Pipeline and Hazardous Materials Safety Administration
Docket Number PHMSA 2008-2085
TransCanada Keystone Pipeline, L.P.
Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to Concerned Citizens of Eastern Montana Comment 2008-0285-009.1

Pipelines are one of the safest forms of crude oil transportation and provide a cost effective and safe mode of transportation for oil on land. Overland transportation of oil by truck or rail produces higher risk of injury to the general public than the proposed pipeline (USDOT 2002).

The Keystone XL Pipeline system will be designed, constructed and maintained in a manner that meets or exceeds industry standards. Historically, the most significant risk associated with operating a crude oil pipeline is the potential for third-party excavation damage. The pipeline will be built with deeper cover than standard requirements and within an approved right-of-way (ROW). Warning signs will be installed at all road, railway, and water crossings. Keystone will mitigate third-party excavation risk by implementing a comprehensive Integrated Public Awareness program focused on education and awareness in accordance with 49 CFR 195.440 and API RP1162.

Further, Keystone will complete and document regular visual inspections of the ROW as per 49 CFR 195.412 and monitor activity in the right-of-way to mitigate unauthorized trespass or access. Keystone will have maintenance, inspection, and repair programs that maximize the integrity of its pipeline. Keystone's annual Pipeline Maintenance Program (PMP) will include routine aerial patrol of the ROW, periodic inline inspections and cathodic protection system readings to ensure facilities are reliable. Data collected in each year of the PMP will be fed back into the decision making process for the development of the following year's program. In addition, the pipeline system will be remotely monitored 24 hours a day, 365 days a year from the oil control center using leak detection systems and supervisory control and data acquisition (SCADA). Prior to operation, Keystone will have an Emergency Response Program in place to manage a variety of events in accordance with 49 CFR 194.

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Docket Number PHMSA 2008-2085
TransCanada Keystone Pipeline, L.P.
Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to Mr. Earnest Fellows Comment 2008-0285-0013

April 3, 2009

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1. "why not have it above ground where we can see a leak sooner"

Keystone Response: In accordance with 49 CFR 195.248(a), all pipe must be buried so that it is below the level of cultivation. Keystone XL pipeline will be equipped with a leak detection system as described in section 2.9 of the Application. The system will be designed in accordance with 49 CR 195.444 and API 1130.

2. "the oil in the pipe will be heated"

Keystone Response: The product transported will not be heated or treated once it enters the pipeline system.

3. "108^{o} and up will kill grass"

Keystone Response: TransCanada Keystone conducted a thermal study for the Keystone pipeline currently under construction and is attached for reference. A similar study is underway for the Keystone XL pipeline. It is anticipated based on the work done in the previous studies (filed with the Department of State); the operations of this pipeline will not result in significant overall effects to the surficial soil temperatures, crops and vegetation.

4. "Keystone wants to raise the pump pressure to 1660 lbs per sq in"

Keystone Response: TransCanada Keystone it is not requesting an increase to the maximum operating pressure of the pipeline. At maximum throughput the pipeline will operate with pump station discharge pressures of no higher than 1440 psig.

5. "Maybe Keystone needs a pump every 10 miles at 550 lbs instead of every 60 miles"

Keystone Response: Pump station locations depend on factors such as local infrastructure (for access and power), pipeline hydraulics and the analysis of frictional losses related to oil flow.

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Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to Pipeline Safety Trust Comment 2008-0285-008.1

April 3, 2009

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1. "Reporting of Over-pressurization Events - all exceedances of 110% of MOP as described in 49 CFR 195.55 (a) (4) should be required to be reported to PHMSA as required in 49 CFR 195.56 without exception…"

Response:

TransCanada Keystone believes the requirements of 49 CFR §191.23(5) address this concern.

2. "Elimination of over-pressure failure possibility caused by SCADA operator - provide an analysis to PHMSA that shows that under their operating plans their SCADA operators will not have the ability to take actions that would cause the pipeline to exceed the allowed pressure as defined in 49 CFR 195.406…"

Response:

TransCanada Keystone believes the requirements in Condition 26, 27 and 30 of the Keystone Pipeline Special Permit (the design bases for the Keystone XL pipeline) address this concern.

3. "Require 100% of the girth welds to be inspected with nondestructive methods - 100% nondestructive inspection of girth welds be required as part of this special permit, and that the inspection records be required to be kept during the life of the pipeline…"

Response:

Please refer to Application page 12 Section 2.4. TransCanada Keystone will inspect 100% all girth welds. In accordance with 49 CFR § 195.266, a complete record showing the total number of girth welds and the number nondestructively tested, including the number rejected and the disposition of each rejected weld must be maintained by the operator involved for the life of the facility.

4. "Proper Surge Pressure Analysis and Protections - PHMSA is provided a comprehensive surge pressure analysis to review to ensure that surge has been properly engineered for and that protections are well designed and placed…"

Pipeline Safety Trust Response

Response:

TransCanada Keystone will conduct a surge study as part of the Keystone XL detailed design phase. The surge analysis will be consistent with those already undertaken for the Keystone pipeline.

5. "Internal Corrosion Program – To ensure added protection at these increased operating pressures we ask that PHMSA as part of this special permit require the use of cleaning pigs at regular intervals, (to be determined by PHMSA), with proper analysis of the material removed by the cleaning pigs, be added to the pipeline's overall corrosion protection program…"

Response:

TransCanada Keystone believes the requirements in Condition 35 of the Keystone Pipeline Special Permit (the design basis for the Keystone XL pipeline) address this concern.

6. "Incorporation of Additional Safeties - all of these additional safety items that go beyond current regulatory requirements, which PHMSA finds to be consistent with pipeline safety, be incorporated as requirements of this special permit…"

Response:

As discussed with PHMSA, TransCanada Keystone design basis for the Keystone XL pipeline is the Keystone Pipeline Special Permit conditions, which exceed current regulatory requirements.

7. "**Pipelines and Informed Planning Alliance (PIPA) Recommended Practices –** TransCanada to incorporate the final recommended practices from the PIPA that apply to pipeline operators into their public education program, and that measurement of the use of these practices be incorporated into the measurement requirements of their 1162 program…"

Response:

TransCanada Keystone is a participant of the PIPA and will review the final recommended practices for applicability to the Keystone XL project and will incorporate them if applicable into its Integrated Public Awareness Program.

General:

TransCanada Keystone it is not requesting an increase to the maximum operating pressure of the pipeline. At maximum throughput the pipeline will operate with pump station discharge pressures of no higher than 1440 psig.

Paragraph #4 Response:

Please refer to Keystone XL Special Permit Application page 23. "Under Section 60118 of the *Pipeline Safety Act*, PHMSA may grant a special permit in relation to any regulatory requirement if granting the waiver is "not inconsistent with pipeline safety." 49 U.S.C. § 60118. The special permit that Keystone seeks in this petition is not inconsistent with pipeline safety. As demonstrated in the chart included in Appendix D, the standards that Keystone will use to design, construct and operate the Keystone XL Pipeline will meet or exceed the requirements of DOT regulations and will result in a higher degree of pipeline safety than the minimum safety standards provided in the regulations."

Bullet #1 Response:

In certain areas, the pipeline will be subject to additional risks of potential damage. For instance, above-ground facilities must be able to withstand greater variations in temperature than below-ground facilities. Pipe pulled or pushed through the ground in drilling or boring operations (below roads, railroads and navigable waterways) must be able to withstand the additional stresses caused by those activities. And, in more heavily populated areas, where other underground utilities – such as water, sewer, natural gas, electric and telecommunications facilities – are prevalent, additional mitigation beyond increased depth of cover is required to maintain pipeline safety.

Because it is difficult to demonstrate increased protection from the additional risks in these areas, TransCanada has not sought to apply the updated standard where they may occur. The result is a pipe that has safety characteristics appropriate to mitigate risk of failure in both urban and rural areas, below waterways and below fields, over valuable aquifers and in established industrial areas.

Bullet # 2 Response:

The Keystone XL pipeline will be outfitted with Pressure Control and Over-Pressure Protection Systems which provide two independent levels of protection for the pipeline and associated facilities. The Pressure Control System primarily keeps the pump station discharge pressures within acceptable boundaries under MOP by modulating one pump speed at each pump station, complemented with protective logic that takes corrective action when pump station discharge pressures move outside of acceptable boundaries. The Pressure Control System is designed to be reliable and failsafe. In addition, the Over-Pressure Protection System provides a second level of protection from an over-pressure condition (up to 110% MOP) derived from sudden events such as a single station outage or system-wide shut-down.

Bullet #3 Response:

Please refer to Application page 12 Section 2.4. TransCanada Keystone will inspect 100% of all girth welds. In accordance with 49 CFR § 195.266, a complete record showing the total number of girth welds and the number nondestructively tested, including the number rejected and the disposition of each rejected weld must be maintained by the operator involved for the life of the facility.

In addition, PHMSA conducted 20 separate site visits to the Keystone pipeline construction in 2008 where welding, inspection and other construction activities were observed. The circumference of each field weld is 100% inspected as dictated in the TransCanada specification.

Bullet #4 Response:

Keystone XL will transport crude oils similar to those already being transported by other major cross border oil pipeline systems into the United States. The commodity specification is outlined in the Keystone XL Special Permit Application, Appendix G Clause 1.5 Page 7 & 8. Keystone has evaluated the range of possible products which may be transported and determined it does not meet the sour service criteria defined in NACE MR0175 Part 2 Annex C. Furthermore, please also find attached response to the Department of State data request outlining typical chemical composition of crude oil streams generated from the oil sands.

Bullet #5 Response:

Keystone's proposed depth of cover exceeds all federal requirements. During operations, Keystone will conduct periodic visual inspection of the right-of-way, identify potential areas of concern and remediate them accordingly.

Bullet #6 Response:

Please refer to Keystone XL Special Permit Application Appendix E.

Bullet #7 Response:

All pipe purchased for the Keystone XL pipeline must meet the requirements in API 5L 44th Edition regardless of supplier source (domestic/foreign). All manufacturing mills and steel source suppliers involved in pipe production for the project will undergo a formal prequalification and qualification program. The TransCanada pipe mill qualification process assures that each pipe mill is certified by the API 5L governing body to fabricate steel pipe for pipeline transportation systems. All manufacturers of steel, skelp and pipe must implement a quality management system in conformance with international standards (ISO and API). In addition, Keystone implements continuous surveillance during the entire pipe manufacturing process.

Bullet #8 Response:

Keystone is currently updating the as-filed (with PHMSA) emergency response and oil spill clean up plan in accordance with the requirements in 49 CFR 194 for this pipeline system.

Pipeline and Hazardous Materials Safety Administration
Docket Number PHMSA 2008-2085
TransCanada Keystone Pipeline, L.P.
Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to Western Organization of Resource Councils Comment 2008-0285-007.1

The comments in this submission are reflective of those submitted by the Pipeline Safety Trust and by Sierra Club and Plains Justice. Please refer to the responses prepared for the Pipeline Safety Trust comment 2008-0285-008.1 and for Sierra Club and Plains Justice comment 2008-0285-006.1.

Pipeline and Hazardous Materials Safety Administration
Docket Number PHMSA 2006-26617
TransCanada Keystone Pipeline, L.P.
Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to United Steel Workers Comment 2008-0285-0015.1

General:

TransCanada Keystone it is not requesting an increase to the maximum operating pressure of the pipeline. At maximum throughput the pipeline will operate with pump station discharge pressures of no higher than 1440 psig.

Bullet #1 Response:

The Keystone XL pipeline will be outfitted with Pressure Control and Over-Pressure Protection Systems which provide two independent levels of protection for the pipeline and associated facilities. The Pressure Control System primarily keeps the pump station discharge pressures within acceptable boundaries under MOP by modulating one pump speed at each pump station, complemented with protective logic that takes corrective action when pump station discharge pressures move outside of acceptable boundaries. The Pressure Control System is designed to be reliable and failsafe. In addition, the Over-Pressure Protection System provides a second level of protection from an over-pressure condition (up to 110% MOP) derived from sudden events such as a single station outage or system-wide shut-down. The operations control systems are detailed in Section 2.9 of the Application.

Bullet #2 Response:

Puncture resistance calculations are found in Appendix E of the Keystone XL Special Permit Application. The analysis was performed using the PRCI 244-9729 study "Reliability-based Prevention of Mechanical Damage to Pipelines" and Kiefner "Impact of 80%SMYS Operations on Resistance to Third Party Mechanical Damage".

Bullet #3 Response:

Keystone XL will transport crude oils similar to those already being transported by other major cross border oil pipeline systems into the United States. The commodity specification is outlined in the Keystone XL Special Permit Application, Appendix G Clause 1.5 Page 7 & 8. Keystone has evaluated the range of possible products which may be transported and determined it does not meet the sour service criteria defined in NACE MR0175 Part 2 Annex C.

Keystone has filed with the Department of State data request outlining typical chemical composition of crude oil streams generated from the oil sands, attachment submitted as part of the Sierra Club/Plains Justice 2008-0285-006.1 response to public comment.

USW Comment Response

Bullet #4 Response:

In certain areas, the pipeline will be subject to additional risks of potential damage. For instance, above-ground facilities must be able to withstand greater variations in temperature than below-ground facilities. Pipe pulled or pushed through the ground in drilling or boring operations (below roads, railroads and navigable waterways) must be able to withstand the additional stresses caused by those activities. And, in more heavily populated areas, where other underground utilities – such as water, sewer, natural gas, electric and telecommunications facilities – are prevalent, additional mitigation beyond increased depth of cover is required to maintain pipeline safety.

Because it is difficult to demonstrate increased protection from the additional risks in these areas, TransCanada has not sought to apply the updated standard where they may occur. The result is a pipe that has safety characteristics appropriate to mitigate risk of failure in both urban and rural areas, below waterways and below fields, over valuable aquifers and in established industrial areas.

Bullet #5 Response:

All pipe purchased for the Keystone XL pipeline must meet the requirements in API 5L 44th Edition regardless of supplier source (domestic/foreign). All manufacturing mills and steel source suppliers involved in pipe production for the project will undergo a formal prequalification and qualification program. The TransCanada pipe mill qualification process assures that each pipe mill is certified by the API 5L governing body to fabricate steel pipe for pipeline transportation systems. All manufacturers of steel, skelp and pipe must implement a quality management system in conformance with international standards (ISO and API). In addition, Keystone implements continuous surveillance during the entire pipe manufacturing process.

DEPT OF TRANSPORTATION DOCKETS

09 JUN 30 A 9:39

June 25, 2009

Dockets of Operations
U. S. Department of Transportation
M-30 West Building Ground Floor
Room W12-140
1200 New Jersey Ave., SE
Washington, D. C, 20590

Please help the farmers and ranchers of eastern Montana and not approve the construction of this unsafe crude oil pipeline. If it can't be built right don't build it. The following article will be published in the Billings Gazette Saturday.

Sincerely

Wesley P James
440 N. Ferndale Dr
Bigfork, MT 59911

Keystone Pipeline - Gold Mine or Environmental Disaster for Montana

The Governor wants the pipeline for the jobs, county commissioners want the pipeline for the property taxes and local businesses want the pipeline for the economic activity generated by the construction and operation of the pipeline.

The proposed 36-inch diameter, pipeline will operate at a pressure of 1500 psi or about twice the pressure of most crude oil pipelines and about 25 times the pressure in a city water distribution system. A fire hose connected to a city water supply can spray water a distance of 200 ft while a break in the pipeline could in theory spray oil a distance of 25 times 200 or 5000 ft. If a valve in the pipeline is closed too rapidly, a 300 psi pressure surge will be generated and the total pressure in the pipeline will be 1800 psi. Pipeline safety regulations require that the wall thickness be 0.748 inch. The Keystone pipeline proposed for eastern Montana will have a wall thickness of 0.465 inch or about half that required by regulation. At a pressure of 1800 psi and a wall thickness of 0.465 inch, stress in the pipeline will be 70,000 psi which is equal to the yield stress of the steel and the pipeline will probably rupture. The highest pressure in the pipeline will occur where the elevation is the lowest or at stream crossings. Having a simple operational error causing a major oil spill is unacceptable. Pressure surges in long pipelines are common and are generally caused by valve movement, check valves, pump startup, and power failure.

Pipeline safety regulations in both the U. S. and Canada require that the factor of safety (bursting stress divided by the operating stress) be not less than 2.0. So why is Keystone Pipeline proposing a safety factor of 1.2 for Montana? Apparently it is cheaper for Keystone Pipeline to pay for oil spill cleanup than to build a safe pipeline and prevent oil spills. It's like a farmer buying car tires for his truck because they are cheaper.

Operating at a pressure of 100 psi, he may be able to haul several loads on a smooth pavement but in the long run you know that there will be trouble down the road. This is equally true of the pipeline as over the 50-yr life of the project, corrosion will reduce the wall thickness of the pipeline and leaks and ruptures will become more frequent. If the pipe is made in China, there will also be quality control issues with the manufacturing of the pipe.

The original design using standard wall thickness pipe was economically feasible only when the price of crude oil was over $100 per barrel. Now that the price of crude oil is under $100 per barrel, the pipeline is apparently feasible only if Keystone Pipeline can use cheaper thin-walled pipe. If Keystone Pipeline's request to use thin-walled pipe is approved, they will end up with the gold mine and we will end up with an environmental disaster in our back yard.

This pipeline runs through our family homestead east of Circle for a distance of two miles and I am concerned that the pipeline will be substandard and unsafe to live near. When I get all the data on the pipeline, I plan to develop an unsteady-state computer model of the pipeline to see where the pipeline will rupture. Why? Because this is the type of work that I have been doing for the last 40 years and land owners should have this information before they sign an easement.

Wesley P. James
Bigfork, MT

DEPT OF TRANSPORTATION DOCKETS August 7, 2009

2009 AUG 14 A 9:27

Dockets Operations
U.S. Department of Transportation
M-30 West Building Ground Floor
Room W12-140
1200 New Jersey Avenue, SE
Washington DC 20590

RE: TransCanada Keystone Pipeline

The Keystone pipeline runs through our family homestead east of Circle, MT for a distance of two miles and I am concerned that the pipeline will be substandard and unsafe to live near. The pipeline crosses both Redwater Creek and Buffalo Spring Creek on our farm.

