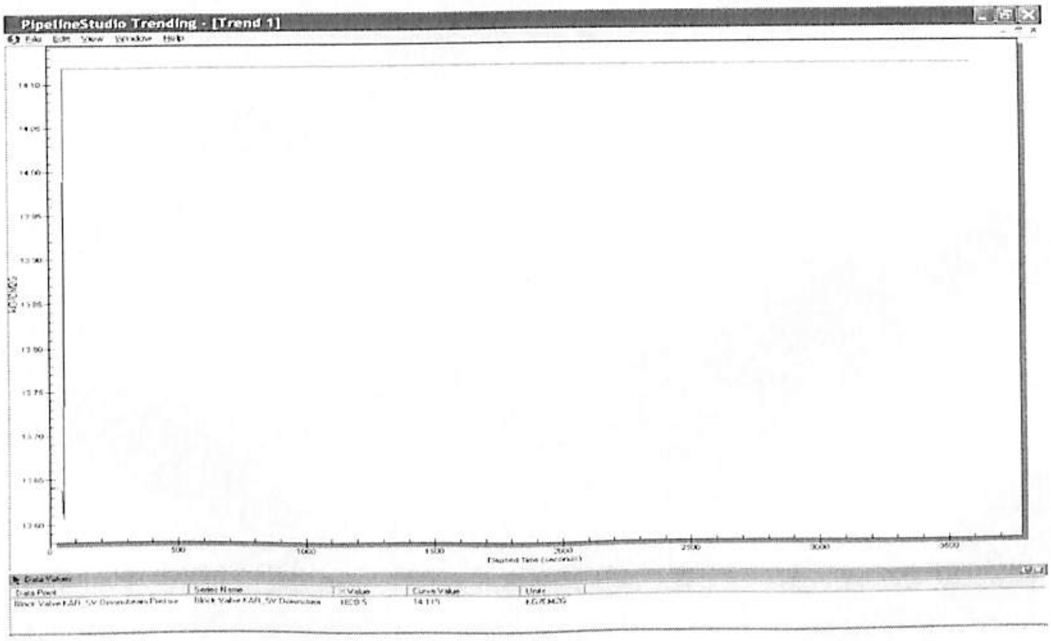


Fig 19

Accumulated volume Vs Time graph for BK-17:

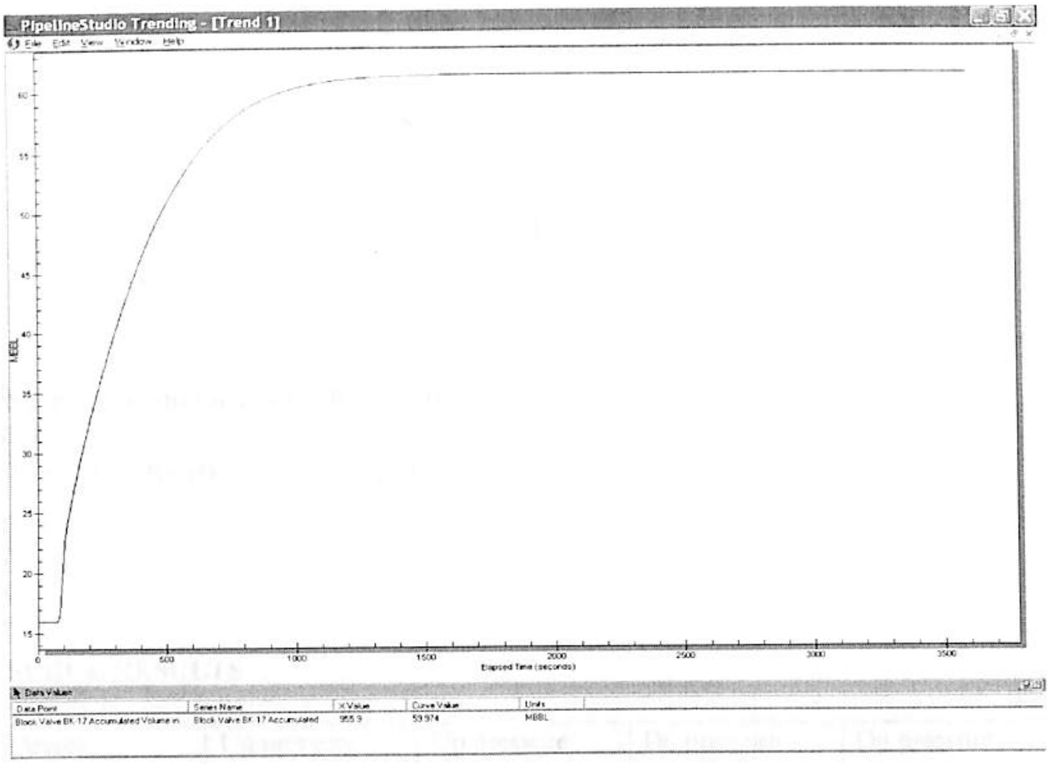


Fig 20

Surge analysis scenario for ESD at block valve BK-15:

The surge analysis scenario is used for running the transient simulation is given below:

	Device type	Name	Set point	units	Initial	60	3600
1.	Block valve	BK-15	% open	percent	100	0	0

Surge scenario for ESD valve closure.

The ESD valve BK-15 delivery end is closed after 60 seconds and it continues to remain close till 1 hour.

SURGE RESULTS

Device	Up pressure (kg/cm^2 g)	Up pressure time(sec)	Dn pressure (kg/cm^2 g)	Dn pressure Time(sec)
PL-17	49.513	328	49.530	285
BK-15	50.9408	405	16.799	50

Upstream Pressure Vs Time graph for PL-17:

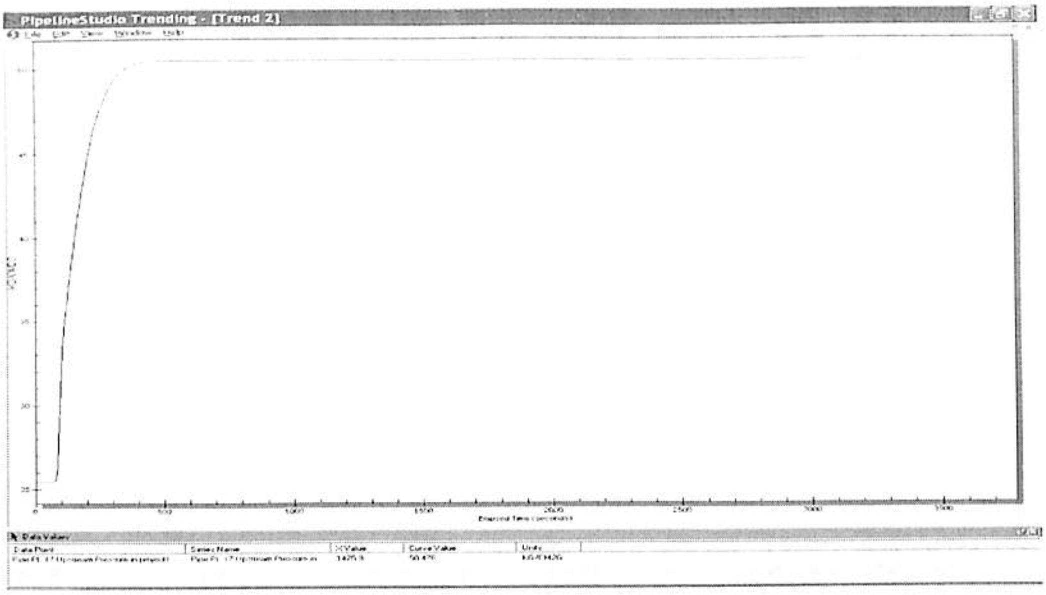


Fig 21

Downstream Pressure Vs Time graph for PL-17:

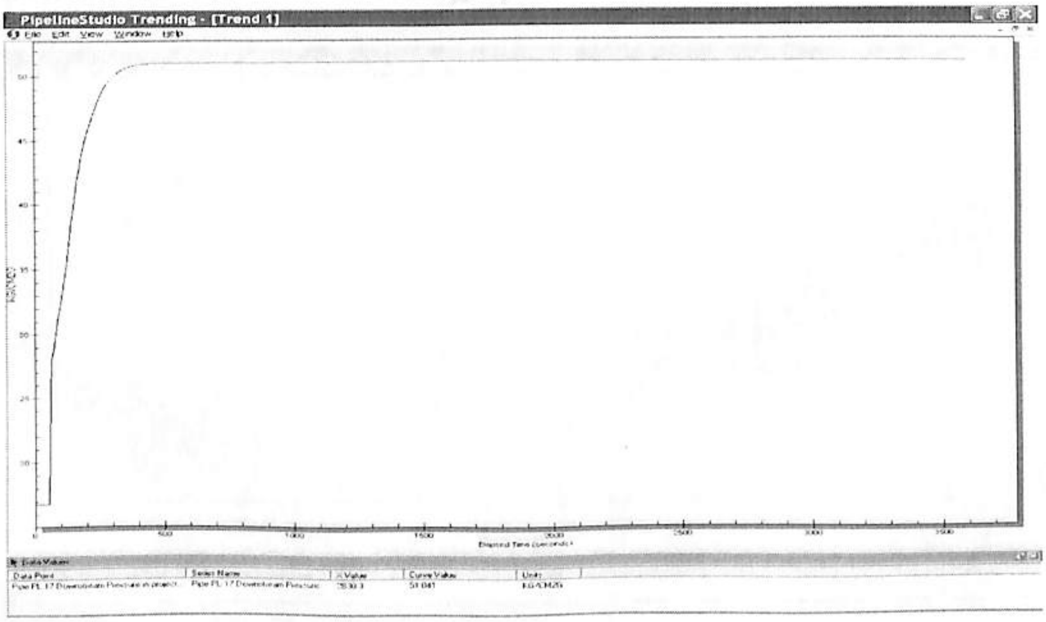


Fig 22

Upstream Pressure Vs Time graph for BK-15:

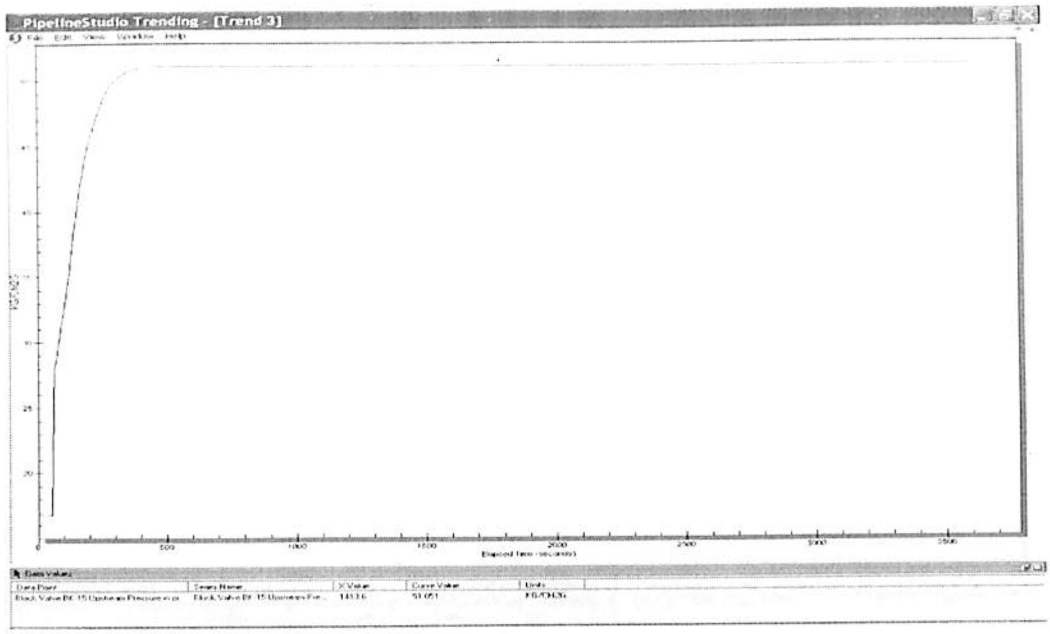


Fig 23

Downstream Pressure Vs Time graph for BK-15:

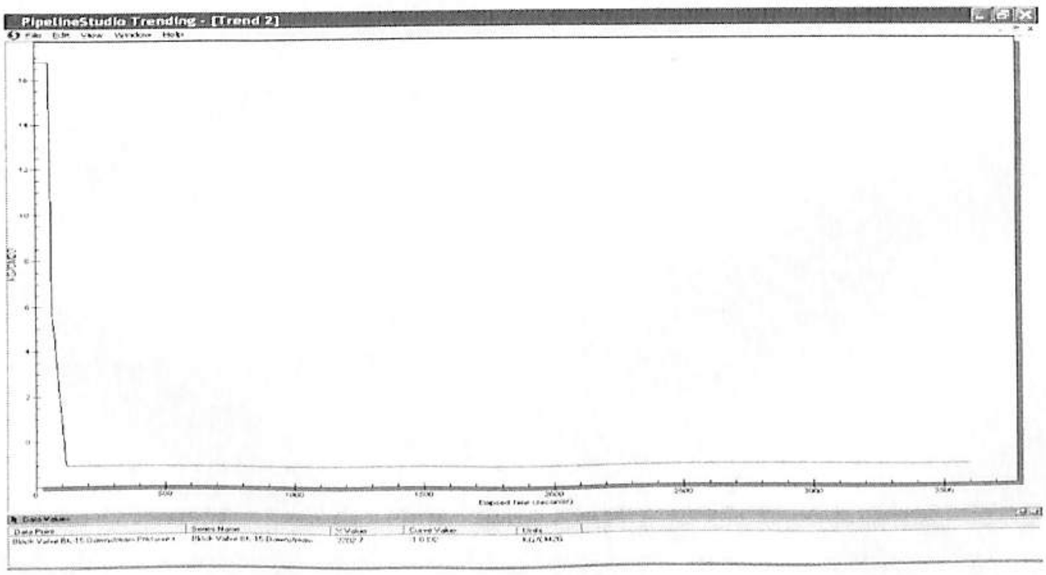


Fig 24

Accumulated volume Vs Time graph for BK-15:

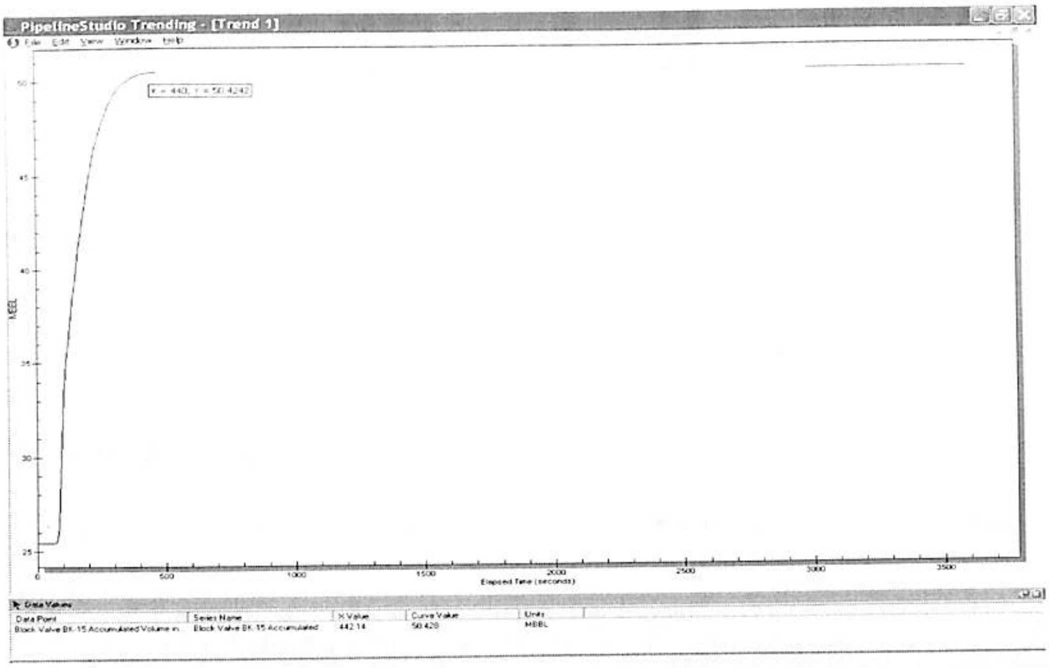


Fig 25

Surge analysis scenario for ESD at block valve BK-12:

The surge analysis scenario is used for running the transient simulation is given below:

	Device type	Name	Set point	units	Initial	60	3600
1.	Block valve	BK-12	% open	percent	100	0	0

Surge scenario for ESD valve closure:

The ESD valve BK-12 delivery end is closed after 60 seconds and it continues to remain close till 1 hour.

SURGE RESULTS

Device	Up pressure (kg/cm^2 g)	Up pressure time(sec)	Dn pressure (kg/cm^2 g)	Dn pressure Time(sec)
PL-13	84.12	142	74.132	120
BK-12	74	120	25.44	50

Upstream Pressure Vs Time graph for PL-13:

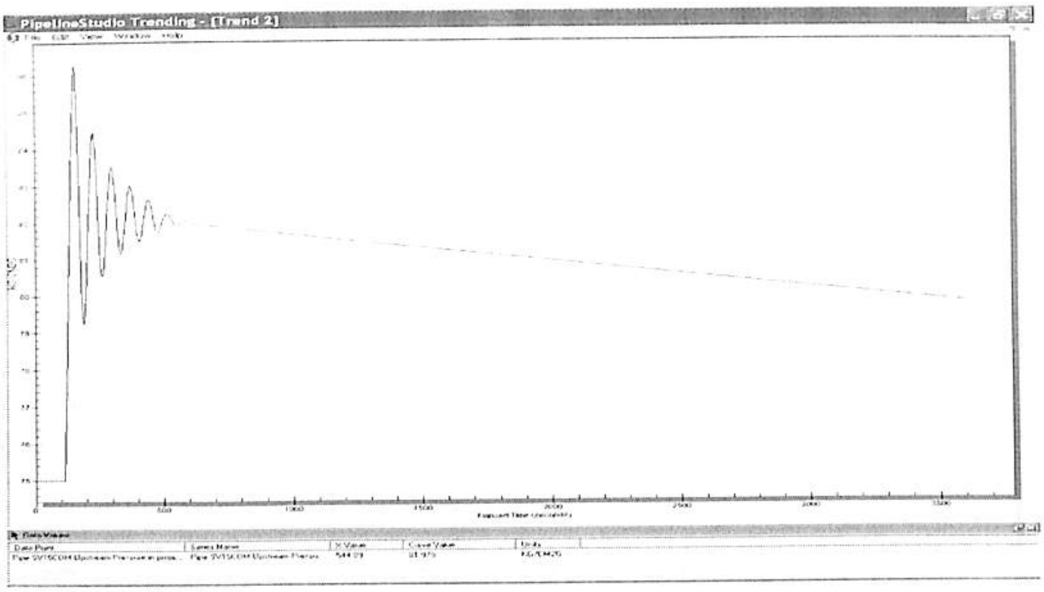


Fig 26

Downstream Pressure Vs Time graph for PL-13:

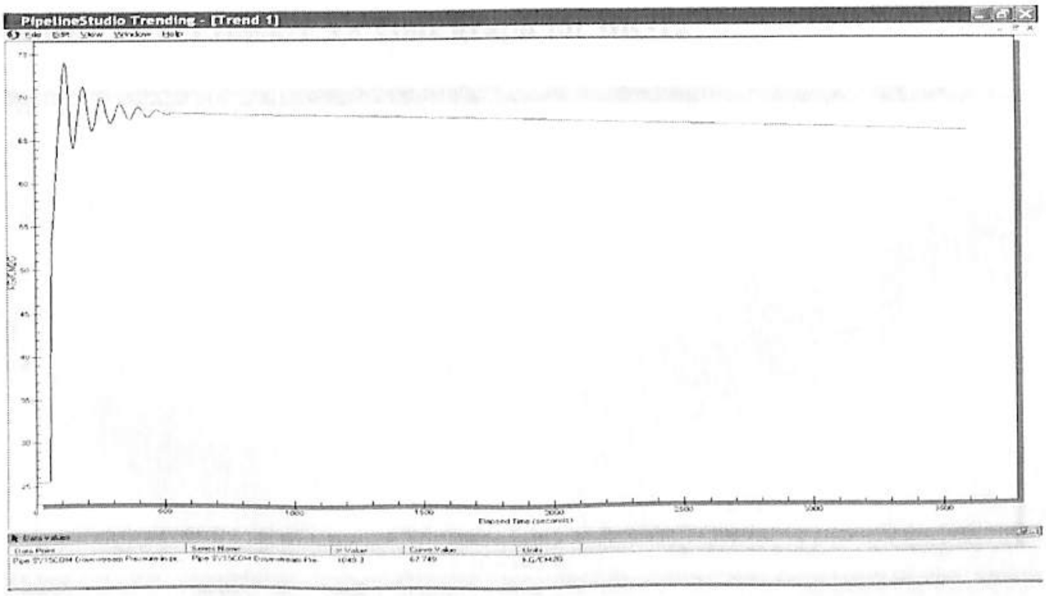


Fig 27

Upstream Pressure Vs Time graph for BK-12

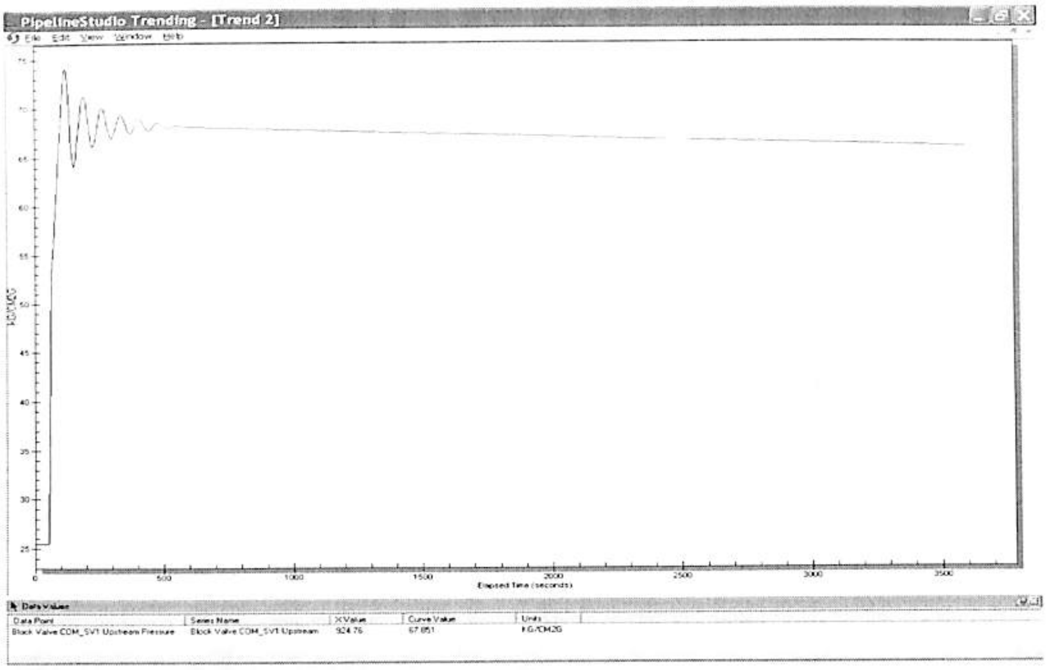


Fig 28

Downstream Pressure Vs Time graph for BK-12

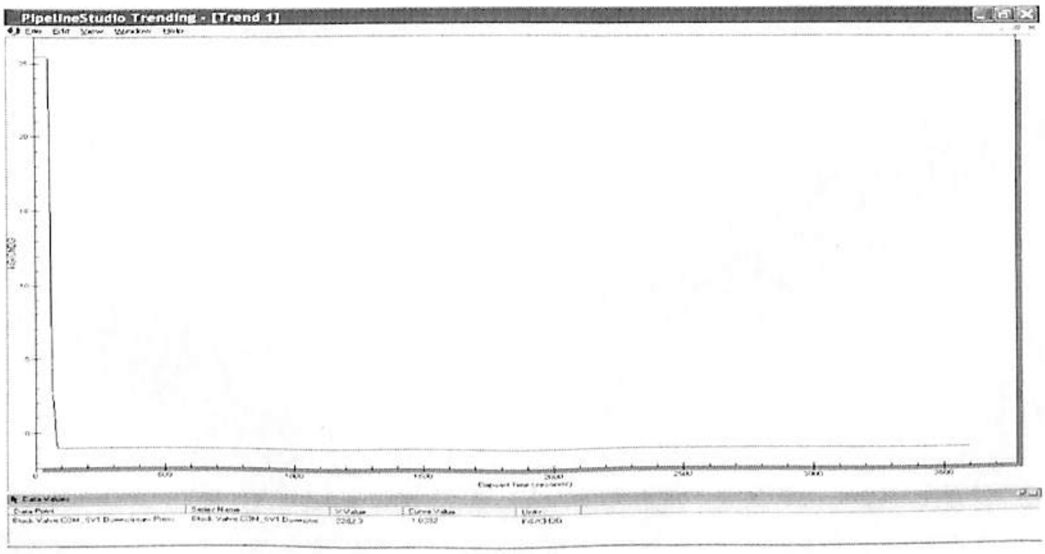


Fig 29

Accumulated volume Vs Time graph for BK-12:

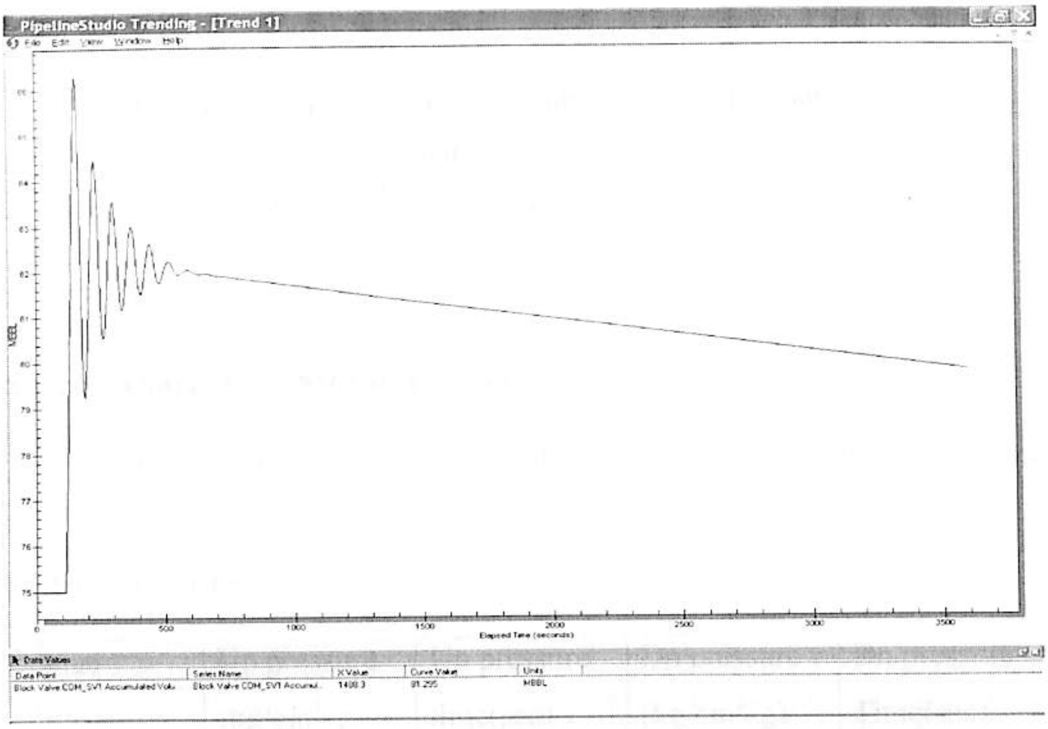


Fig 30

Surge analysis scenario for ESD at block valve BK-10:

The surge analysis scenario is used for running the transient simulation is given below:

	Device type	Name	Set point	units	Initial	60	3600
1.	Block valve	BK-10	% open	percent	100	0	0

Surge scenario for ESD valve closure:

The ESD valve BK-10 delivery end is closed after 60 seconds and it continues to remain close till 1 hour.

SURGE RESULTS

Device	Up pressure (kg/cm^2 g)	Up pressure time(sec)	Dn pressure (kg/cm^2 g)	Dn pressure Time(sec)
PL-11	82.939	130	83.017	133.7
BK-10	82.017	130.77	29.162	40

Upstream Pressure Vs Time graph for PL-11:

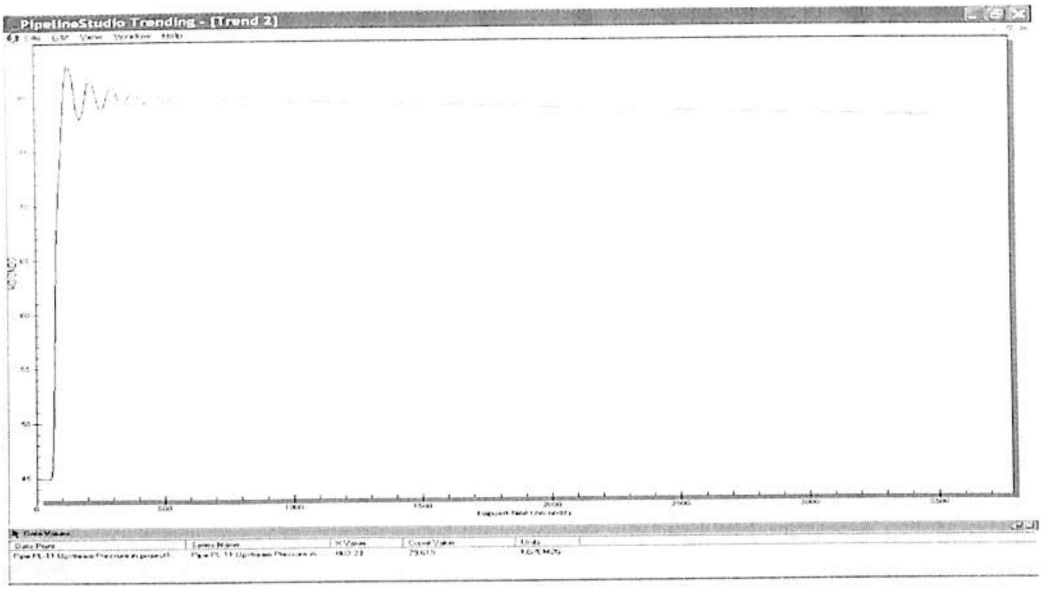


Fig 31

Downstream Pressure Vs Time graph for PL-11

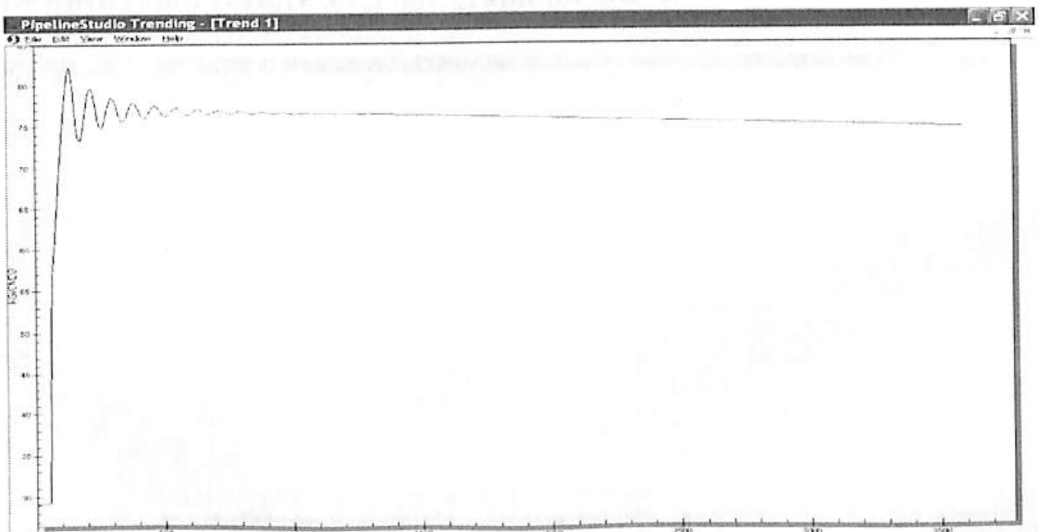


Fig 32

Upstream Pressure Vs Time graph for BK-10

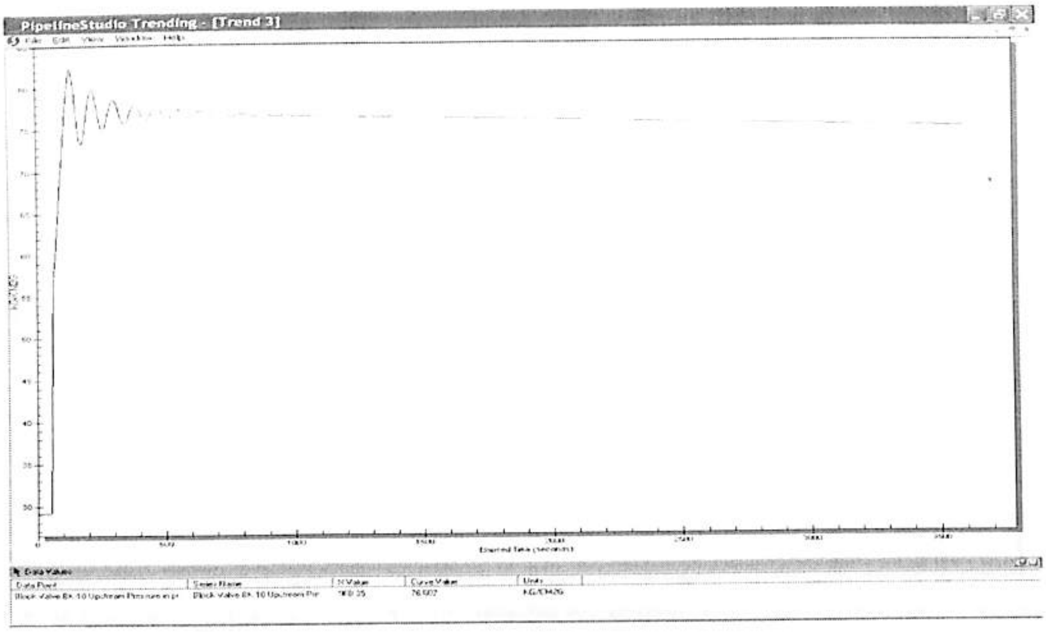


Fig 33

Downstream Pressure Vs Time graph for BK-10

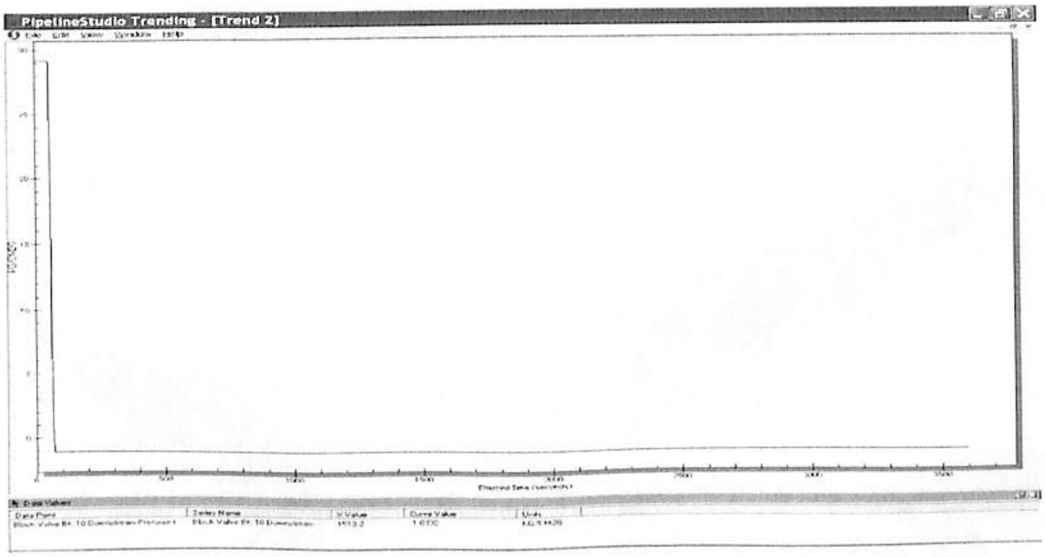


Fig 34

Accumulated volume Vs Time graph for BK-10:

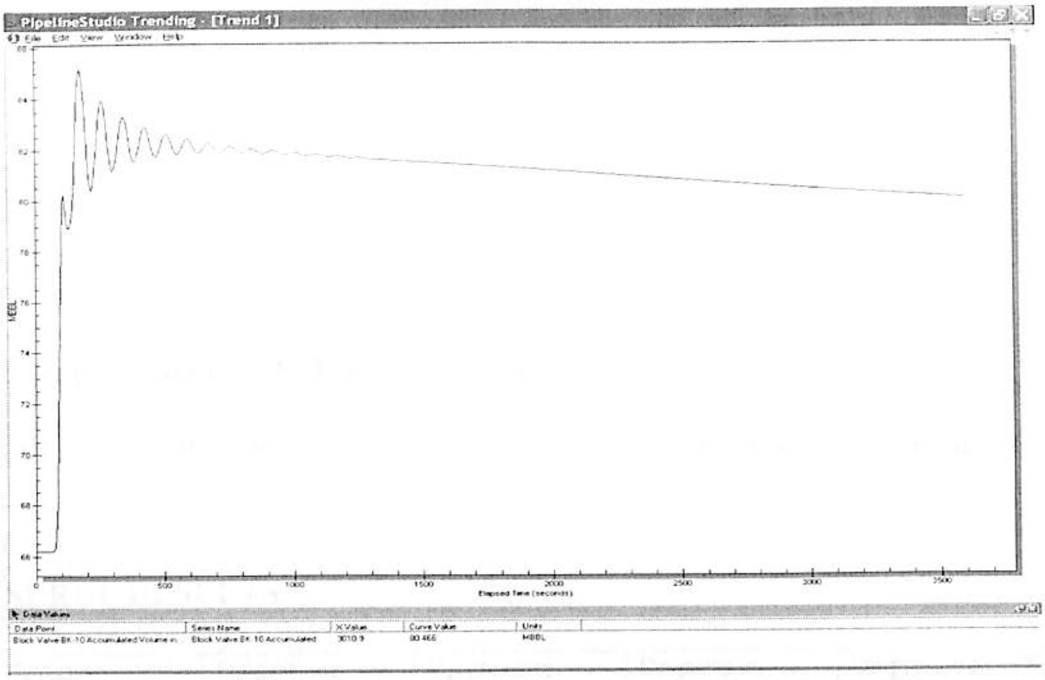


Fig 35

Surge analysis scenario for ESD at block valve BK-7:

The surge analysis scenario is used for running the transient simulation is given below:

	Device type	Name	Set point	units	Initial	60	3600
1.	Block valve	BK-7	% open	percent	100	0	0

Surge scenario for ESD valve closure.

The ESD valve BK-7 delivery end is closed after 60 seconds and it continues to remain close till 1 hour.