Pipeline Wall Thickness is Inadequate

The proposed 36-inch diameter (D) pipeline will operate at a pressure (P) of 1500 psi or about twice the pressure of most crude oil pipelines and will have a wall thickness (t) of 0.465 inches. This gives an operating stress in the pipeline wall of

$$P * D / (2 * t) = 58,000 \text{ psi}$$

The yield stress of the steel is 70,000 psi and the yield pressure in the pipeline is

$$2 * 70,000 * 0.465 / 36 = 1800 \text{ psi}$$

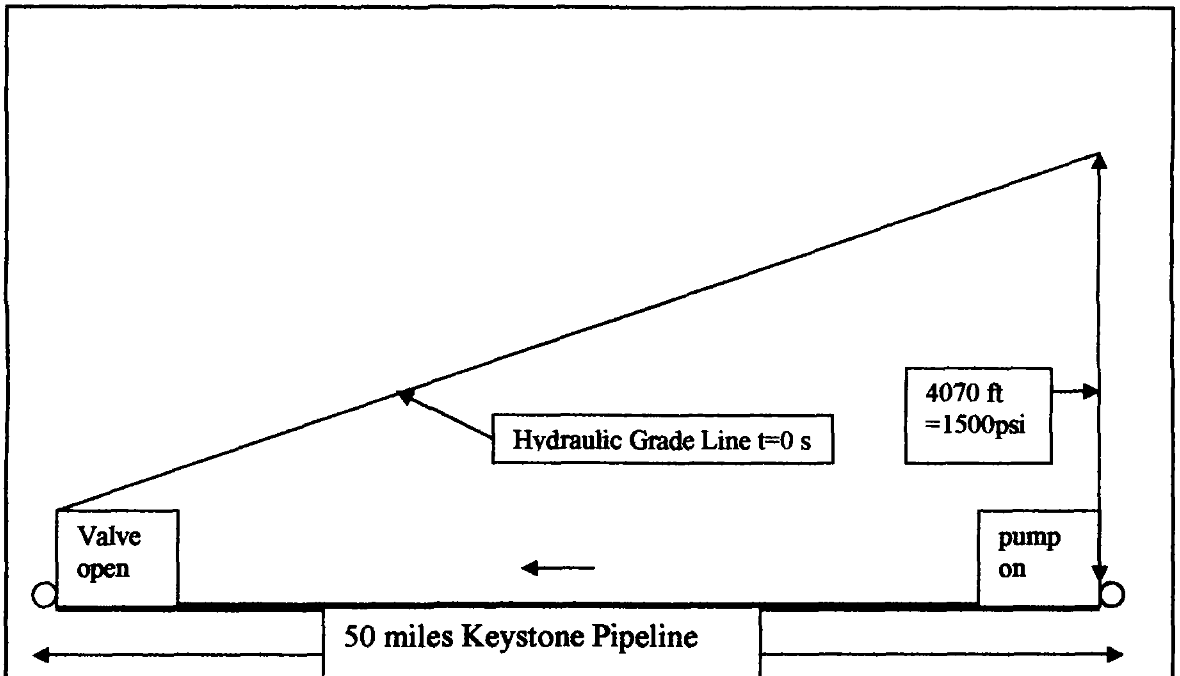
The factor of safety for the pipeline is only

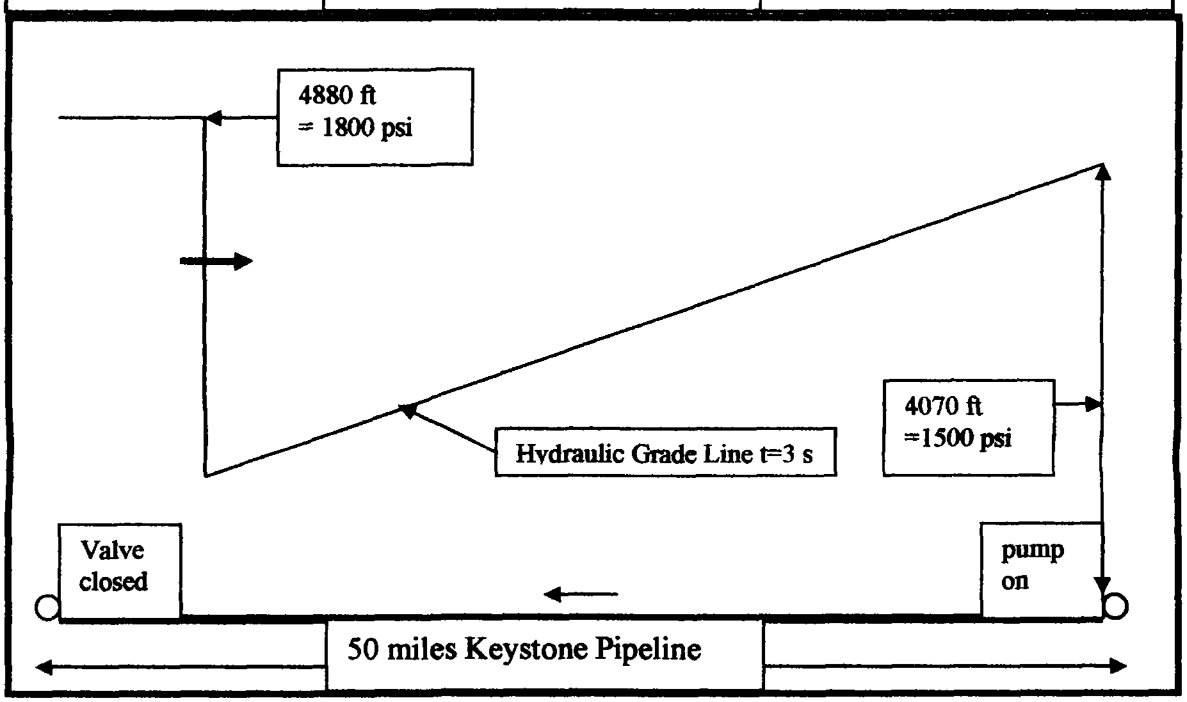
$$1800 / 1500 = 1.2$$

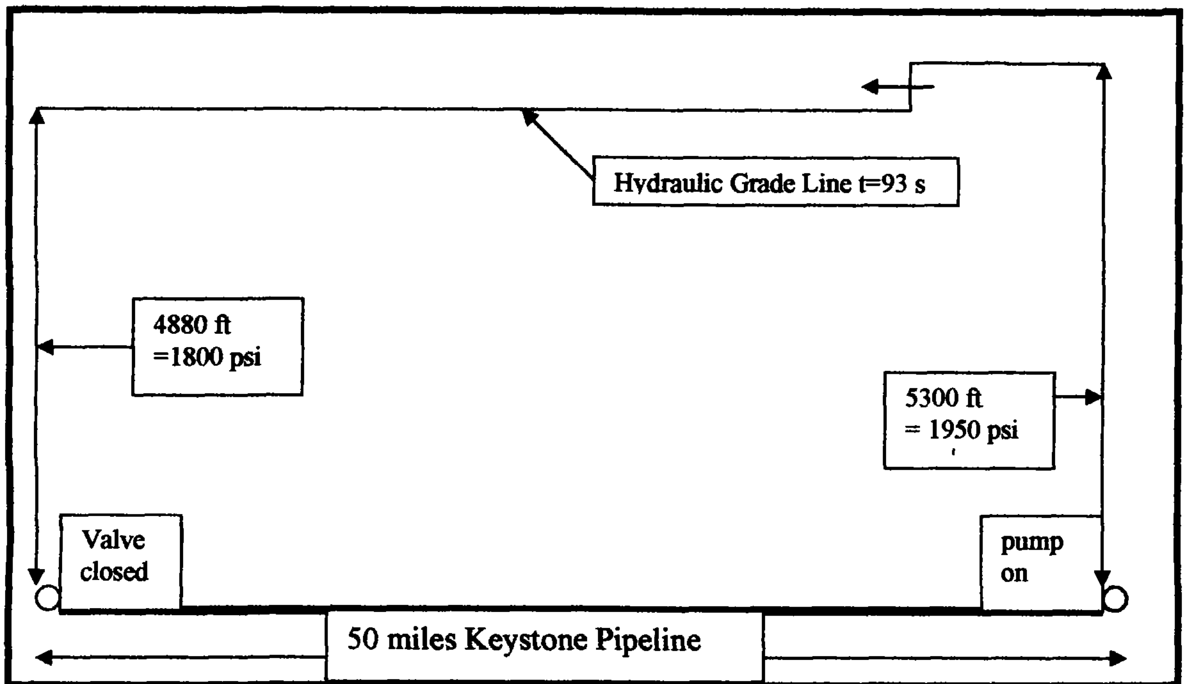
This maybe adequate for a gas pipeline but is not adequate for a crude oil pipeline for the follow reasons:

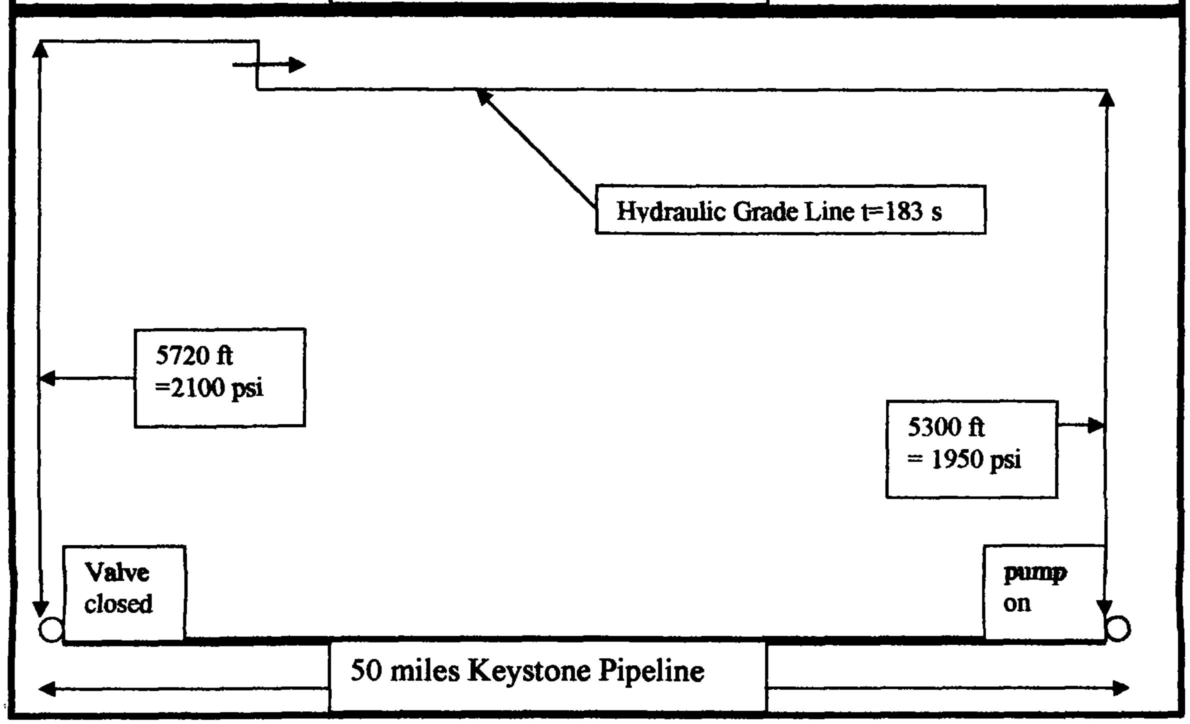
1. The pressure in a gas pipeline is provided by compressors while the pressure in a crude oil pipeline is provided by centrifugal pumps. The cut pressure (pressure at zero discharge) for a centrifugal pump is typically 30% greater than the operating pressure. If a valve in the discharge line is closed while the pumps are running, the pressure in the discharge line would increase to 1950 psi and the pipeline would fail.
2. Because the density of the crude oil is greater than the density of the gas, unsteady flow surges are greater in a crude oil pipeline. Some common causes of surges in a pipeline are pump startup, power failure, valve movement, column separation and air removal. Pressure surges as much as 300 psi can occur in this pipeline resulting in a total pressure of 2250 psi. The bursting pressure for this pipeline is 2070 psi.
3. A study of major Canadian pipeline ruptures (Jeglic, 2004) have found that during the first ten years of operation, stress cracking was the most common cause of pipeline ruptures while during the next ten years of operation, external corrosion was the most common cause of pipeline ruptures. Both causes of ruptures are time dependent and will be a major concern with the Keystone Pipeline because there is no extra steel in the walls of the pipe to compensate for pipeline deterioration. Research (Kiefner, 2001) has shown that a longitudinal stress crack 16 inches long and less than 1/16 inch deep will cause the pipeline to rupture at the normal operating pressure of 1500 psi.

A graphic representation of the pressure distribution in the pipeline is shown below where the vertical distance between the pipeline and the hydraulic grade line represents the pressure in the pipeline. The top figure represents the pressure in the pipeline under normal operating conditions where the pressure varies from 1500 psi at the upstream pumping plant on the right to some minimum value at a valve on the left located near the downstream pumping plant a distance of about 50 miles.









The second sketch represents the hydraulic grade line 3 seconds after a valve in the pipeline has been closed generating a 300 psi pressure surge in the pipeline. The pressure surge travels upstream at a velocity of about 3000 fps and reaches the upstream pumping plant in approximately 90 seconds. The discharge rate at the pump is zero and the pump is operating at the cut off pressure or 1950 psi. At t = 93 seconds the pressure surge is traveling downstream towards the valve. The last sketch shows the pressure distribution in the pipeline after the surge has reached the valve and is traveling upstream. The pressure in the pipeline exceeds the bursting pressure of the pipeline. To get a more accurate description of the pressure distribution in the pipeline, a detailed unsteady state model of the pipeline will be required.

Spray Zone for a Pipeline Rupture

Keystone pipeline will be operated a very high pressure and when the pipeline ruptures, crude oil will discharge from the rupture onto the adjacent land. It is important that landowners understand the magnitude and extent that a pipeline rupture will have on their property.

Height (H) of a crude oil storage tank to give the same pressure (P) as in the pipeline (1500 psi)

$$H = P/\gamma = 1500 * 144 / (62.4 * 0.85) = 4070 \text{ ft}$$

The velocity (V) that the crude oil will discharge from a rupture in the pipeline

$$V = C * (2g * H) ^\wedge 0.5 = 0.6 * (64.4 * 4070) ^\wedge 0.5 = 300 \text{ fps} = 200 \text{ mph}$$

The discharge rate (q) of crude oil from the pipeline from a circular rupture of diameter (d)

d	Area	q	q	q
in.	sq ft	cu ft/sec	gpm	BPD
1*	0.0055	1.65	740	25,000*
2	0.0218	6.54	3940	135,000
3	0.049	14.7	6600	226,000
4	0.087	26.1	11700	400,000

* This rupture is probably too small to be detected with the Keystone leak detection system.

The following sketch shows the trajectory of crude oil discharging from a pipeline rupture. Dx is the horizontal distance from the pipeline to highest point (Dy) in the crude oil trajectory. The width of crude oil spray zone (Wsz) for the pipeline is Wsz = 4 * Dx. Example computations for $\beta = 30°$ follows

$Vy = 300 * \sin 30° = 150$ fps

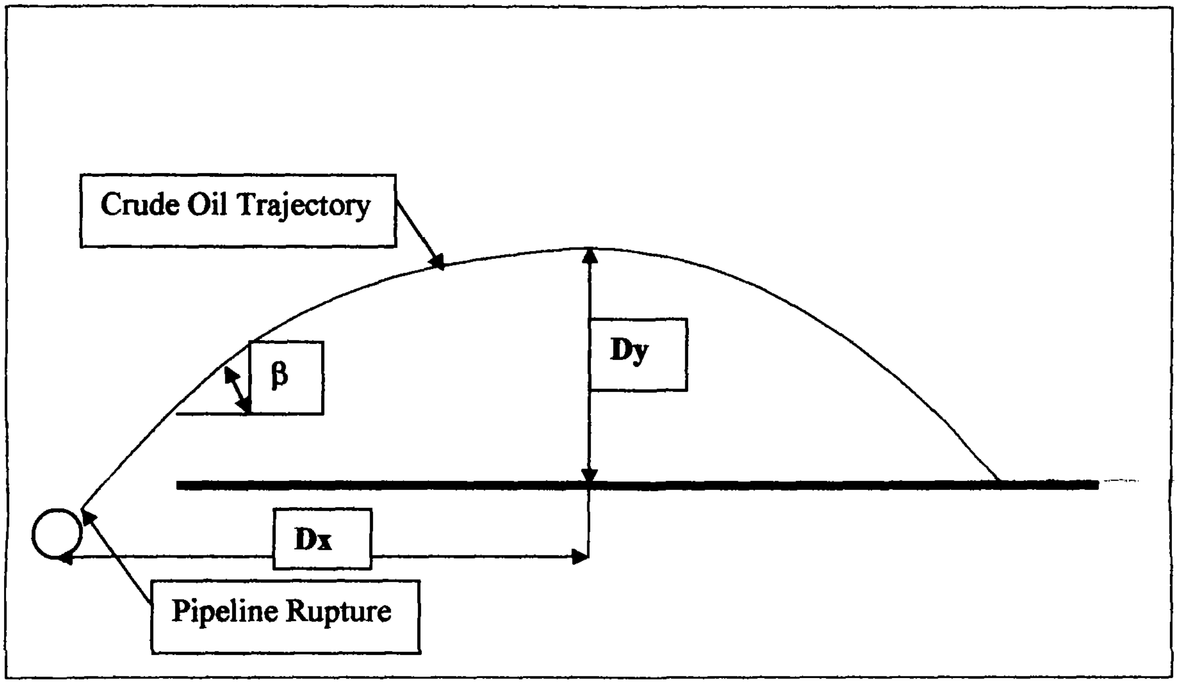
$Vx = 300 * \cos 30° = 260$ fps

t = time to peak = 150 / 32.2 = 4.66 sec

Dx = 260 * 4.66 = 1210 ft

Wsz = 4 * 1210 = 4840 ft

$$Dy = Vy * t - 16.1 * t^2 = 150 * 4.66 - 16.1 * 4.66^2 = 350 \text{ ft}$$



Crude oil trajectories for β = 30, 45, 60 and 90° are summarized in the following table

β	Vy	Vx	t	Dx	Dy	Wsz
°	fps	fps	sec	ft	ft	ft
30	150	260	4.66	1210	350	4840
45	210	210	6.56	1380	685	5520
60	260	150	8.07	1210	1050	4840
90	300	0	9.32	0	1400	0

The width of the crude oil spray zone is approximately one mile (½ mile each side of the pipeline) and the maximum height of the crude oil trajectory in 1400 ft. The pipeline will limit land use and decrease property values for ½ mile on each side of the pipeline.

Conclusion

While TransCanada may save money using a thin wall pipe, they have shifted the risk and cost of pipeline rupture to the land owners. A pipe wall thickness of 0.465 inch is not adequate to protect the environment against crude oil ruptures from Keystone Pipeline.

References

Jeglic, Franci, "Analysis of Ruptures and Trends on Major Canadian Pipeline Systems", Copyright 2004 by ASME.

Kiefner, John F., "Role of Hydrostatic Testing in Pipeline Integrity Assessment", Northeast Pipeline Integrity Workshop, Albany, New York, June 12, 2001.

I hope that you will agree with my conclusion and not permit the use of the thin wall pipe in the Keystone Pipeline.

Sincerely

Wesley P. James
440 N. Ferndale Dr.
Bigfork, MT 59911
406 837-4041

Please provide

- A static and dynamic model of the pipeline for each section from pump discharge to pump suction along the entire US portion of the system.
- A valve closure scenario at the MLV just upstream of the downstream pump station at the midpoint in the discharge to suction section and at the MLV immediately downstream of the upstream pump station.
- The valve closure and pump shut down response times to adequately gauge the most likely volume estimates

Response:

1. Pressure Plot of the Keystone XL Pipeline Static Model:

Steady state hydraulic simulations have been performed for various pipeline operating scenarios. The Keystone XL (KXL) pipeline system is hydraulically balanced between Q1 (winter) & Q3 (summer) hydraulic results with a comparable number of pump units required and equivalent total power consumption. The presented results are for the hydraulic design to satisfy the system's nominal flow capacity (900 kbpd).

Appendix-A shows the graphical representation of pressure profiles for the above mentioned scenario The graph clearly indicates that the system pressures are well below the system's maximum allowable operating pressure (MAOP).

2. Keystone XL Pipeline Transient Simulation:

KXL transient hydraulics analysis is performed in four stages, as defined below:

Stage I: Identify the pressure surge potentials of the pipeline system

The initial stage simulates the pressure surges with pump station local pressure controls including pump unit cascade shutdown pressure set point, pump unit shutdown pressure set point and pump station shutdown pressure set point at each station. The triggering events for initiating pipeline pressure surges include:

- Mainline valve (MLV) closure,
- Station valve closure,
- Pressure control valve (PCV) failure or closure,

Response

- Pump station power failure or shutdown and;
- Inspection Pig sudden stoppage

Stage II: Define the pressure control logics to prevent pressure surges

In this stage, the transient hydraulic model incorporates the pressure control logics within the pump station controller and implements the links between stations with and without communication outages.

The station power failure or shutdown and pig sudden stoppage did not show any potential overpressure in Stage I analysis, therefore only those scenarios that exhibited potential overpressure were analyzed in this second stage.

In addition, pressure control valves were installed at select stations to allow for the minimum pressure control for maintaining backpressure to avoid the column separation in the pipeline system when it is shutdown. The following parameters were included in this stage of the model.

- Two-stage closing characteristic curve is used for all mainline valves
- Batch fluid delivery pressure profile is used as the initial condition for transient pressure surge simulation, which is the worst case due to high pressure profile

Stage III: Mitigate any potential overpressure conditions through pressure control logics

The mitigation strategies for preventing overpressure conditions in the pipeline are analyzed in the third stage and include:

- Extending the valve closure time longer to allow for the station to operate in an acceptable safe pressure range before the complete closure of mainline valves (considering the two-stage valve closing characteristic)
- Timely closing the pipeline sectionalizing valves when the system is shutdown

Stage IV: Refinement of the overall pressure logics

In the final stage, a number of model parameters are refined to ensure that no overpressure events are observed during the transient hydraulic simulation when the above described pressure surge events are initiated. Assigned settings are listed below:

- For the mainline block valve,, the potential pipeline overpressure concern is eliminated by setting a minimum valve closure time of 4 minutes and 50 seconds
- For the station valves, the potential overpressure concern is eliminated by setting the minimum valve closure time at 4 minutes and 10 seconds.

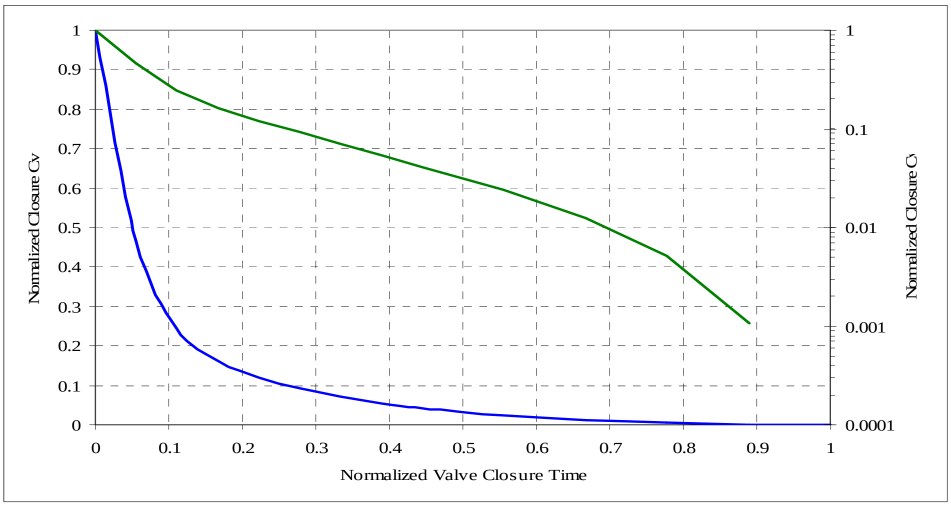
Keystone will standardize the closure time at 4 minutes and 50 seconds for all valves.

3. **Mainline Block Valve and Closure Timings:**

Response

The mainline block valves will be designed as full port ball valves. The valve is 36 inch in size with a full opening flow coefficient of 271300 gpm/psi$^{0.5}$. The equal percentage valve closing characteristic curve (refer Fig 3.1) is applied to these valves.

It should be noted that although the valve coefficient decreases to 3% after 50% closure (refer Fig 3.1), the flow rate through the valve may remain relatively high because the pressure difference across the valve becomes much larger as the valve closes.



- Fig 3.1: Valve Closing Characteristics

4. <u>IMLV Closure Scenarios & Pressure Plots:</u>

When a mainline block valve closes, the pipeline flow is interrupted, which initiates a pressure surge. The pressure wave travels towards the upstream pump station while the downstream pump station experiences a low suction pressure causing pump unit or station shutdown.

For detailed graphical representation for different scenarios, refer attached Appendix B.

<u>[1] - Safe Mode:</u>

If communication failure continues for more than 3 minutes, the control system would declare the communication outage & trigger the Safe Mode command. Under Safe Mode all the stations pressure settings revert to the safe mode settings, which are evaluated as the safest values and eliminates the potential of increasing system pressure over the system's maximum allowable operating pressure (MOP) under zero flow rate & other potential upset conditions.

Response

Protection Strategies

If transient pressure surges were to occur, both the suction pressure and discharge pressure at the upstream station will increase. If the suction pressure is above the station high suction pressure shutdown set point, it can trigger all upstream stations to shutdown.

If a communication outage were to occur, the control system will be unaware of this event but will notify the upstream station to initiate timing to revert to the Safe Mode with in 3 minutes. When this occurs, the pump station discharge pressure set point ramps down to the Safe Mode pressure set point along with pump unit cascade shutdown set point and pump unit shutdown set point also ramp down accordingly. As the mainline valve closure time is set as 4.5 minutes, the pump station will be in Safe mode [1] before the valve is completely closed.

Following are the selected scenarios for mainline valve closures & their results.

Scenario I – MLV at suction side of a pump station:

If the mainline valve is located some distance away from the upstream station, the pressure at this location is relatively low. However, it takes longer for the upstream pump station to sense the pressure wave and to response to the pressure upset and the high pressure is more likely due to the line packing from the upstream running pump station.

Comparing the mile post for the MLVs & pump stations along the pipeline, The closest MLV to the suction side of a pump station is 4.62 miles.

Refer Table 3.1 for the tabular results & Appendix-B for the complete graphical pressure profile variation in different times.

Response

Scenario II – MLV at discharge side of a pump station:

If a mainline block valve closer to the upstream station, the normal operating pressure is generally higher at the upstream valve. When this valve closes, the pressure surge at the valve upstream will rise quickly and may exceed the pipeline MOP before the upstream pump station senses the pressure increase and responses to the pressure surge.

Comparing the mile post for the MLVs & pump stations along the pipeline, The closest MLV to the discharge side of a pump station is 2.54 miles. Results are shown in Table 3.1 & Appendix-B.

Scenario III – MLV at the mid point between two stations:

Comparing the mile post for the MLVs & pump stations along the pipeline, The a midpoint MLV is 22.59 miles from the upstream station and 22.71 miles from the downstream station. Refer Table 3.1 & Appendix-B for the results.

Table: 3.1 – Simulation results for mainline valve closures

Scenario	110% MOP (psig)	Valve Upstream Pressure after closure (psig)
I	1584	1526
II	1584	1379
III	1584	1546

5. Pressure Control Valve:

To prevent the column separation after the pipeline is shutdown, the pressure control valves (PCVs) will be installed at selected stations and a sufficient high backpressure (minimum inlet pressure control) will be set to maintain the fluid pressure along the pipeline above the liquid vapor pressure value.

Moreover, when mainline block valves at low elevation points close, the static pressure from high elevation points, can result in a potential overpressure of pipeline segments at low points. The PCVs function combined with setting a discharge pressure control to limit the static pressure at the downstream when the system is shutdown will prevent this occurrence.

Pressure surge analysis has been performed in case of unplanned closure of selected PCVs. Being on conservative side, the analysis also assumed communication outage at the pump stations having these PCVs installed.

Response

Table 5.1 summarized the pressure surge results for the selected PCVs along with inlet & outlet pressure set points to avoid column separation & potential static overpressure at low elevation pipeline segments under pipeline shutdown condition.

Table: 5.1 – Simulation results and set points for pressure control valves.

Pressure Control Valve No.	110% MOP (psig)	Valve Upstream Press. after close (psig)	Inlet Press. Set Point (psig)	Outlet Press. Set Point (psig)
PCV 1	1584	1535	1015	1073
PCV 2	1584	1504	1015	1232
PCV 3	1584	1520	870	1073
PCV 4	1584	1506	1015	275

6. Mainline Valve and Pump Station Shutdown Response Times:

From the transient hydraulic studies, Keystone has determined the pipeline overpressure potential conditions can be eliminated by setting the mainline valve closure time to 4.5 minutes.

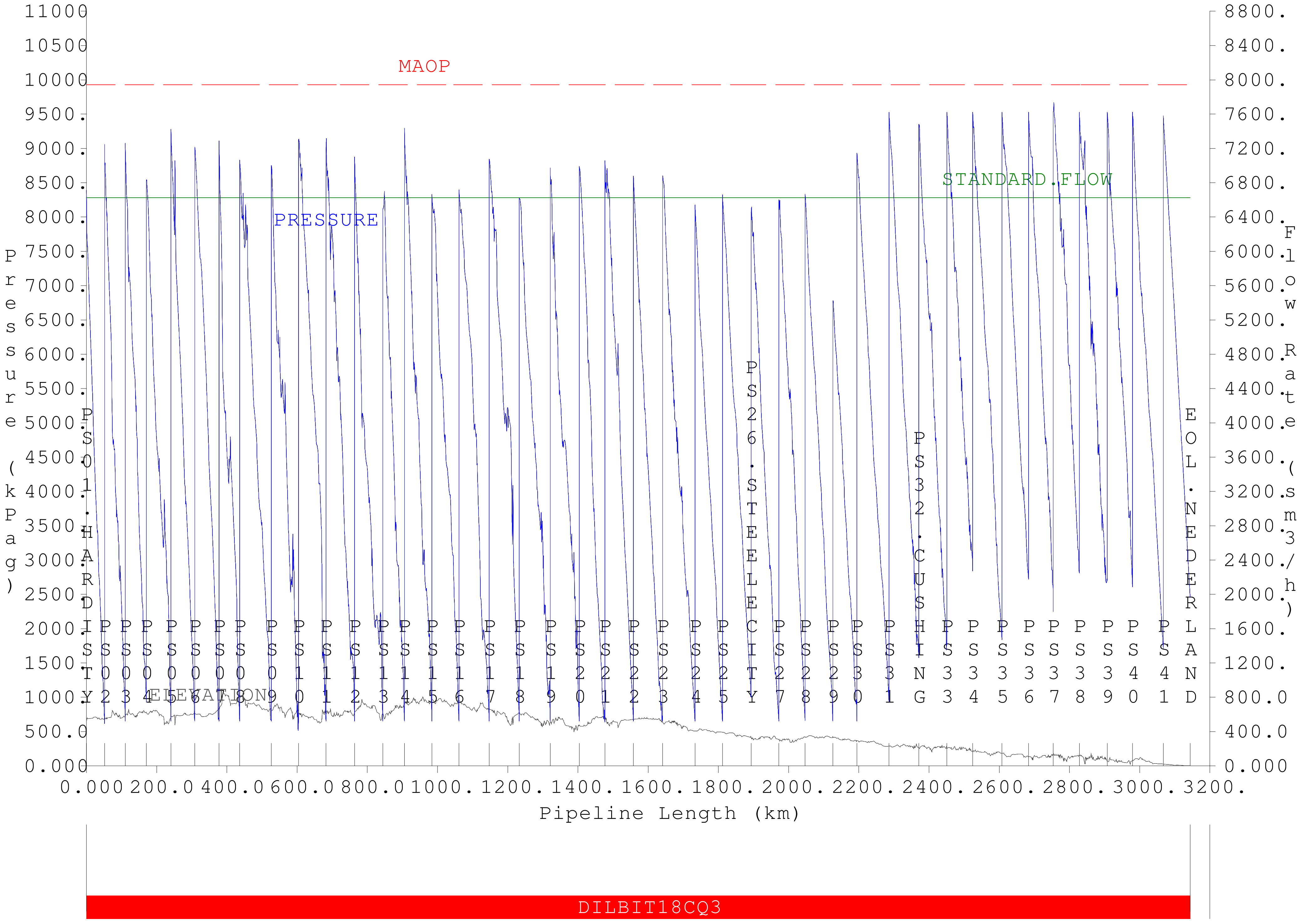
In case of a pump station shutdown event (initiated by the control system or Operator), pump station with five(5) units operating would require around 2 minutes to completely spin-down to full stop.

Appendix A

Steady State Pressure Profile

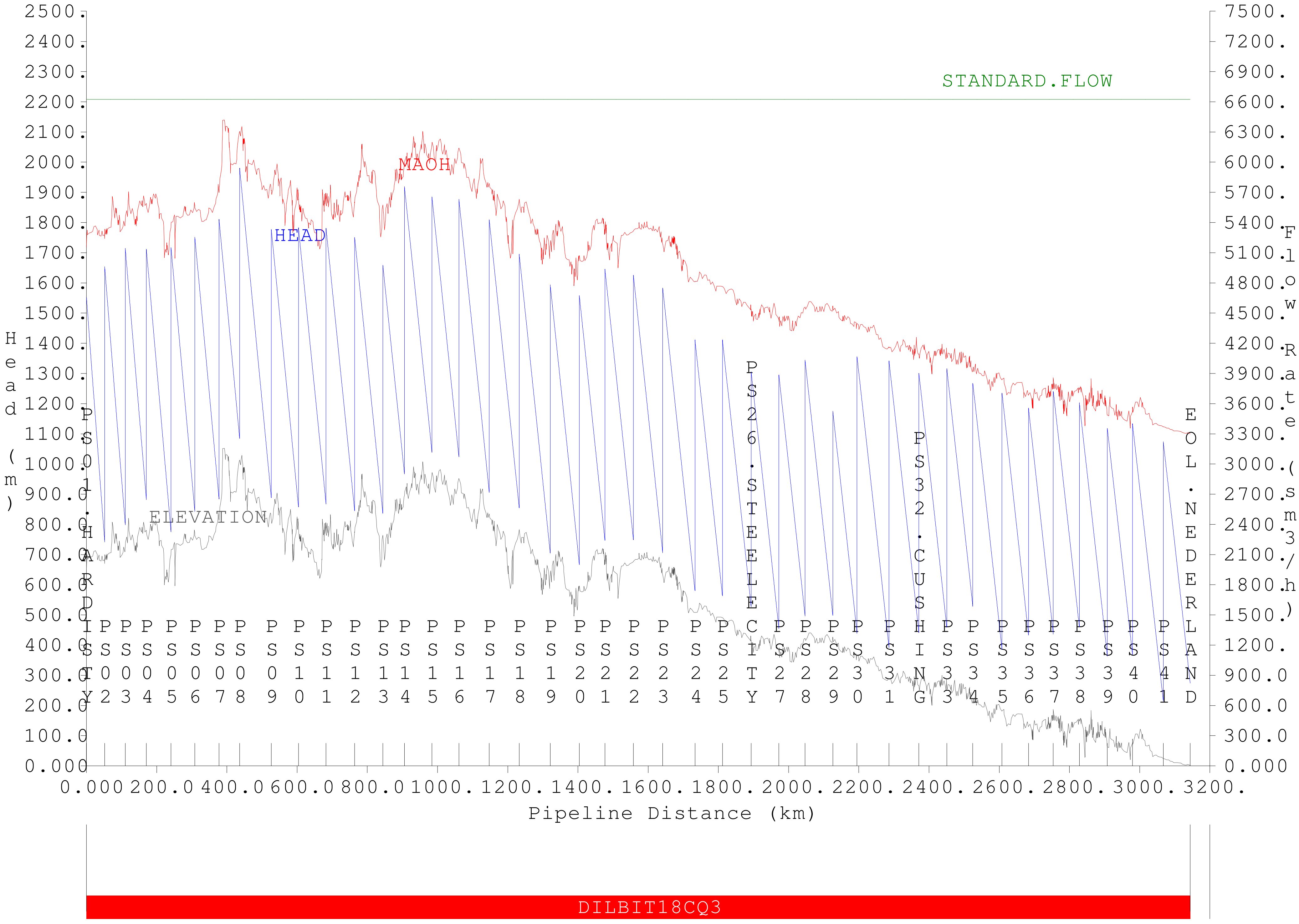
TIME = 05/07 00:52:46
STEP = 00:14:54

KXL Update: Pressure and Flow Rate Profiles (Dilbit Q3 at 1000 kbpd)



TIME = 05/07 00:52:46
STEP = 00:14:54

KXL Update: Head and Flow Profiles (Dilbit Q3 at 1000 kbpd)