SURGE RESULTS

Device	Up pressure (kg/cm^2 g)	Up pressure time(sec)	Dn pressure (kg/cm^2 g)	Dn pressure Time(sec)
PL-7	75.4547	2220	74.99	40
BK-7	80.18	1569.3	75.241	1385.6

Upstream Pressure Vs Time graph for PL-7

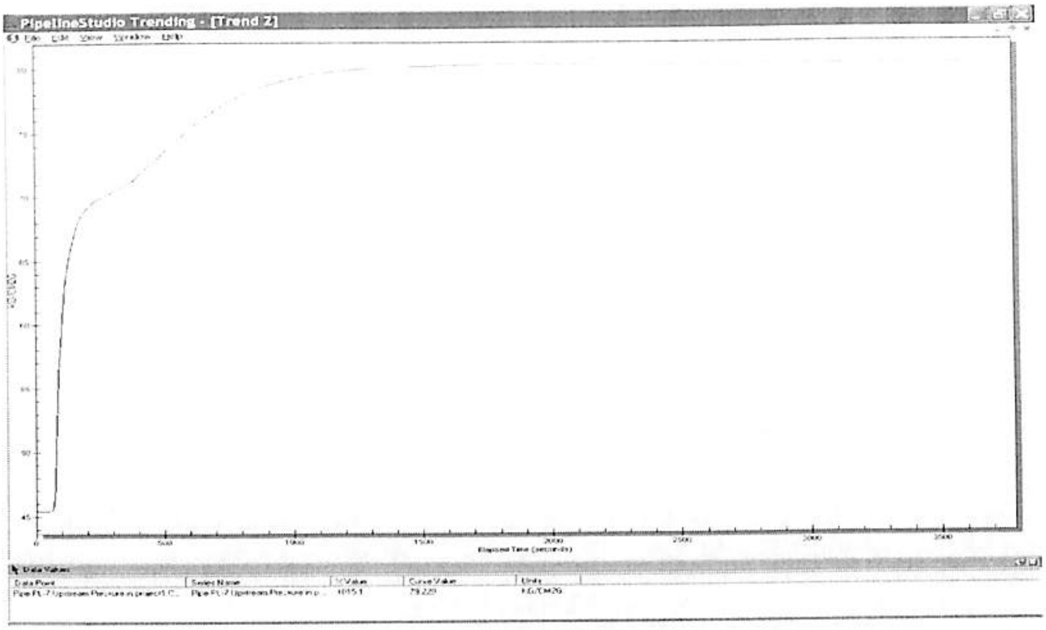


Fig 36

Downstream Pressure Vs Time graph for PL-7

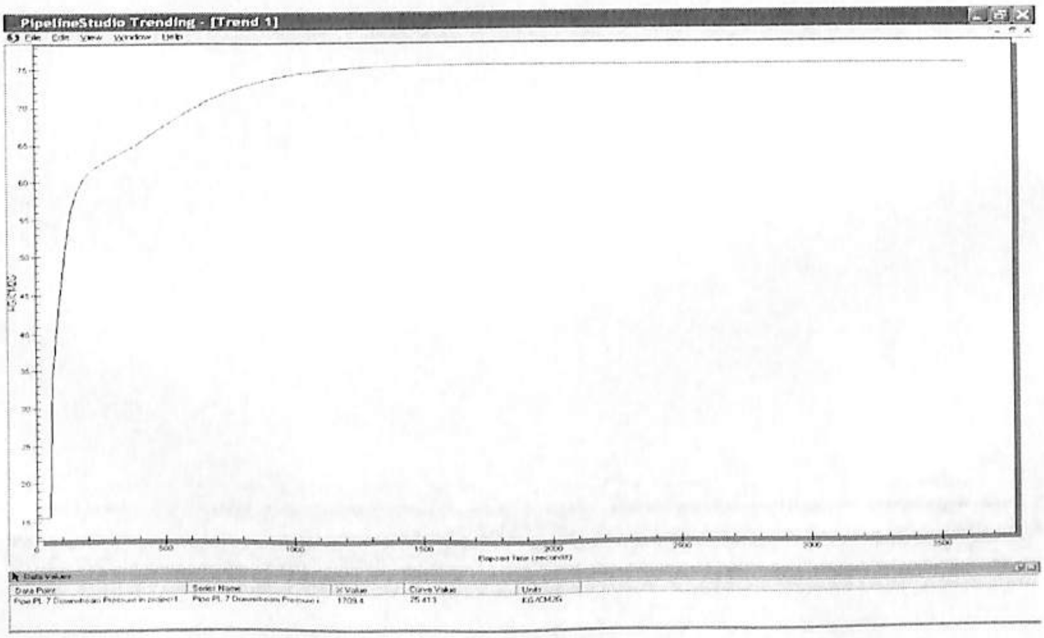


Fig 37

Upstream Pressure Vs Time graph for BK-7

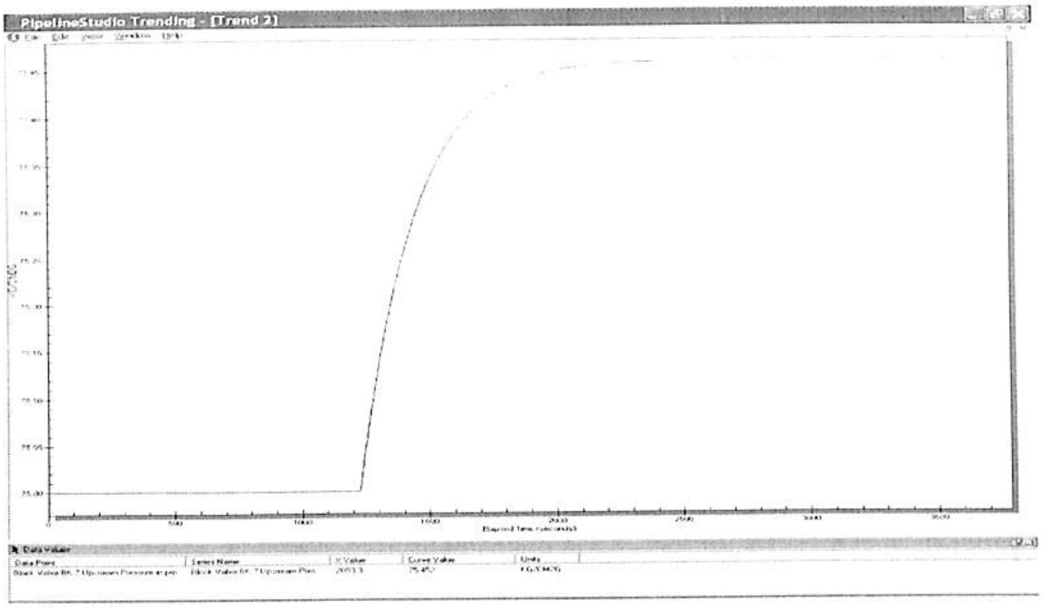


Fig 38

Downstream Pressure Vs Time graph for BK-7

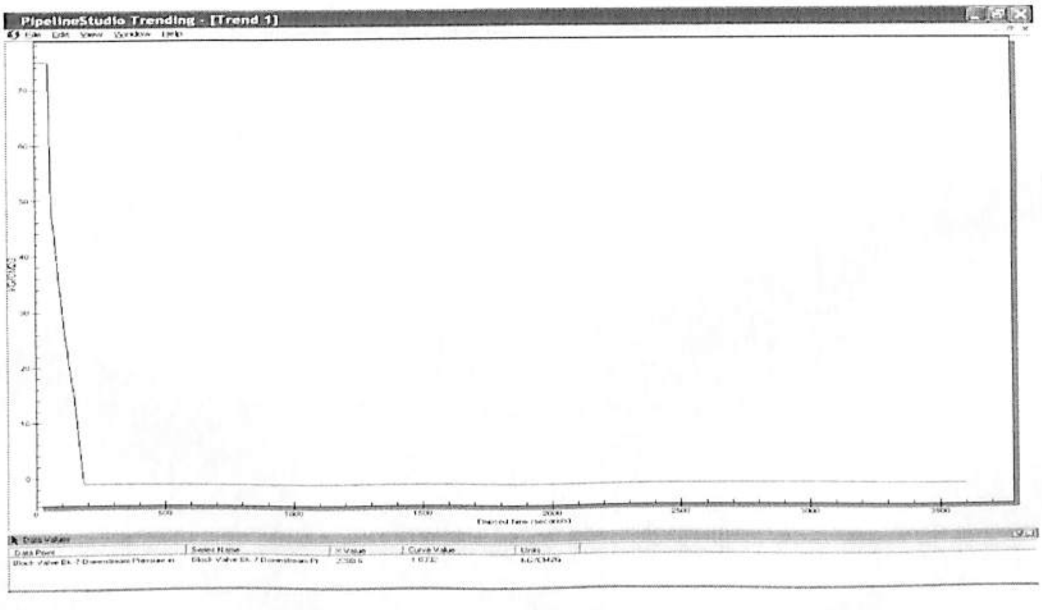


Fig 39

Accumulated volume Vs Time graph for BK-7

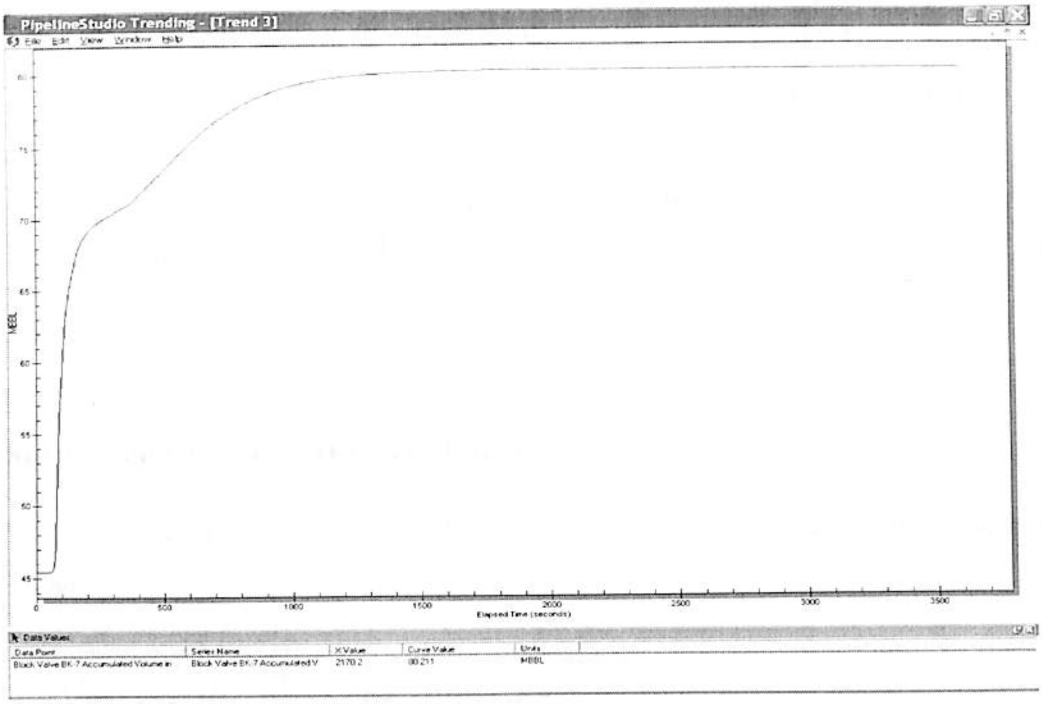


Fig 40

Surge analysis scenario for ESD at block valve BK-4:

The surge analysis scenario is used for running the transient simulation is given below:

	Device type	Name	Set point	Units	Initial	60	3600
1.	Block valve	BK-4	% open	percent	100	0	0

Surge scenario for ESD valve closure.