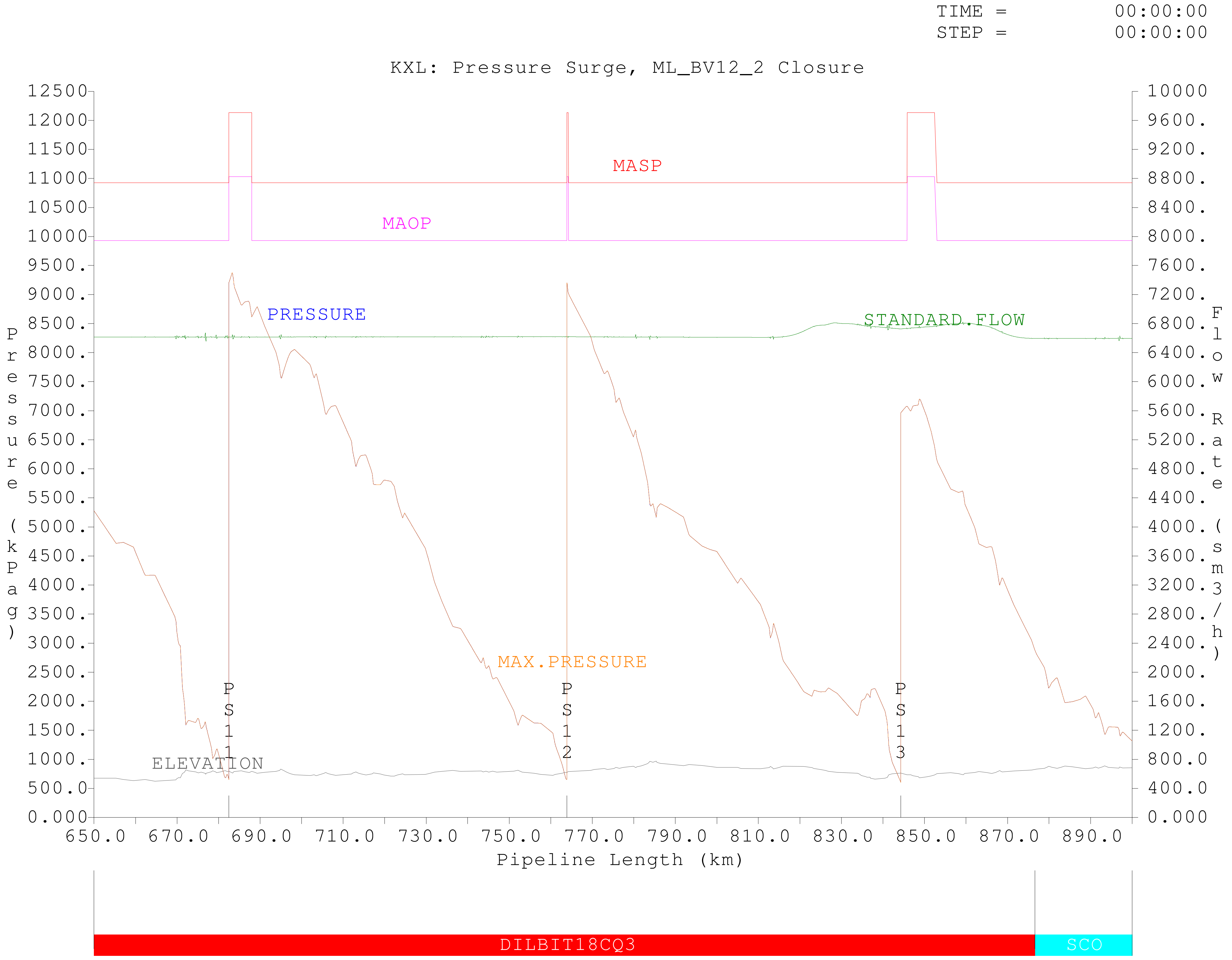


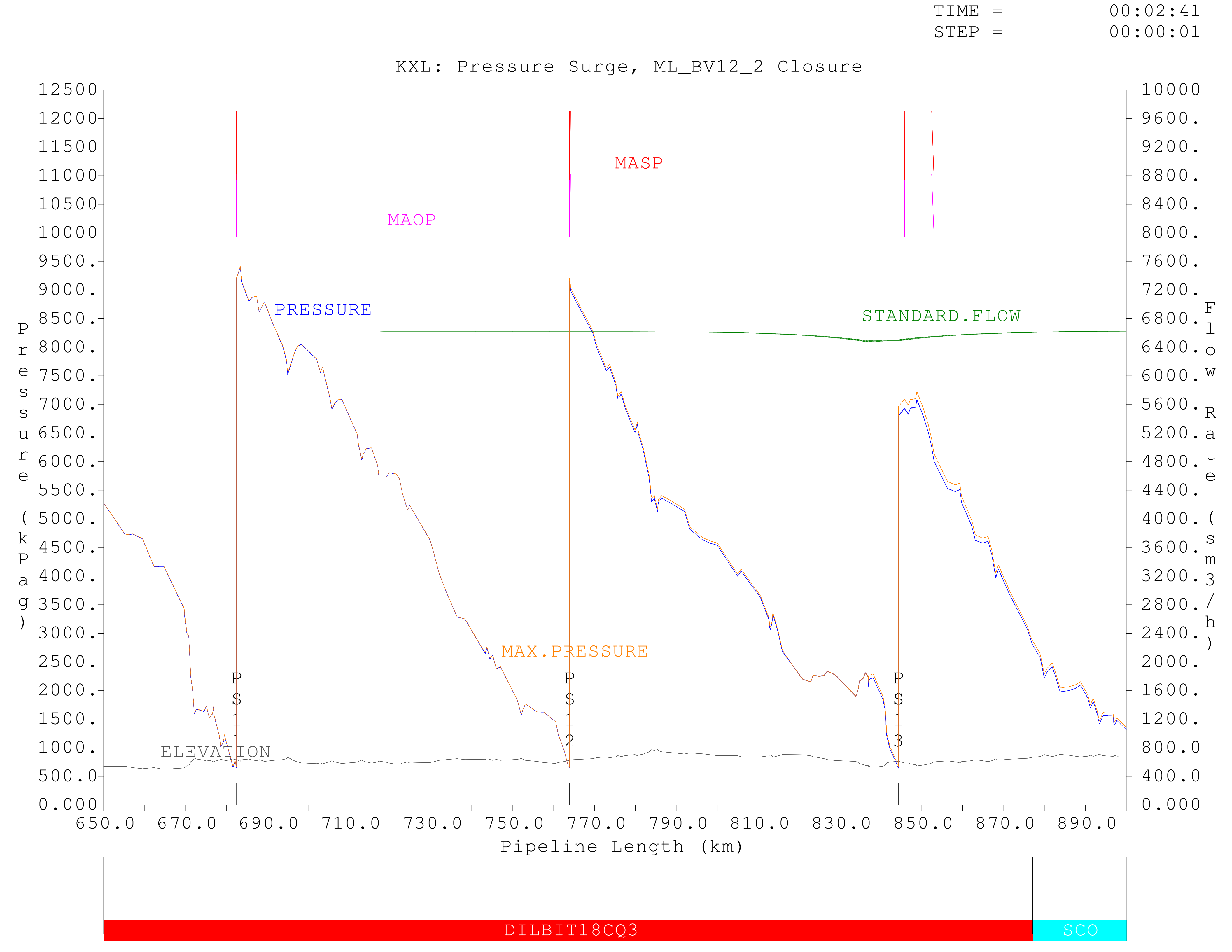
Appendix B

Transient Pressure Profiles

Scenario I

Mainline Valve at Suction Side of a Pump Station

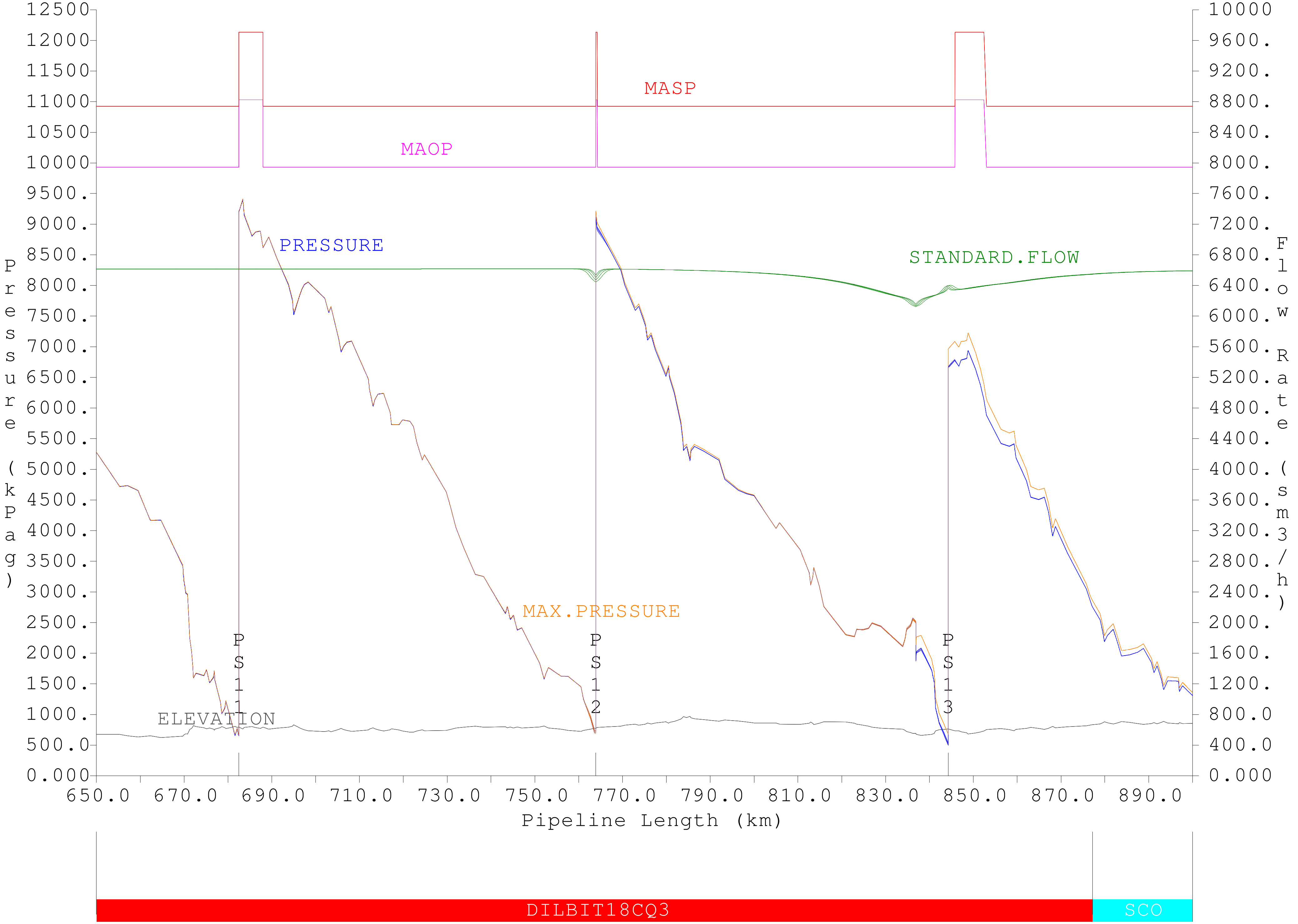

TIME = 00:00:00
STEP = 00:00:00
KXL: Pressure Surge, ML_BV12_2 Closure
MASP
MAOP
PRESSURE
STANDARD.FLOW
MAX.PRESSURE
ELEVATION
PS11
PS12
PS13
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
12500
12000
11500
11000
10500
10000
9500.
9000.
8500.
8000.
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
3500.
3000.
2500.
2000.
1500.
1000.
500.0
0.000
10000
9600.
9200.
8800.
8400.
8000.
7600.
7200.
6800.
6400.
6000.
5600.
5200.
4800.
4400.
4000.
3600.
3200.
2800.
2400.
2000.
1600.
1200.
800.0
400.0
0.000
650.0
670.0
690.0
710.0
730.0
750.0
770.0
790.0
810.0
830.0
850.0
870.0
890.0
DILBIT18CQ3
SCO

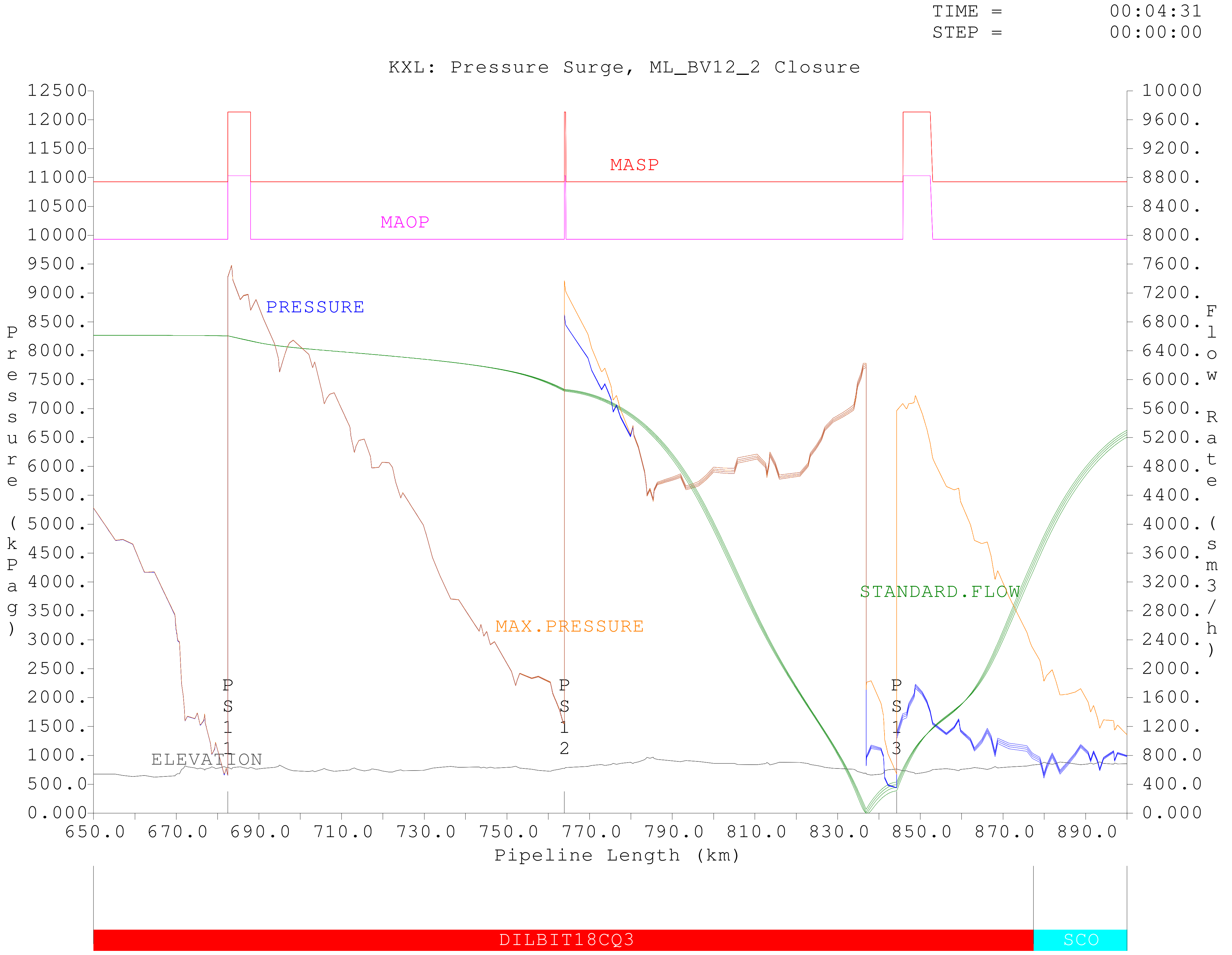


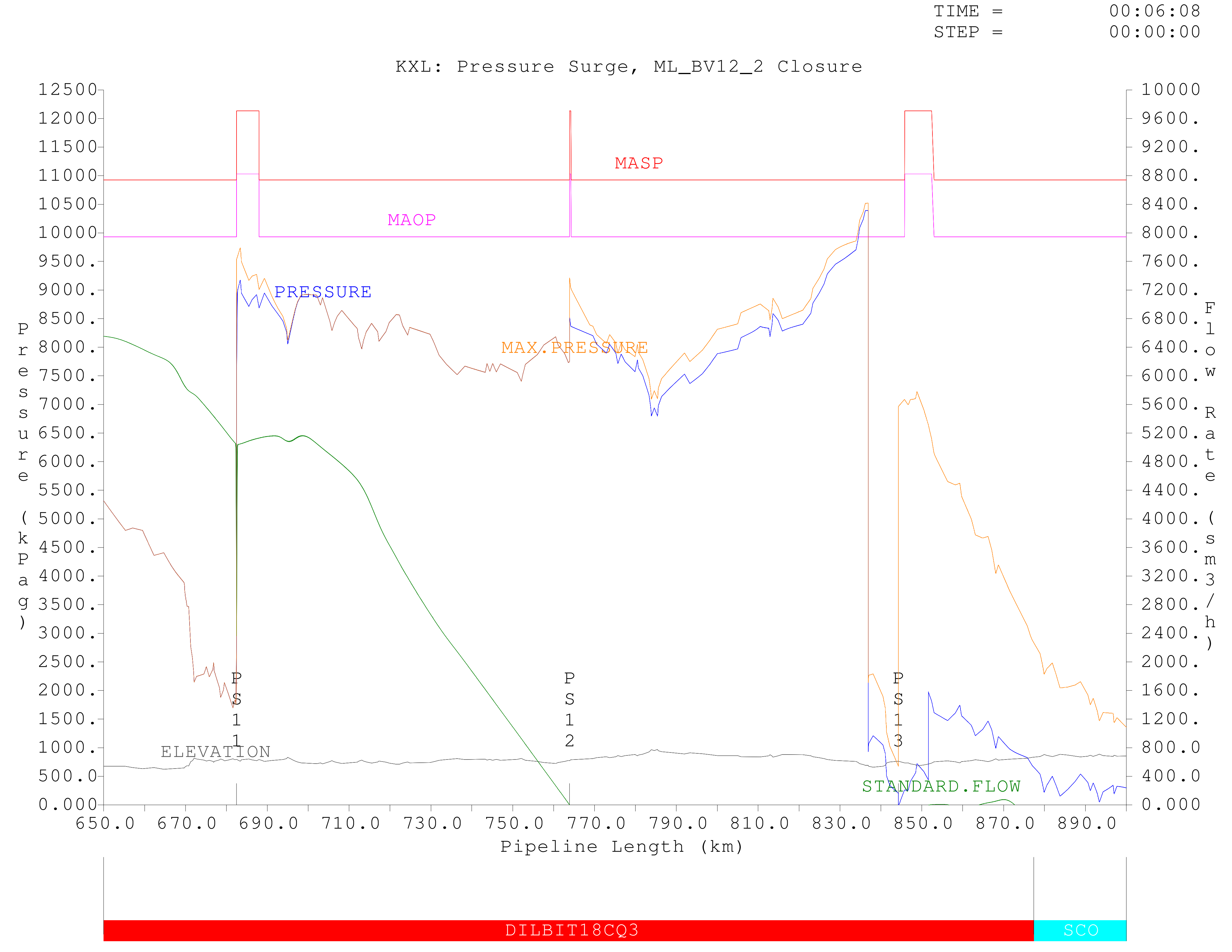
TIME = 00:02:41
STEP = 00:00:01
KXL: Pressure Surge, ML_BV12_2 Closure
MASP
MAOP
PRESSURE
STANDARD.FLOW
MAX.PRESSURE
ELEVATION
PS11
PS12
PS13
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3
SCO