The ESD valve BK-4 delivery end is closed after 60 seconds and it continues to remain close till 1 hour.

SURGE RESULTS

Device	Up pressure (kg/cm^2 g)	Up pressure time(sec)	Dn pressure (kg/cm^2 g)	Dn pressure Time(sec)
PL-3	90.0301	120	96.1656	125
BK-4	96.1656	125	30.9280	40

Upstream Pressure Vs Time graph for PL-3

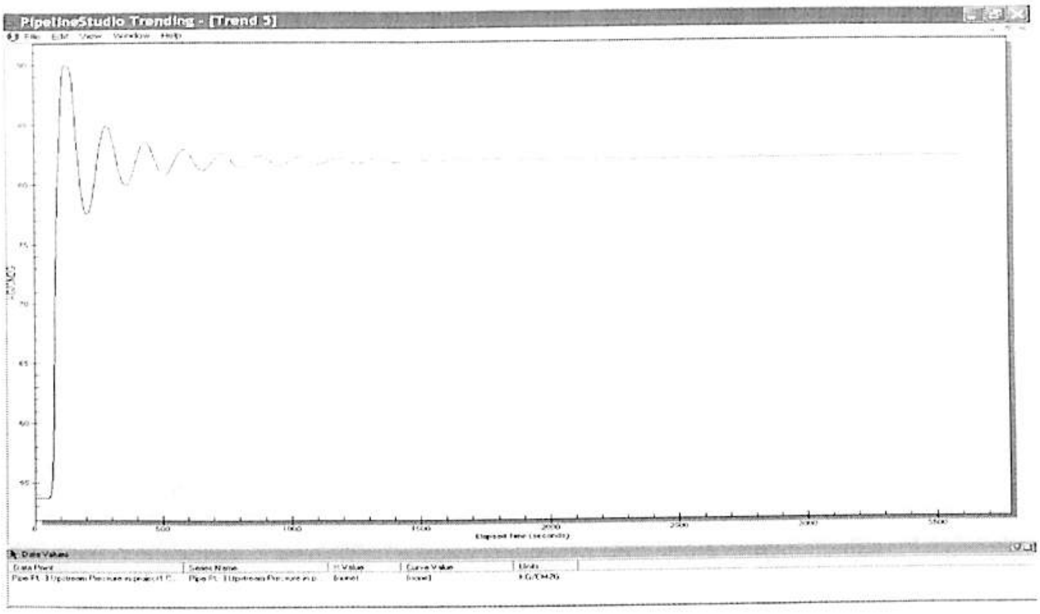


Fig 41

Downstream Pressure Vs Time graph for PL-3

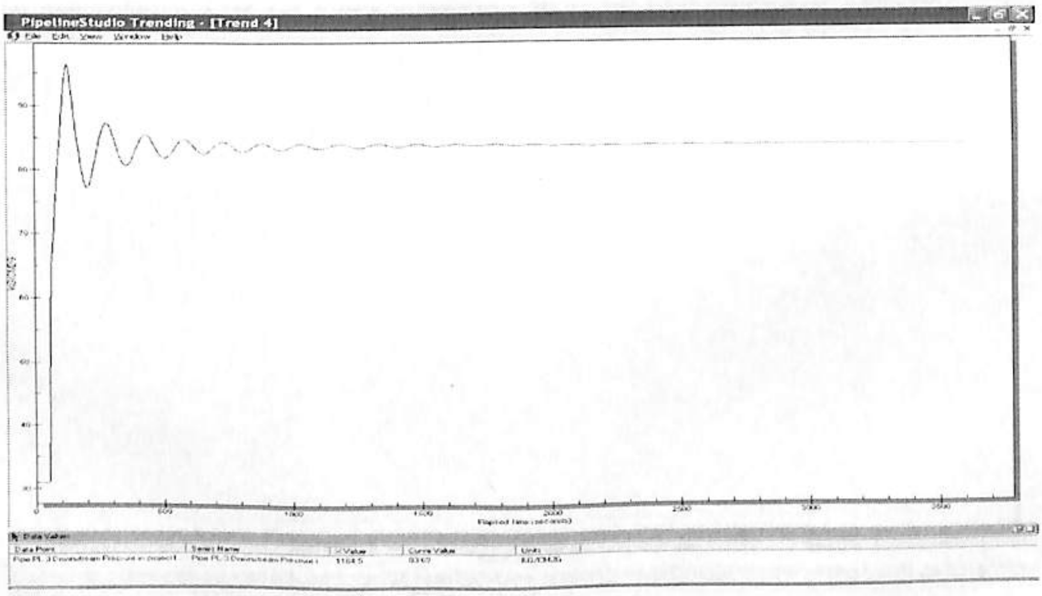


Fig 42

Upstream Pressure Vs Time graph for BK-4

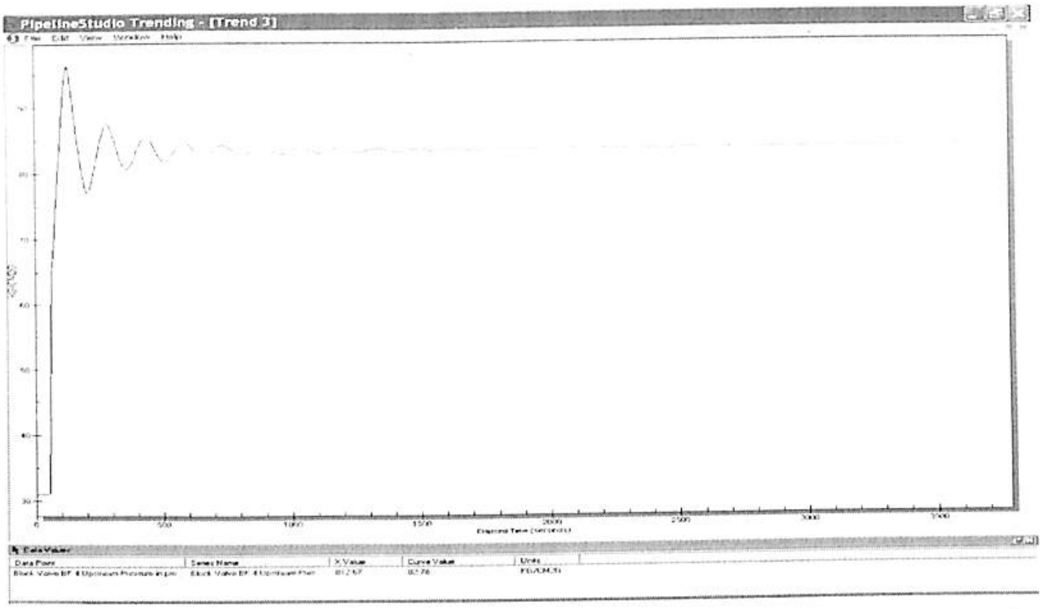


Fig 43

Downstream Pressure Vs Time graph for BK-4

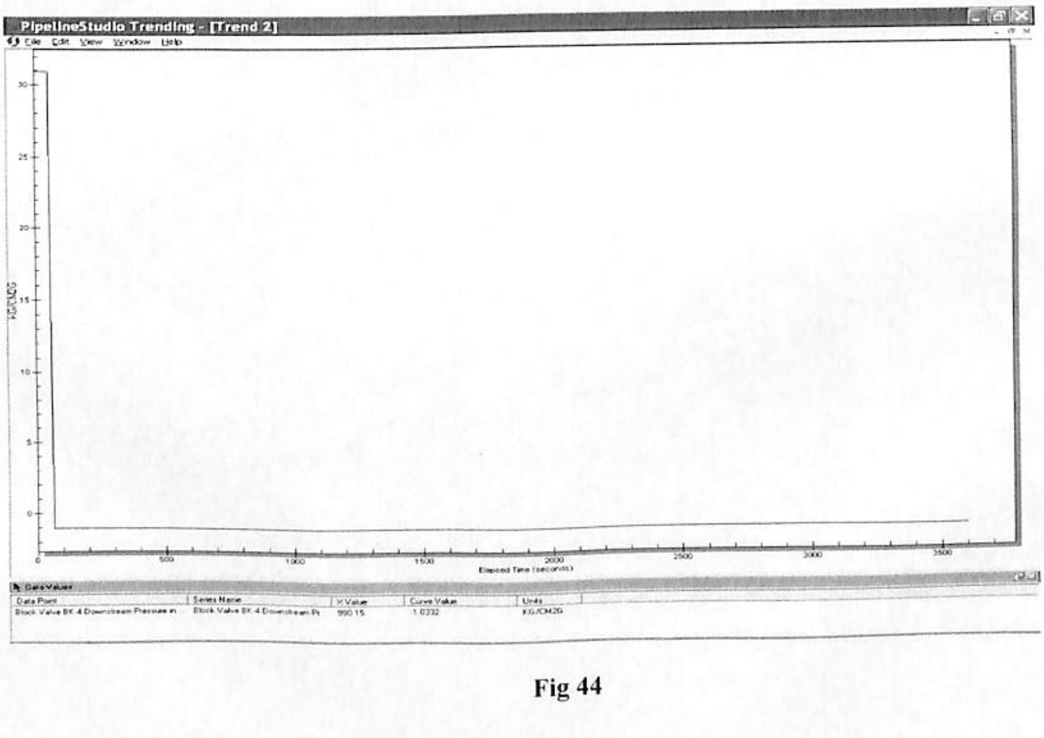


Fig 44

Accumulated volume Vs Time graph for BK-4

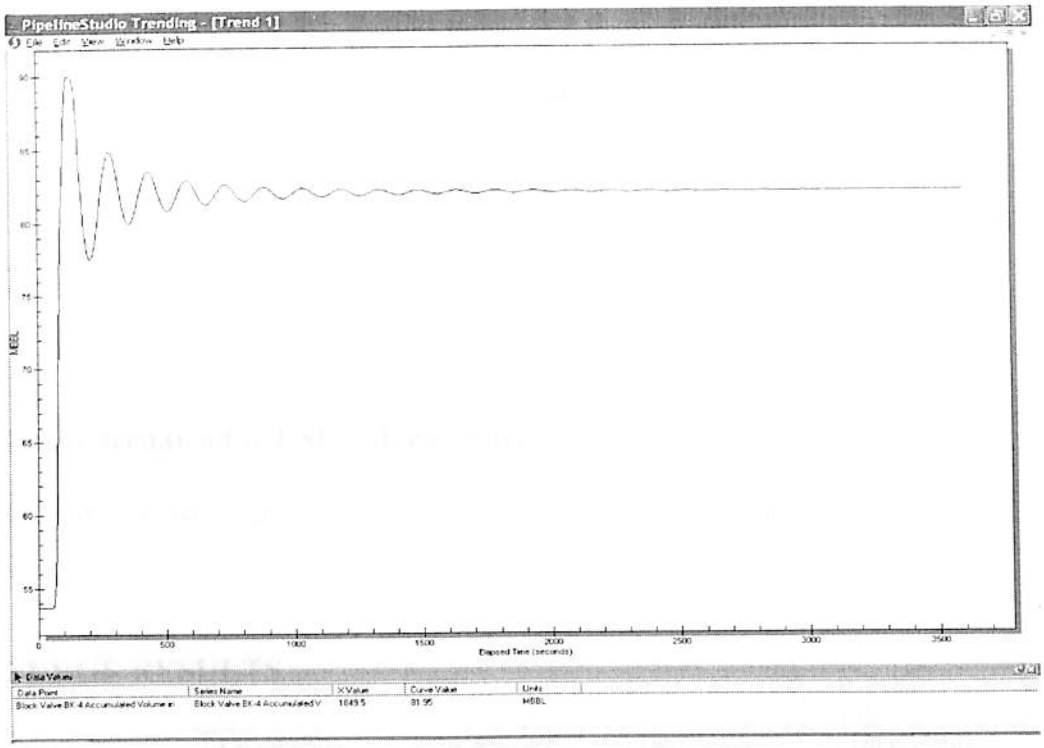


Fig 45

Surge analysis scenario for ESD at block valve BK-2:

The surge analysis scenario is used for running the transient simulation is given below:

	Device type	Name	Set point	units	Initial	60	3600
1.	Block valve	BK-2	% open	percent	100	0	0

Surge scenario for ESD valve closure.

The ESD valve BK-2 delivery end is closed after 60 seconds and it continues to remain close till 1 hour.

SURGE RESULTS

Device	Up pressure (kg/cm^2 g)	Up pressure time(sec)	Dn pressure (kg/cm^2 g)	Dn pressure Time(sec)
PL-1	84.005	80	99.4	65.12
BK-2	99.998	66.129	67.15	40