TIME = 00:03:09
STEP = 00:00:01

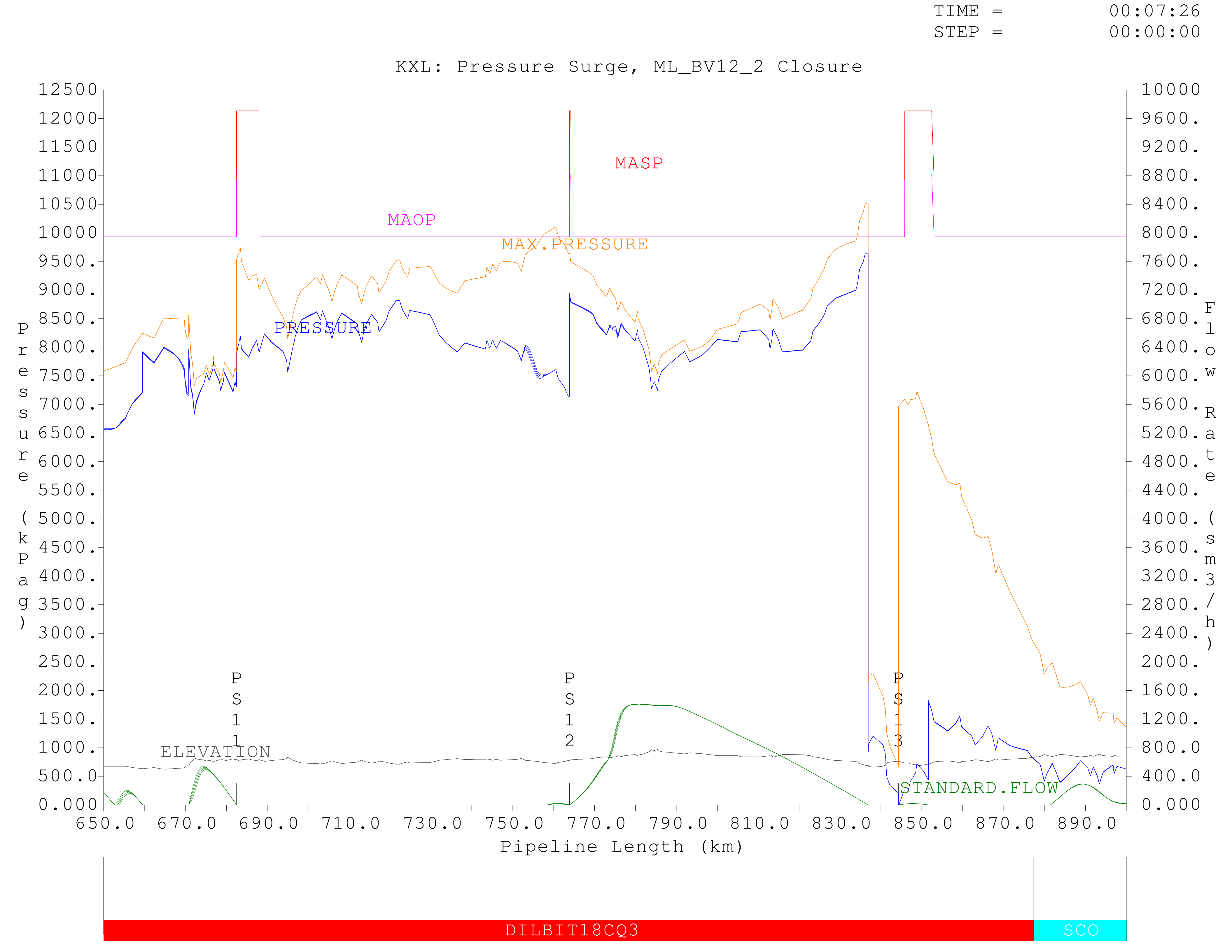
KXL: Pressure Surge, ML_BV12_2 Closure




TIME = 00:04:31
STEP = 00:00:00
KXL: Pressure Surge, ML_BV12_2 Closure
Pressure (kPag)
Flow Rate (sm3/h)
MASP
MAOP
PRESSURE
MAX.PRESSURE
STANDARD.FLOW
ELEVATION
PS11
PS12
PS13
Pipeline Length (km)
DILBIT18CQ3
SCO



TIME = 00:06:08
STEP = 00:00:00
KXL: Pressure Surge, ML_BV12_2 Closure
Pressure (kPag)
Flow Rate (sm3/h)
12500
12000
11500
11000
10500
10000
9500.
9000.
8500.
8000.
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
3500.
3000.
2500.
2000.
1500.
1000.
500.0
0.000
10000
9600.
9200.
8800.
8400.
8000.
7600.
7200.
6800.
6400.
6000.
5600.
5200.
4800.
4400.
4000.
3600.
3200.
2800.
2400.
2000.
1600.
1200.
800.0
400.0
0.000
MASP
MAOP
PRESSURE
MAX.PRESSURE
ELEVATION
STANDARD.FLOW
PS11
PS12
PS13
650.0
670.0
690.0
710.0
730.0
750.0
770.0
790.0
810.0
830.0
850.0
870.0
890.0
Pipeline Length (km)
DILBIT18CQ3
SCO


TIME = 00:07:26
STEP = 00:00:00
KXL: Pressure Surge, ML_BV12_2 Closure
Pressure (kPag)
Flow Rate (sm3/h)
MASP
MAOP
MAX.PRESSURE
PRESSURE
ELEVATION
STANDARD.FLOW
PS11
PS12
PS13
Pipeline Length (km)
DILBIT18CQ3
SCO

TIME = 00:07:51
STEP = 00:00:00
KXL: Pressure Surge, ML_BV12_2 Closure
10923
9930
PS11_BV_OUT:P+
PS12_P05:P+
ML_BV12_2:P-
PS12_P01:P-
PS12_P05:RPM
ML_BV12_2:Q-
Pressure (kPag)
Flow (m3/h), RPM
Time (minute)

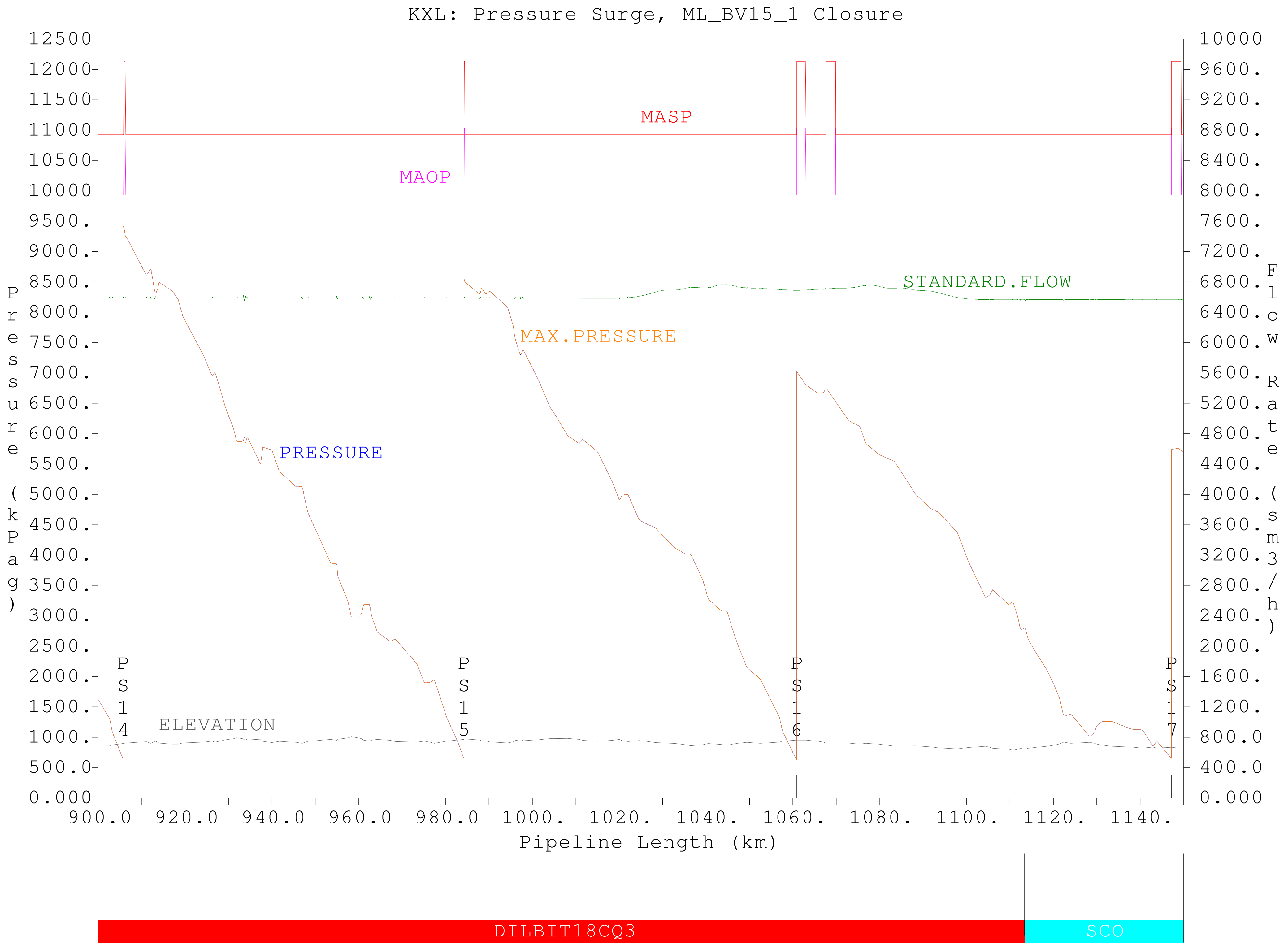
Appendix B

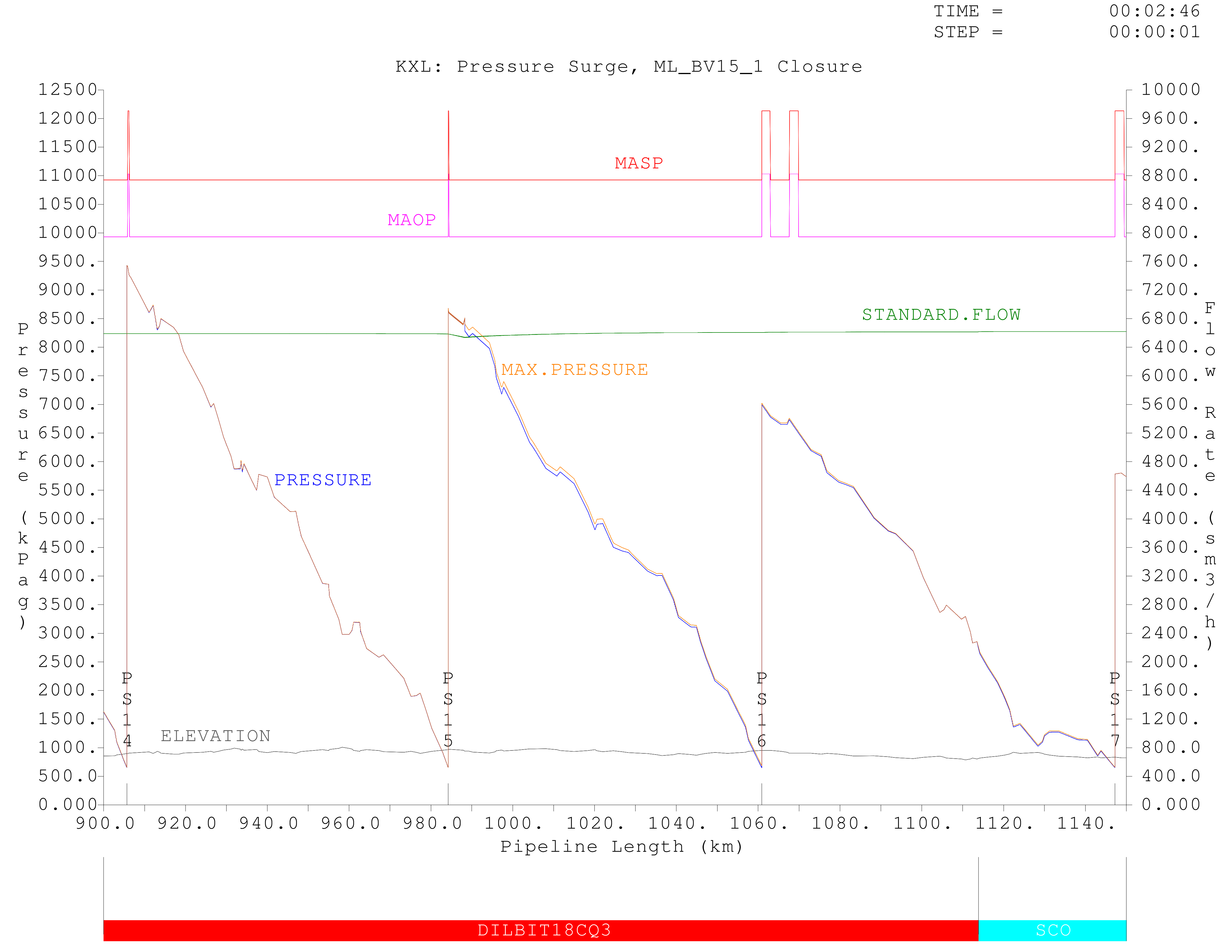
Transient Pressure Profiles

Scenario II

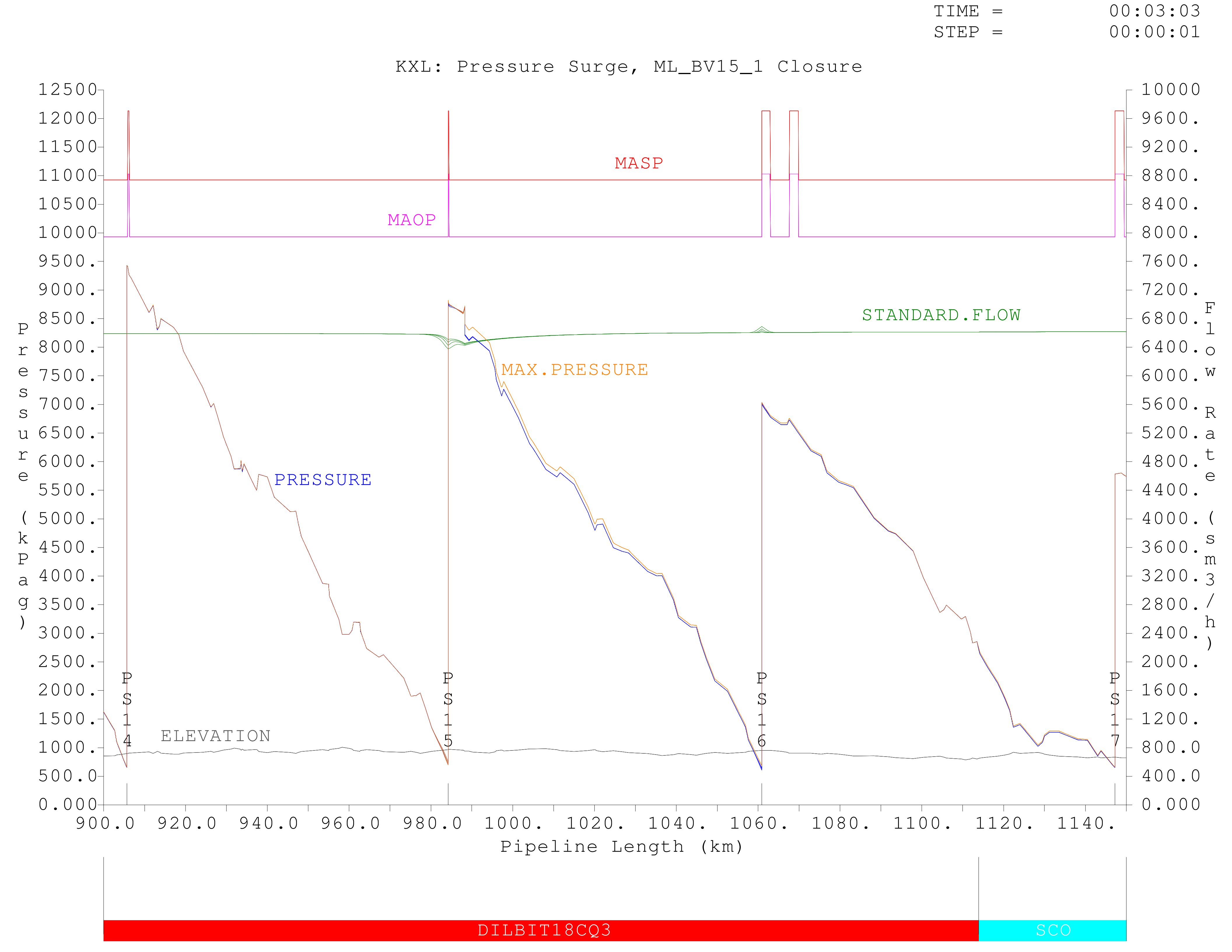
Mainline Valve at Discharge Side of a Pump Station

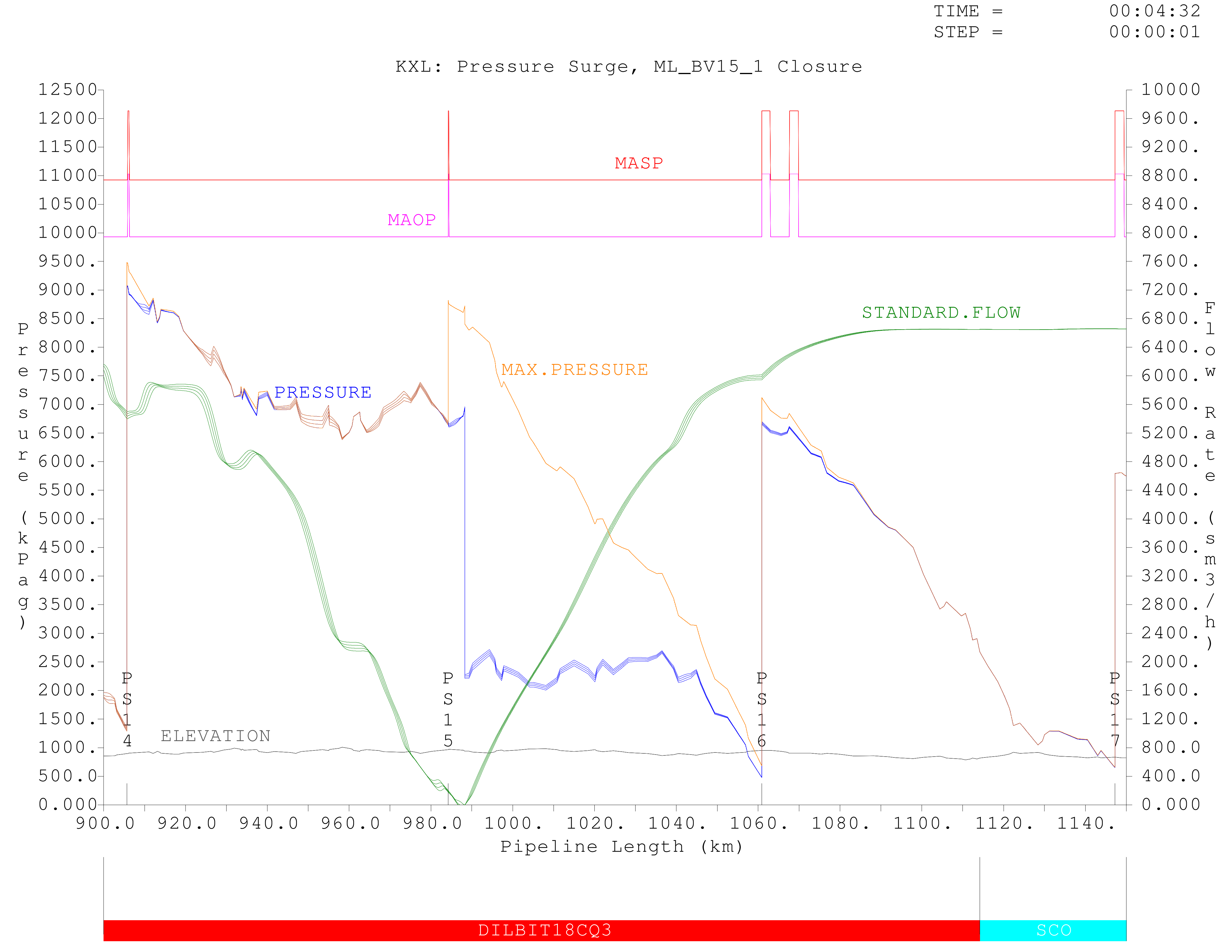
TIME = 00:00:00
STEP = 00:00:00



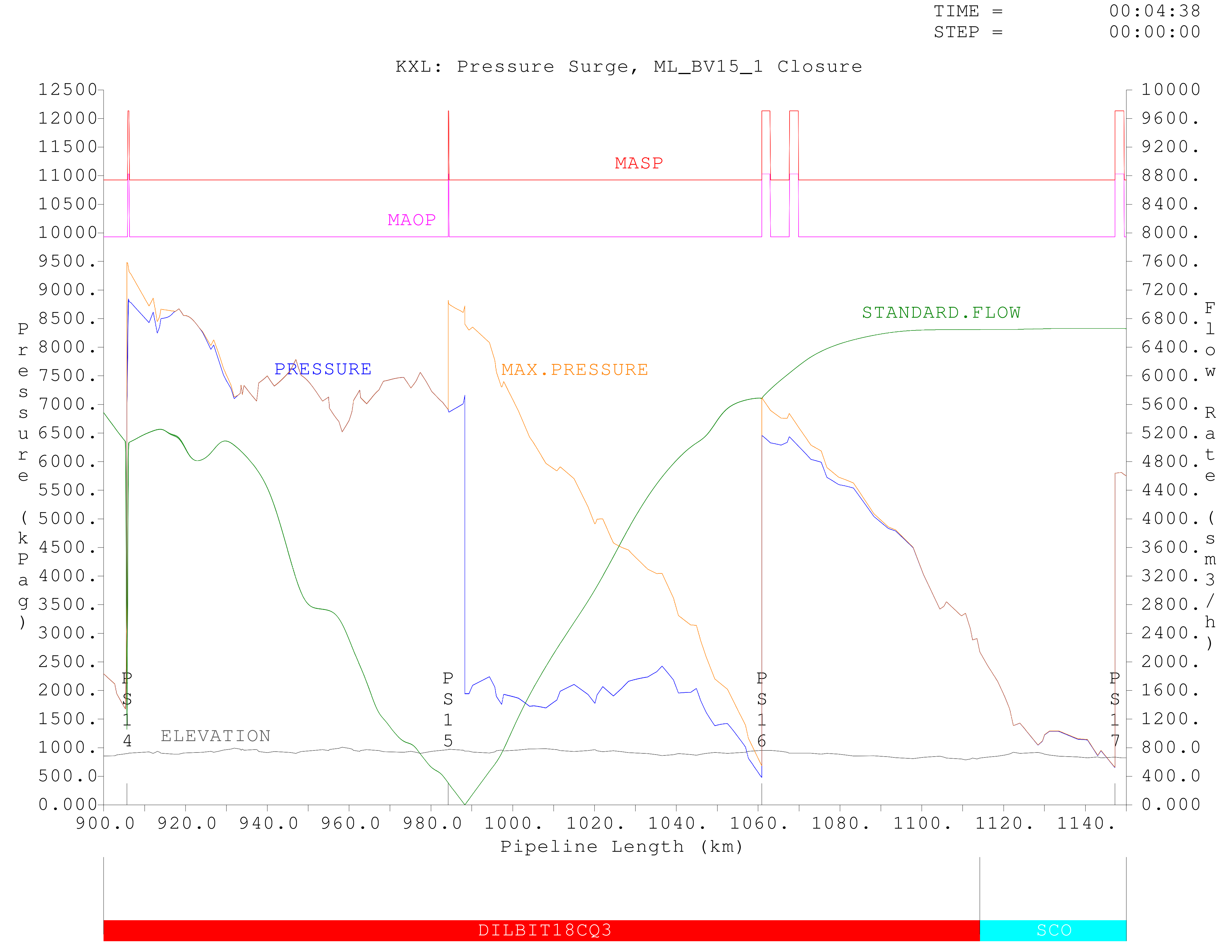


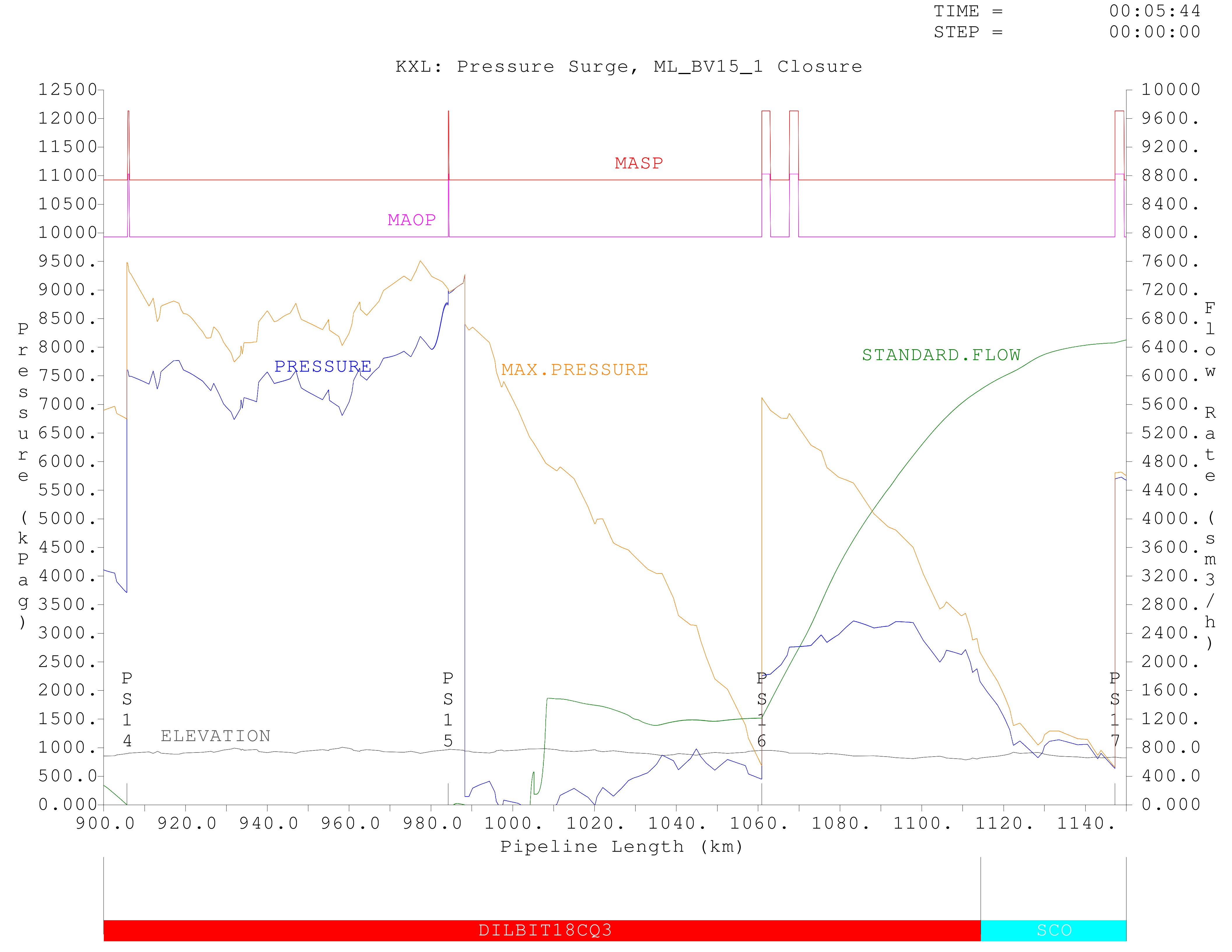
TIME = 00:02:46
STEP = 00:00:01
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
PS14
PS15
PS16
PS17
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3
SCO


TIME = 00:03:03
STEP = 00:00:01
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
PS14
PS15
PS16
PS17
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3
SCO

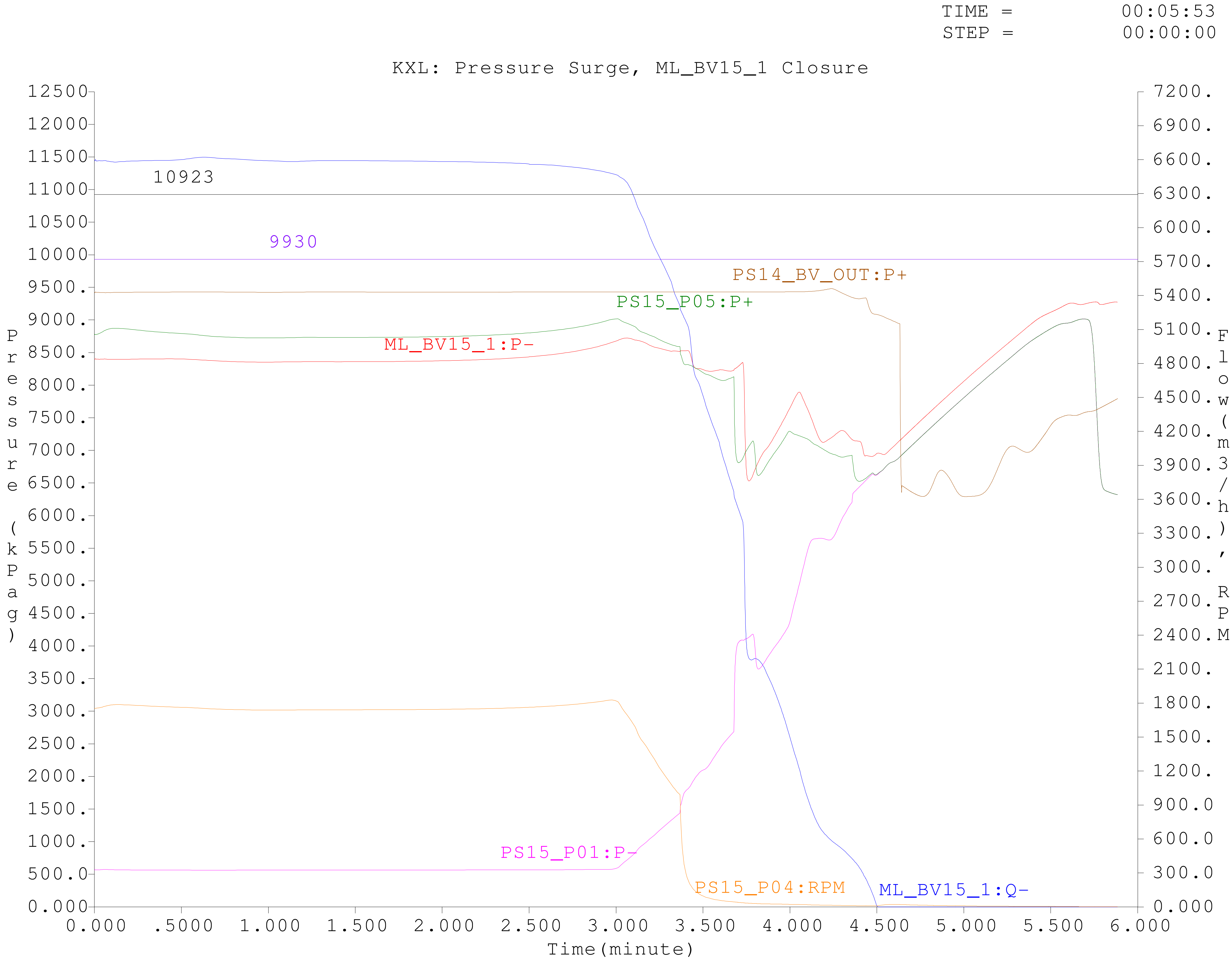


TIME = 00:04:32
STEP = 00:00:01
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
PRESSURE
MAX.PRESSURE
STANDARD.FLOW
ELEVATION
PS14
PS15
PS16
PS17
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3
SCO


TIME = 00:04:38
STEP = 00:00:00
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
PRESSURE
MAX.PRESSURE
STANDARD.FLOW
ELEVATION
PS14
PS15
PS16
PS17
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3
SCO



TIME = 00:05:44
STEP = 00:00:00
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
PRESSURE
MAX.PRESSURE
STANDARD.FLOW
ELEVATION
PS14
PS15
PS16
PS17
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3
SCO



TIME = 00:05:53
STEP = 00:00:00
KXL: Pressure Surge, ML_BV15_1 Closure
Pressure (kPag)
Flow (m3/h), RPM
Time (minute)
10923
9930
PS14_BV_OUT:P+
PS15_P05:P+
ML_BV15_1:P-
PS15_P01:P-
PS15_P04:RPM
ML_BV15_1:Q-
12500
12000
11500
11000
10500
10000
9500.
9000.
8500.
8000.
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
3500.
3000.
2500.
2000.
1500.
1000.
500.0
0.000
7200.
6900.
6600.
6300.
6000.
5700.
5400.
5100.
4800.
4500.
4200.
3900.
3600.
3300.
3000.
2700.
2400.
2100.
1800.
1500.
1200.
900.0
600.0
300.0
0.000
0.000
.5000
1.000
1.500
2.000
2.500
3.000
3.500
4.000
4.500
5.000
5.500
6.000