Upstream Pressure Vs Time graph for PL-1

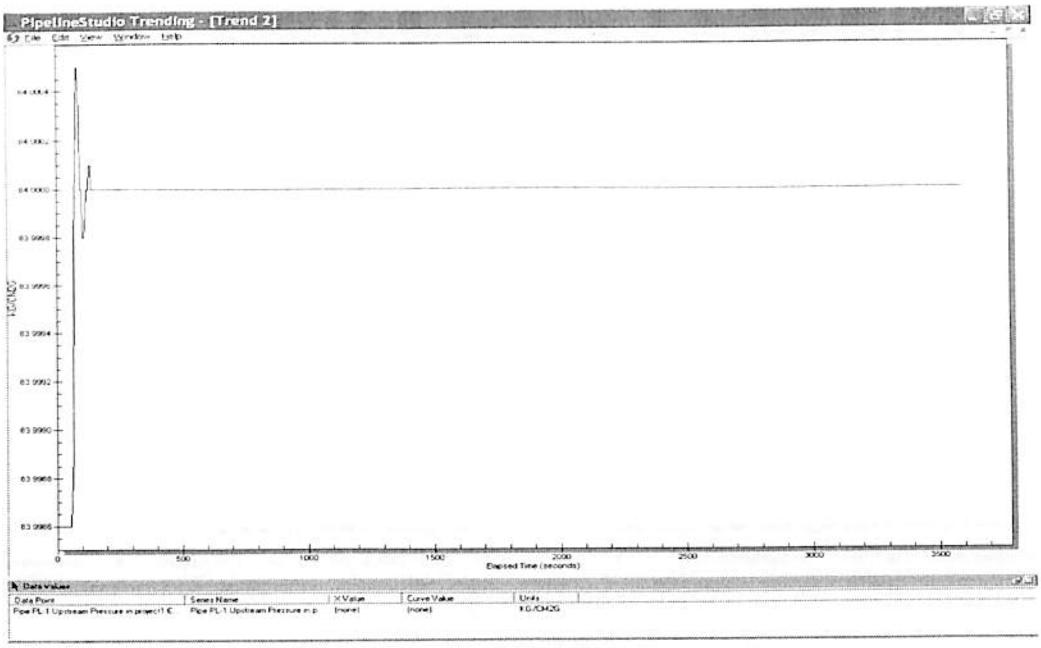


Fig 46

Downstream Pressure Vs Time graph for PL-1

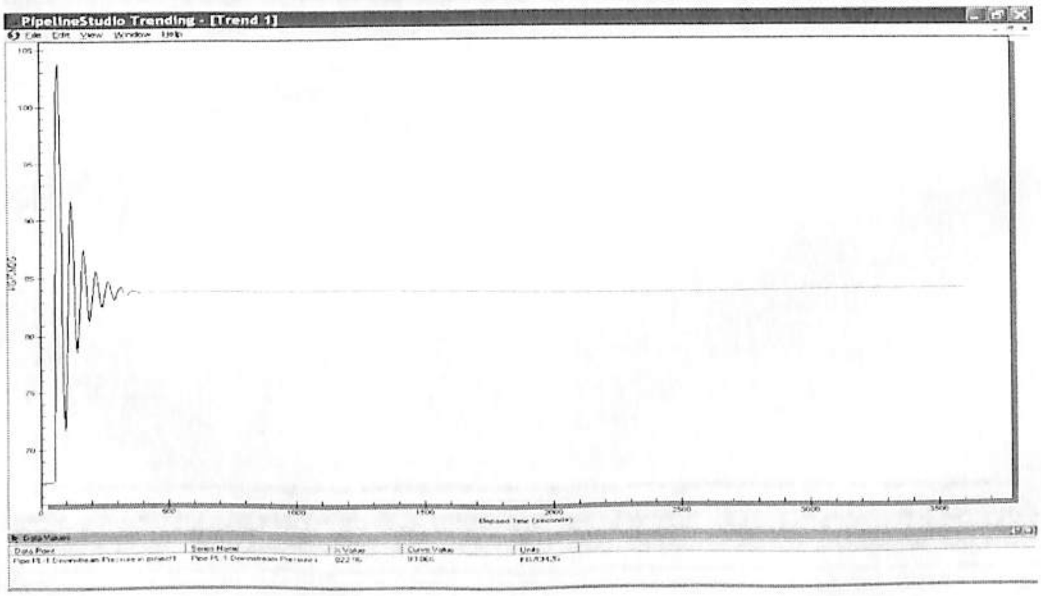


Fig 47

Upstream Pressure Vs Time graph for BK-2

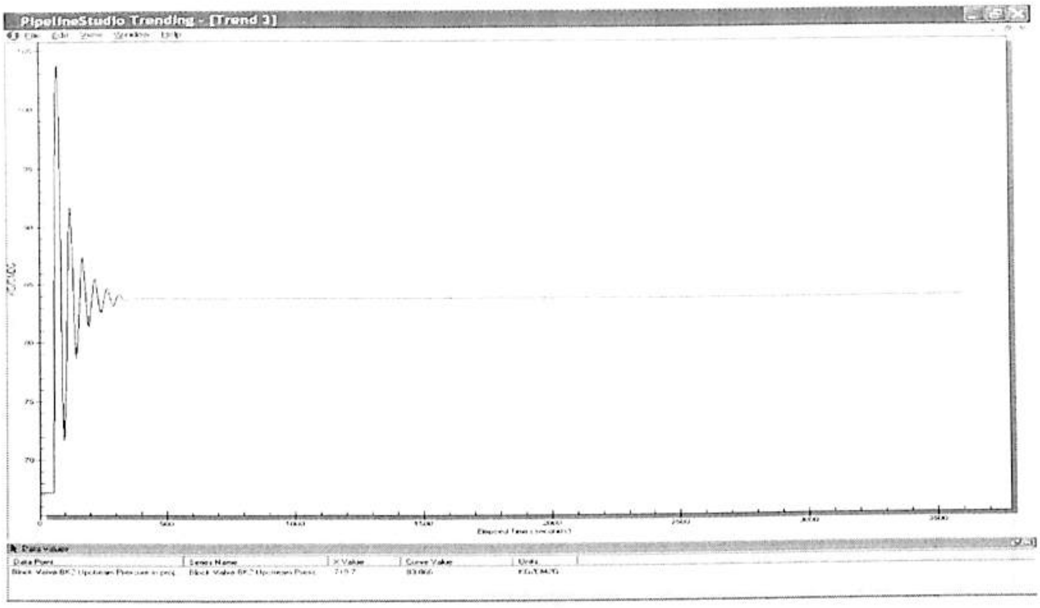


Fig 48

Downstream Pressure Vs Time graph for BK-2

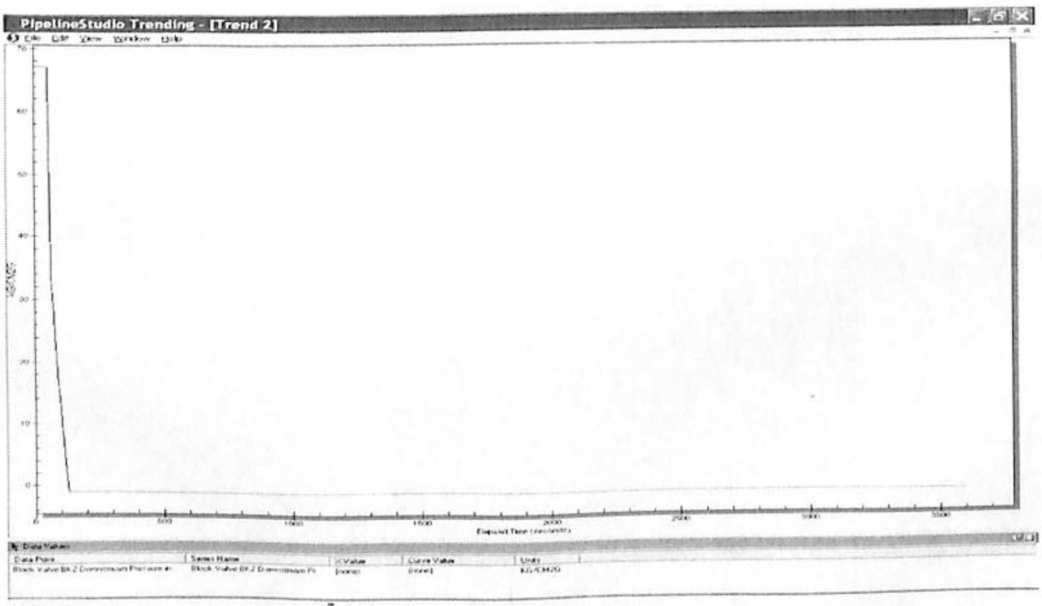


Fig 49

Accumulated volume Vs Time graph for BK-2

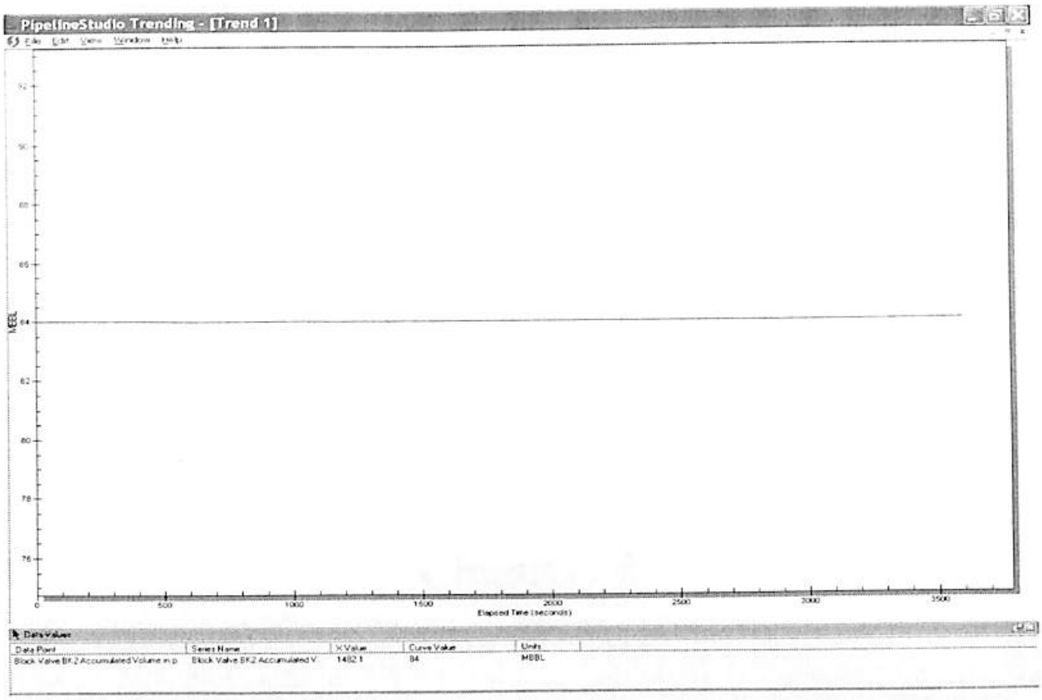


Fig 50

Chapter: 5

RESULTS AND DISCUSSION

5. RESULTS:

5.1 Case-1: By closing sectionalizing valves one after the other from the delivery end to supply end.

Sr. No.	Case no.	Valve station closed	MAOP kg/cm^2g	MAOP violated
1	Case 1	BK-17	49.5	YES
2	Case 2	BK-15	49.5	YES
3	Case 3	BK-12	84	-----
4	Case 4	BK-10	84	-----
5	Case 5	BK-7	84	-----
6	Case 6	BK-4	99.5	-----
7	Case 7	BK-2	99.5	-----

Case no.	Relief valve distance from supply (km)	Volume delivered MBBL
Case 1	292.189	2.61381
Case 2	216.458	1.14012

Table 6

5.2 Case-2: By introducing sectionalizing valve at deliveries one after the other from the delivery end to supply end.

Case no.	Delivery	Valve station closed	MAOP kg/cm^2g	Pipe press kg/cm^2g	MAOP violated	Acc. Vol. MBBL	Valve distance Km
1	D-6	BK-17	84	72.6593	NO	3.97510	500.189
2	D-5	BK-15	49.5	69.0465	YES	0.06929	292.189
3	D-4	BK-12	99.5	85.6610	NO	2.42158	982.597
4	D-3	BK-10	99.5	34.2868	NO	2.51592	472.579
5	D-2	BK-7	84	25.4491	NO	0	182.597
	D-2	BK-4	84	65.8792	NO	0	182.597
6	D-1	BK-2	84	31.9271	NO	1.35851	205.597

Case no.	Relief valve distance from supply (km)	Volume delivered MBBL	Pipe pressure after introducing relief valve (kg/cm^2g)
Case-2	292.189	2.61388	41.0235

Table 7

5.3 DISCUSSION AND ANALYSIS

As described in the preceding sections, hydraulic and surge states of a cross-country pipeline is conducted. In this project by running steady state simulation on given pipeline network and given conditions, MAOP of different pipes is being obtained.

After getting MAOP from steady state results, we have closed sectionalizing valves one after other from delivery end to supply end. By giving scenario table for the valve closure and putting the values of MAOP for the pipe in sectionalizing valve HI-HI alarm and Low –Low alarm, we obtained the surge pressure in pipeline, in sectionalizing valves and also calculated time period at which the upstream and downstream pressure exceeds the value of MAOP.

The purpose of this study is that if the pipe upstream pressure will exceeds the value of MAOP, the pipe will burst and leakage will occur. To overcome this problem relief valve at pressure below MAOP is being configured.

Chapter: 6

CONCLUSION AND RECOMMENDATION

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion:

From the study, it was concluded that the pressure values are normal under the steady state conditions. However, the surge pressure values will exceeds the MAOP value when the sectionalizing valves are closed at the delivery end i.e. at transient conditions.

Since surge pressures exceed the MAOP, relief valves are configured at a distance of 292.189km and 216.458km. The surge pressure in this case will not exceed the allowable pressure. In the transient state study, after closing the sectionalizing valve, the time period at which upstream pressure of pipe exceeds the MAOP value is calculated.

6.2 Recommendations:

Surge mitigation by using surge relief valve is very costly method. So it is better to follow some design precautions and design criteria during the design of pipeline before installation.