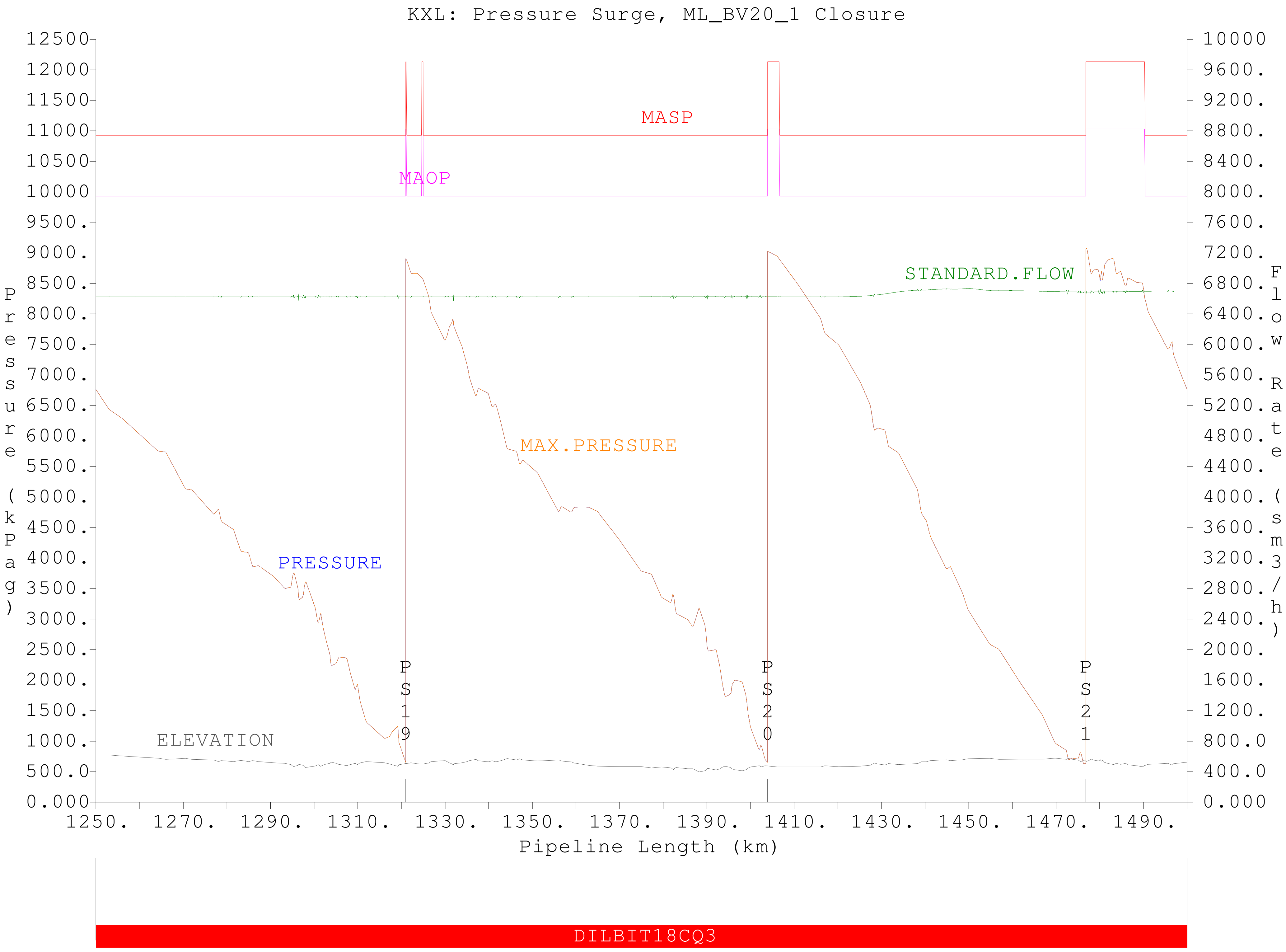
Appendix B

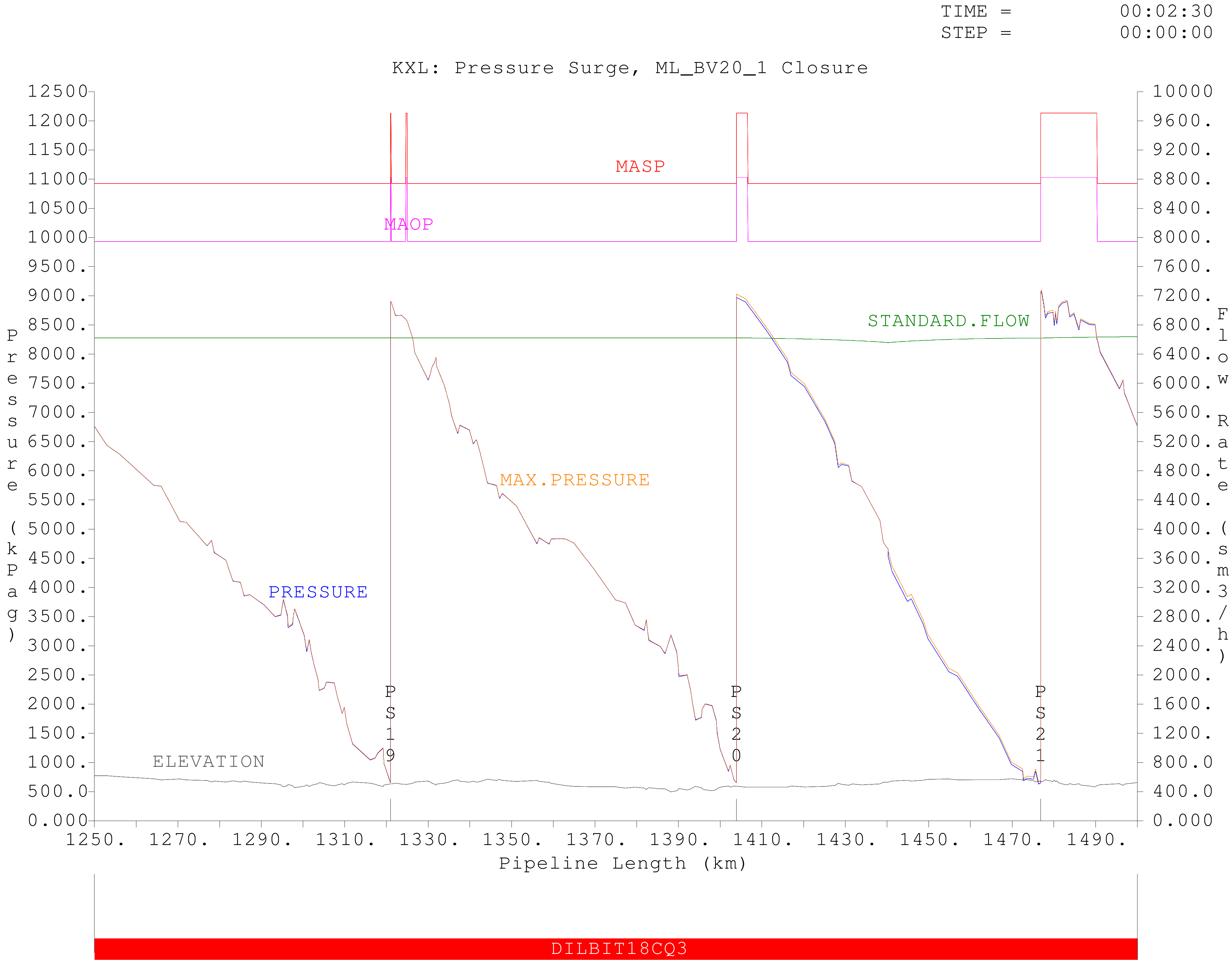
Transient Pressure Profiles

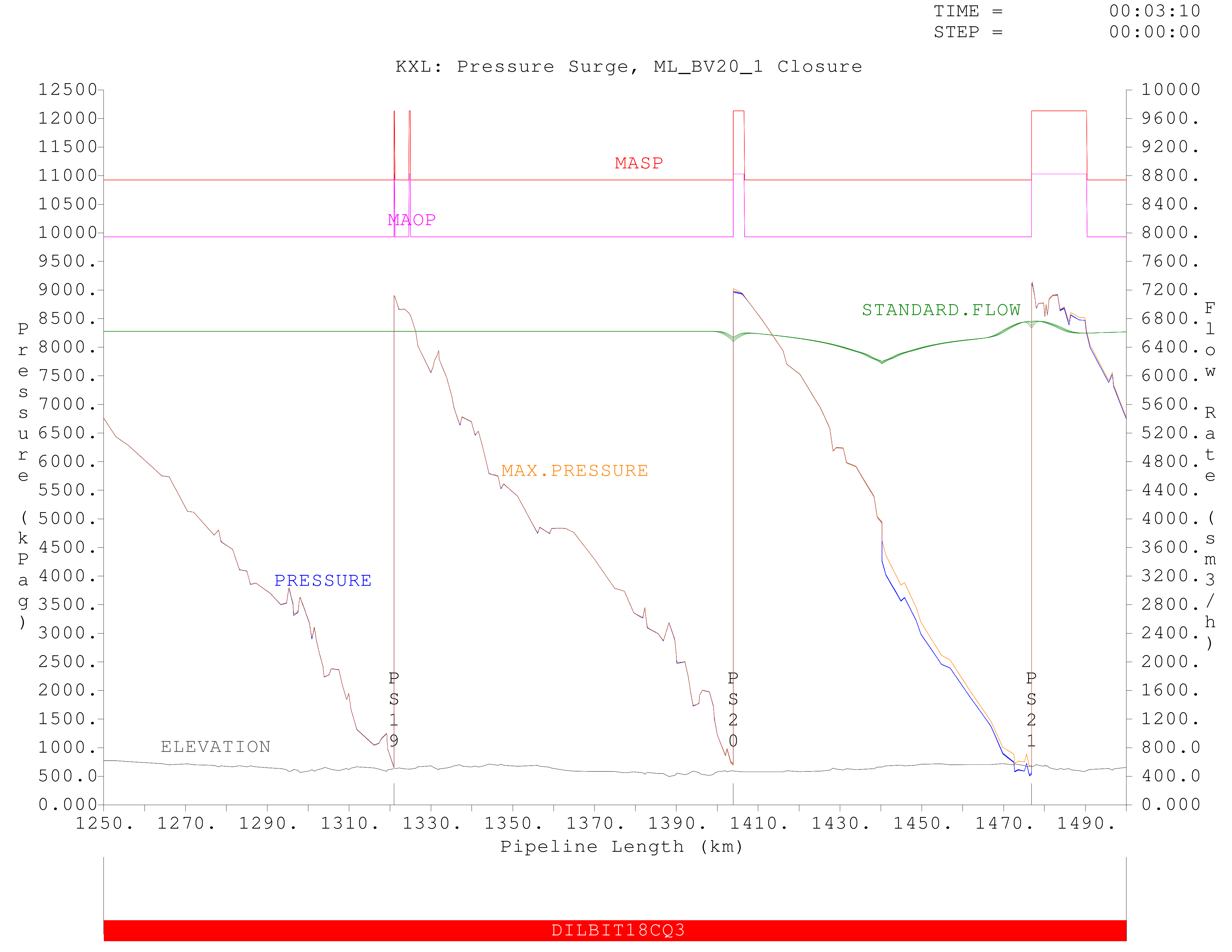
Scenario III

Mainline Valve at the Midpoint between Two Pump Stations

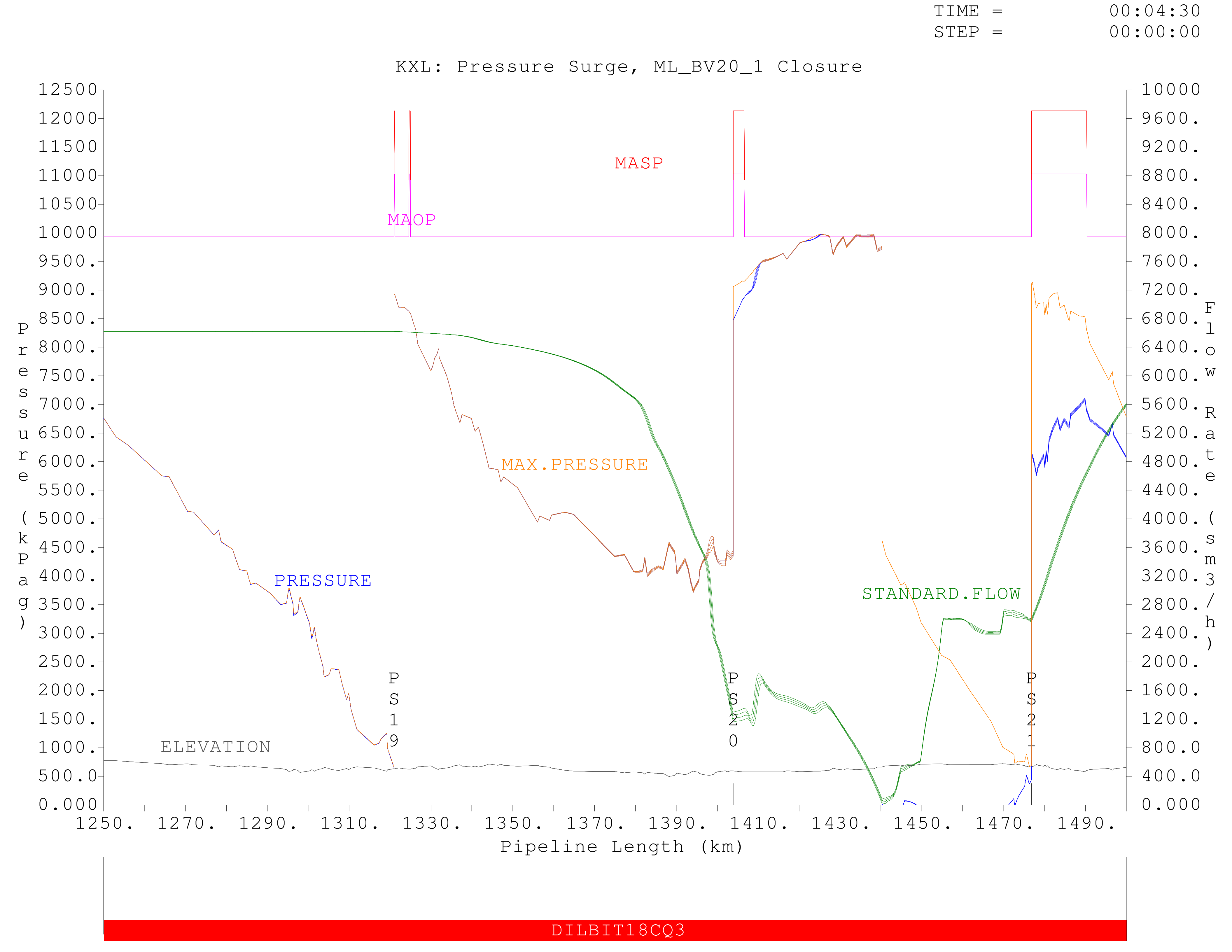
TIME = 00:00:00
STEP = 00:00:00




TIME = 00:02:30
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
PS19
PS20
PS21
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3

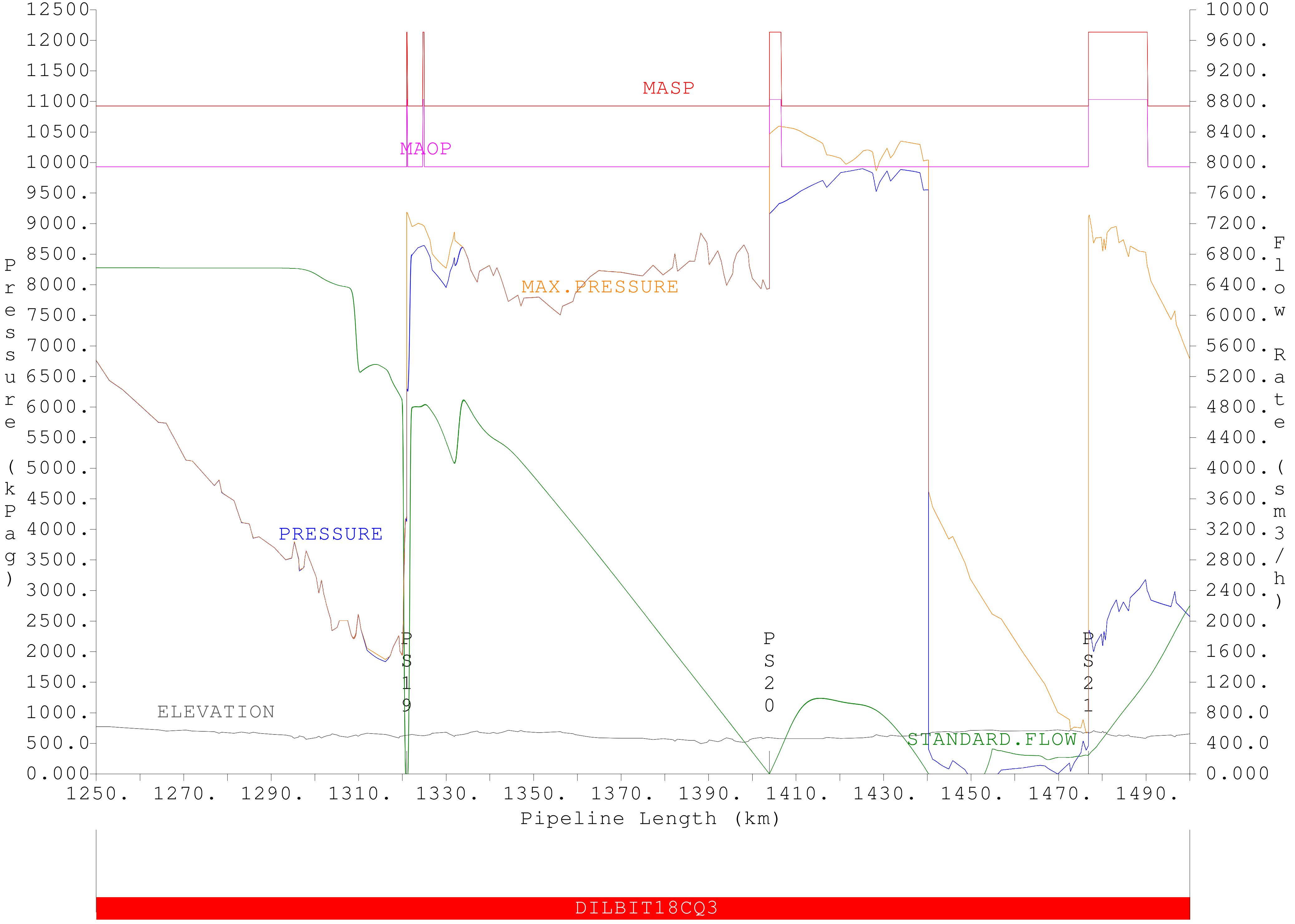


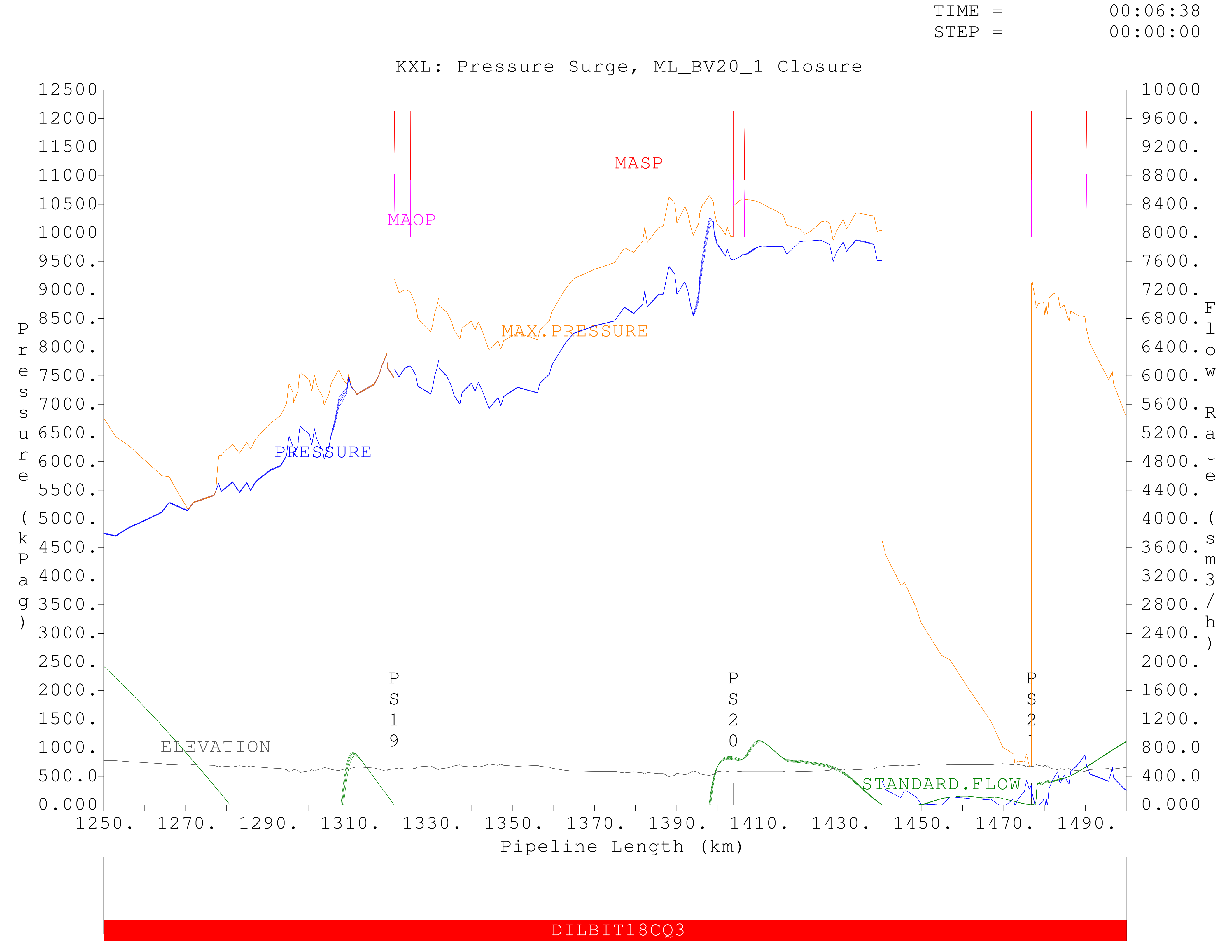
TIME = 00:03:10
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
PS19
PS20
PS21
Pressure (kPag)
Flow Rate (sm3/h)
12500
12000
11500
11000
10500
10000
9500.
9000.
8500.
8000.
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
3500.
3000.
2500.
2000.
1500.
1000.
500.0
0.000
10000
9600.
9200.
8800.
8400.
8000.
7600.
7200.
6800.
6400.
6000.
5600.
5200.
4800.
4400.
4000.
3600.
3200.
2800.
2400.
2000.
1600.
1200.
800.0
400.0
0.000
1250. 1270. 1290. 1310. 1330. 1350. 1370. 1390. 1410. 1430. 1450. 1470. 1490.
Pipeline Length (km)
DILBIT18CQ3

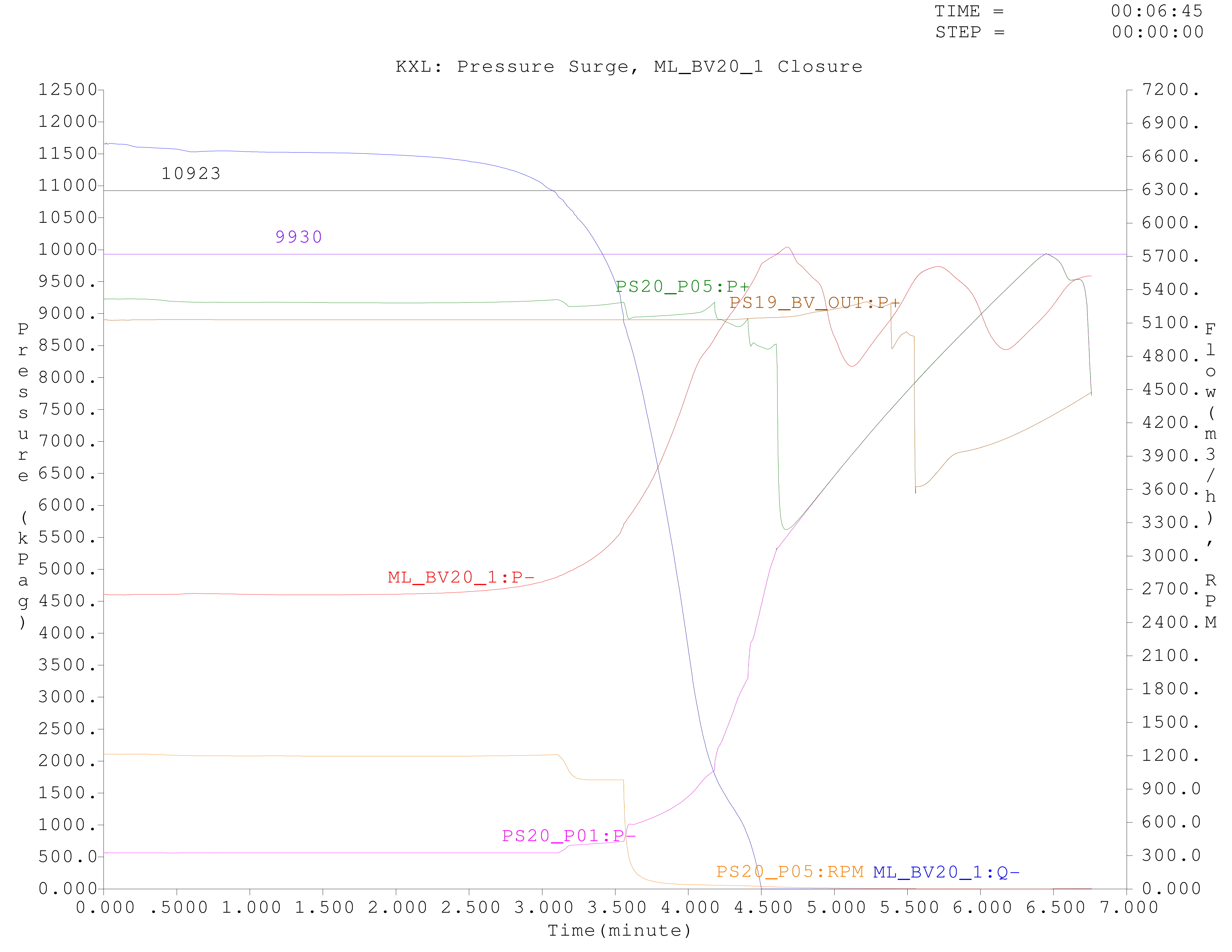

TIME = 00:04:30
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
MASP
MAOP
MAX.PRESSURE
PRESSURE
STANDARD.FLOW
ELEVATION
PS19
PS20
PS21
Pressure (kPag)
Flow Rate (sm3/h)
Pipeline Length (km)
DILBIT18CQ3