1) Stronger Pipe work to Withstand Pressure Surges: Pipe work can be designed to withstand the damaging effects of pressure surges. Increase in pipe wall thickness, flange rating and pipe supports can be designed to withstand pressure surges.
2) Although a more costly method of mitigating transient pressures, once installed higher class pipe work does not require further maintenance and testing as other mitigation devices require.
3) Increased Diameter of Pipeline: Increase the diameter of the pipeline the immediate effect is to reduce the surge pressures.
4) Valve Opening and Closing Times: A common form of surge pressure initiation has been the rapid closing of a valve. So that there should be two stage closing process whereby the valve is closed to a 15-20% open position rapidly and then the last closure is over an extended period. Similarly the valve opening should be a two stage process.

BIBLIOGRAPHY

1) Theoretical overview of surge analysis by S J VAN VURREN. University of Pretoria.
2) Pipeline Rules of Thumb Handbook; page no 313-337. sixth edition. Gulf publishing company 1993.
3) Keech, Andrew. The engineering significance of Pressure surges.
4) Waters. Gary Z. Analysis and control of unsteady flow in pipeline, Butter worth's publishers, 1984.
5) ASME B31.8-1999 edition, Gas transmission and distribution piping systems.
6) ASME B31.4-2002 Liquid pipeline transportation systems for liquid hydrocarbons and other liquids.
7) Surge Analysis for Water Injection Systems in the Offshore Oil & Gas Industry by Flow master Group 2009.
8) Cavitation and bubble dynamics by Christopher E. Brennen.
9) An introduction to liquid pipeline surge relief.
10) Introduction to Fluid Mechanics Prof Nakayama & RF Boucher.
11) Dynamic performance of Air Valves BHRA Group 2004 International conference on Pressure Surges.
12) Kroon, J. R., M. A. Stoner, and W. A. Hunt. 1984. "Water Hammer: Causes and Effects."Journal of the American Water Works Association. 76: 39–45.
13) Parmakian, J. 1963. Water hammers Analysis Dover Publications.
14) Sharp, B.B. and D. B. Sharp. 1996. Water Hammer: Practical Solutions. New York: Halsted Press.
15) Weis, F. 1996. "Dispelling Common Misconceptions about Water Hammer." Water Engineering and Management. 143: 24–30.
16) Water hammer T. Webb & BW Gould Water hammers Mitigation.
17) www.pipelineandgasjournalonline.com
18) Pipeline studio help topics

Software used: Pipeline studio 3.2.5.6

APPENDIX-1

APPENDIX-2

This appendix attached. lists a number of National Codes. Standards and Industry references where specific requirements to consider surge are provided.

Standards & Codes

A particular industry may use other international standards for the design of their piping systems. These will require that occasional loads. surges or hydraulic transients are taken into account in designing the systems. Common standards used in industries are listed below and all require the designer take into account occasional unsustained loads arising from surge events:

International Standards:

Power Piping	**ASME B31.1**
Process Piping	**ASME B31.3**
Pipeline Transportation Systems for Hydrocarbons and other Liquids	**ASME B31.4**
Pipeline Transportation Systems for Gases	**ASME B31.8**
Refrigeration and Heat Transfer Components	**ASME B31.5**
Building Services Piping	**ASME B31.9**
Slurry Transportation Piping Systems	**ASME B31.11**
Glass-reinforced plastics (GRP) piping	**ISO 14692-3**
Design & Construction of GRP Pip	**BS 7159**
AWWA Fiberglass Pipe	**ANSI/AWWA C95**