TIME = 00:05:33
STEP = 00:00:00

KXL: Pressure Surge, ML_BV20_1 Closure




TIME = 00:06:38
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
Pressure (kPag)
Flow Rate (sm3/h)
12500
12000
11500
11000
10500
10000
9500.
9000.
8500.
8000.
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
3500.
3000.
2500.
2000.
1500.
1000.
500.0
0.000
10000
9600.
9200.
8800.
8400.
8000.
7600.
7200.
6800.
6400.
6000.
5600.
5200.
4800.
4400.
4000.
3600.
3200.
2800.
2400.
2000.
1600.
1200.
800.0
400.0
0.000
MASP
MAOP
MAX.PRESSURE
PRESSURE
ELEVATION
STANDARD.FLOW
PS19
PS20
PS21
1250.
1270.
1290.
1310.
1330.
1350.
1370.
1390.
1410.
1430.
1450.
1470.
1490.
Pipeline Length (km)
DILBIT18CQ3


TIME = 00:06:45
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
Pressure (kPag)
Flow(m3/h), RPM
Time(minute)
10923
9930
PS20_P05:P+
PS19_BV_OUT:P+
ML_BV20_1:P-
PS20_P01:P-
PS20_P05:RPM
ML_BV20_1:Q-
12500
12000
11500
11000
10500
10000
9500.
9000.
8500.
8000.
7500.
7000.
6500.
6000.
5500.
5000.
4500.
4000.
3500.
3000.
2500.
2000.
1500.
1000.
500.0
0.000
7200.
6900.
6600.
6300.
6000.
5700.
5400.
5100.
4800.
4500.
4200.
3900.
3600.
3300.
3000.
2700.
2400.
2100.
1800.
1500.
1200.
900.0
600.0
300.0
0.000
0.000 .5000 1.000 1.500 2.000 2.500 3.000 3.500 4.000 4.500 5.000 5.500 6.000 6.500 7.000

Provide additional detail on “Pipeline segments operating immediately downstream and at lower elevations than a pump station.”

Response:

The maximum operating pressure (MOP) of the KXL Pipeline system is designated as 1440 psig throughout the pipeline except for some segments, which have an MOP of 1600 psig. The 1600 psig sections are not being requested for operation at 80%SMYS.

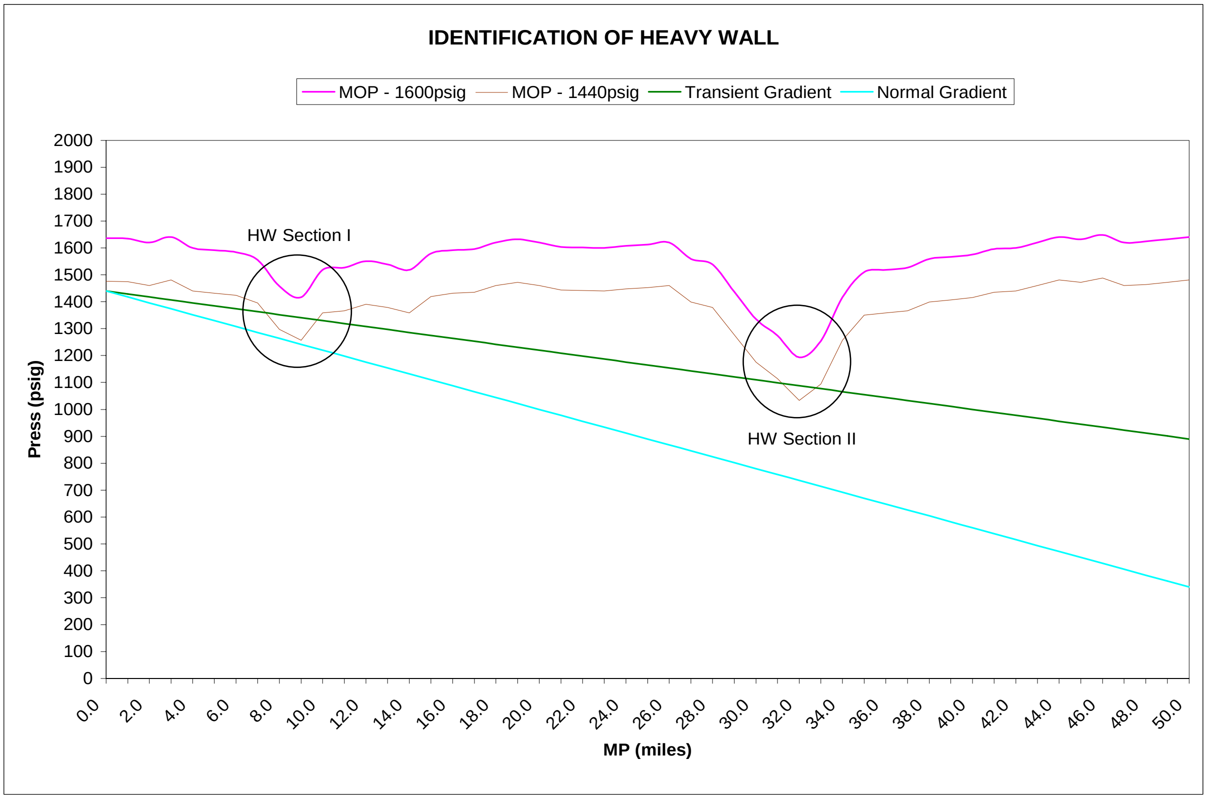
The heavy wall segments are identified considering both the elevation profile as well as the operating pressures (gradient) under transient and normal conditions. It can be observed that low elevation points nearer to a pump station discharge would have the potential of higher gradient than 1440 psig MOP, because these locations may not have enough pressure drops to compensate the high gradient due to lower elevation.

This concept is illustrated with the following example:

Consider a pipeline section of fifty miles downstream of a pump station (PS-A). A pressure gradient is plotted for normal and transient pressure conditions of maximum discharge pressure at PS-A & maximum suction pressure at downstream station along with the corresponding elevation profile as shown in the attached graph.

It is evident, that the transient gradient violates the MOP (of 1440 psig) at two locations (marked as Section I & II) within the lower elevations. Though the normal operation gradient is acceptable in these sections, overpressure potential within these segments is eliminated by installation of pipe designed to operate at a higher MOP (1600 psig).

Response


IDENTIFICATION OF HEAVY WALL
MOP - 1600psig
MOP - 1440psig
Transient Gradient
Normal Gradient
Press (psig)
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
HW Section I
HW Section II
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
32.0
34.0
36.0
38.0
40.0
42.0
44.0
46.0
48.0
50.0
MP (miles)

Response to Spray Calculation in Comment 2008-0285-0016:

The Keystone XL pipeline will be buried at a depth of 48 inches below the grounds surface, ground cover will provide damping and absorption of most of the kinetic energy in the even of a pipeline breach. In most cases, industry experience dictates that crude oil would be expected to simply pool on the surface as opposed to spray in the immediate area of the release. Please refer to the attached paper for further information.

Keystone XL – Spray Analysis

TransCanada Keystone Pipeline, LP

November 19, 2009

Prepared by:

Dynamic Risk Assessment Systems, Inc.

Risk Assessment • Pipeline Integrity • Engineering • GIS • Data Management & Software

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1. Introduction

TransCanada Keystone (Keystone) requested that Dynamic Risk Assessment Systems, Inc. (Dynamic Risk) provide discussion relating to the calculation of spray distance in the event of a pipeline puncture. The details of this review are contained in this report.

2. Spray Analysis

In order to determine the potential distance that crude oil could theoretically be sprayed during a puncture incident, the worst case scenario of a 1-inch puncture on the 36-inch Keystone XL pipeline was modelled. No dampening effects of soil were considered.

2.1. Rate of Release

The rate of release of a leak/rupture failure can be modeled as an aperture with the local pressure by the Bernoulli Equation as follows: (Ref: *Methods for the Calculation of Physical Effects* Page 2.121).

$$q_s = C_d \times A_h \times \sqrt{\left(2\left(P - P_a\right) \times \rho_L\right)}$$

Equation 1

Where

A_h = cross-sectional area of the hole (in^2)

C_d = discharge coefficient (0.62 for sharp orifice)

P = total pressure at opening (psi)

P_a = atmospheric pressure (psi)

q_s = mass flow rate (lb/s)

ρ_L = liquid density (lb/ft^3)

Using Equation 1, a mass flow rate can be calculated. With a leak or rupture, a sharp orifice is assumed giving a discharge coefficient (C_d) of 0.62. A hole area (A_h) of 0.7854 in^2 was used as the basis of the analysis, corresponding to a hole diameter of one inch. The pressure differential is calculated by subtracting the atmospheric pressure (P_a) from the pipe pressure. These two values respectively are 14.7 psi and 1440 psi.

As the density of products transported in the pipeline will range from 51.1285 lb/ft^3 to 58.0580 lb/ft^3, both densities were modeled in this analysis.

Using these variables, the mass flow rate is calculated to be between 87.8715 lb/s and 93.6370 lb/s. This mass flow rate is then converted to a release velocity by dividing by the material density (51.1285 lb/ft^3 to 58.0580 lb/ft^3) and the cross-sectional area of the orifice (0.7854 in^2). In this way, the release velocity was determined to be 295.7 ft/s – 315.1 ft/s.

2.2. Calculation of Spray Zone

The release velocity can be used to calculate a worst case spray radius using kinematics equations. It should be noted that industry experience dictates that buried pipelines do not often result in above-ground trajectories of liquid product streams, which instead tend to pool on the surface in the immediate area of the release. These spray distance calculations therefore carry a high degree of conservatism, as they are representative of worst-case effects for above-ground pipelines. No viscosity factor was used in the calculation of the release viscosity, this further adds to the conservatism of these calculations.

A 45º trajectory was assumed as it represents the furthest possible radius of spray in the horizontal direction.

To calculate the potential spray distance, the horizontal and vertical components of velocity are first determined using the following equations:

$$V_{Vertical} = V \times \sin\theta$$

Equation 2

$$V_{Horizontal} = V \times \cos\theta$$

Equation 3

Where

V = calculated release velocity (ft/s)

Θ = angle of release (degrees)

For a 45-degree release angle, $V_{Vertical}$ is equal to $V_{Horizontal}$. A given cross-section will achieve its apex when its vertical velocity component is equal to zero. If the incident velocity is equal to the vertical component of the spray velocity from the orifice, the final velocity is equal to zero, and assuming a gravitational acceleration of 32.2 ft/s^2, one can determine the time it takes for a cross-section of crude to reach its apex using the following equations:

$$g = \frac{V_1 - V_2}{T_{Apex}}$$

Equation 4

Using this equation, T_{Apex} is calculated to be 6.5034 – 6.9300 seconds. Assuming the ground is level, the time it takes a given cross-section of crude to reach the apex of its trajectory will be half of the time it takes it to complete its trajectory. Since horizontal velocity is not subject to any significant forces of acceleration, the maximum spray distance is calculated using the following formula:

$$D_{Horizontal} = V_{Horizontal} \times (2 \times T_{Apex})$$

Equation 5

Using the variables calculated above, the maximum horizontal spray distance based on the calculations is 2719.7 – 3088.2 feet.

3. Industry Example

The analysis contained in Section 2 represents a conservative estimate of spray distance for above-ground pipelines. In actual practice, the spray distance will be less than cited in Section 2 due to viscosity and friction effects, as well as a spray angle that is unlikely to represent a worst-case situation. The degree of conservatism might be illustrated by considering actual pipeline industry incident examples.

3.1. Trans-Alaska Pipeline – Fairbanks, Alaska (October 4, 2001)

On October 4, 2001, operators of the NPS 48 Trans-Alaska pipeline detected a leak in the pipeline via helicopter patrol. The Trans-Alaska pipeline is an above ground pipeline that transports crude oil from Prudhoe Bay, Alaska to Valdez, Alaska.

Upon investigation, it was determined that the oil leak was a result of a bullet puncture on the side of the pipeline slightly above the horizontal axis of the pipeline. The puncture resulted in a spray of crude oil to the surrounding environment. The operating pressure of the pipeline at the time of the incident was 525 psi. The oil spray covered a distance of approximately 75 feet from the puncture site.

3.2. Lakehead Pipe Line Co. - Bemidji, Minnesota (August 20, 1979)

On August 20, 1979, Lakehead Pipe Line Co. experienced a seam weld related rupture of their NPS 34 pipeline near Bemidji, Minnesota. The cause of the failure was determined to be a failure of the pipeline's long seam.

The operating pressure of the pipeline at the time of the incident was approximately 500 psi. The oil spray covered a distance of approximately 394 feet from the rupture site.

3.3. Kinder Morgan Canada – Burnaby, British Columbia (Jul 24, 2007)

On July 24, 2007, an NPS 24 pipeline operated by Kinder Morgan Canada was punctured by a third party excavator. The height of the spray of oil was approximately 49 – 66 feet high. It should be noted that the extent of the spray was worsened by the closure of the downstream isolating valve which caused the pressure of the pipeline to rise from 75 psi to 250 psi. The oil spray covered a distance of approximately 197 feet from the rupture site.

4. Conclusions

The release velocity for crude oil from an aperture of 1-inch diameter in a pipeline with a 36-inch diameter and a pressure of 1440 psi was calculated. The release velocity calculated is 295.7 ft/s – 315.1 ft/s. This release velocity was calculated using the Bernoulli equation. From this release velocity, a worst case scenario for spray distance was calculated using kinematics equations. This worst case spray distance is 2719.7 – 3088.2 feet. These spray distance calculations therefore carry a high degree of conservatism, since a worst-case assumption was used on trajectory angle, and viscosity and friction effects were ignored.

It should be noted that because the Keystone XL pipeline will be buried at a depth of 48 inches below the grounds surface, ground cover will provide a damping and absorption of most of the kinetic energy. In most cases, industry experience dictates that crude oil would be expected to simply pool on the surface in the immediate area of the release. Industry experience with pipeline failures indicates that for above-ground pipelines, and failures of excavated pipelines, spray distances of 75 – 394 feet are more typical than the values obtained by applying a simple analysis that ignores viscosity and friction effects and that employs worst-case assumptions.

Provide additional info to expand on the following statement: “The alternative to the special permit is to continue to design, construct and operate the Project at 72% SMYS as per 49 C.F.R. § 195.106. This would result in an increased steel requirement for the project which in turn would increase the cost of transportation, stockpiling and certain construction activities, and reduction in pipeline capacity. Pursuing the alternative to the special permit would not allow Keystone to realize all the other potential benefits discussed in this document as well as those recognized by PHMSA in the Special Permit for the Keystone Pipeline and in 73 FR 62148 “Pipeline Safety: Standards for Increasing the Maximum Allowable Operating Pressure for Gas Transmission Pipelines; Final Rule”.

Response:

Based on static and transient hydraulic modeling as well as current physical design of the pipeline system, operating the Keystone XL pipeline at 72% SMYS would require the installation of an additional 8 pump stations to achieve a similar throughput to that which is currently being proposed for the project. An additional 8 pump stations would expand the environmental footprint of the project including the construction of additional power transmission infrastructure to supply these stations. Finally, the additional 8 pump stations would require a significant amount of incremental consumption of electricity over that of a pipeline operating at 80% SMYS and transmitting the same capacity.

Are there any elements in the crude oil content that can cause internal corrosion? If so, what are they and what are the measures to address?

Response:

The primary constituent in crude oil content that can cause internal corrosion is water, which can potentially corrode steel. In pipelines that do not operate at elevated pressures or turbulent flows, water droplets can fall out from the flow stream and provide an environment for anaerobic bacteria to multiply, potentially leading to microbial-induced internal corrosion.

Measures to address internal corrosion are as follows:

- The commodities will be batched within the pipeline in a turbulent flow regime
- Composite samples will be collected from all batches upon receipt and delivery
- Chemical corrosion inhibitors, biocides, corrosion coupons or probes may be used
- Pipeline cleaning tools will be used on an as required basis
- In-line inspection will be performed to detect and monitor internal corrosion.
- 0.5% solid and water content for commodities to be transported has been specified by tariff
- Random testing of samples for sulfur, micro carbon residue (MCR), total acid number (TAN) will be undertaken in order to monitor and assess pipeline system performance.

There is some concern that even if the process flushes some solids and other "nasty stuff" out, there may be other content that could cause corrosion. Do you have documentation and can you provide content numbers (or at least maximum accepted limits) for the following:

- Volatile Organic Compounds (VOCs) Content
- H2S Content
- Sulfur Content
- CO2 Content
- API gravity limits

We understand you haven't received product specific information from the shippers yet, but does Keystone/TCPL have these limits called out in a procedure or other documentation you can share?

Response:

The majority of the crude oil to be transported by the Project is expected to be derived from the Alberta oil sands region in Canada (i.e., the Western Canadian Sedimentary Basin [WCSB]). The oil extracted from the oil sands is called bitumen, which is highly viscous. In order for the bitumen to be transported by pipeline, it is either mixed with a diluent and transported as diluted bitumen or upgraded to synthetic crude oil. The precise composition of diluted bitumen and synthetic crude oil will determined by shippers and is considered proprietary information. However, these crude oil types are no different than those which are currently being shipped into the United States by other existing international transmission pipelines. In addition, diluted bitumen is similar to other crude oils derived from various locations throughout the world, such as portions of California, Venezuela, Nigeria, and Russia currently being imported into the United States.

The attached typical crude oil properties for heavy and light crude oils can be found on www.crudemonitor.ca. These attachments are provided through the Canadian Association of Petroleum Producers (CAPP), which has sponsored the collection and development of assay data on behalf of its member companies since 2001.

A representative comparison of the characteristics of the crude oils noted above can be made to any crude oil worldwide through the Government of Canada's oil properties database: http://www.etc-cte.ec.gc.ca/databases/OilProperties/Default.aspx. These data indicate that crude oils comparable to the WCSB crude oils shipped on the Keystone XL pipeline will not provide any unusual risk to transportation via pipeline.

Response

The tariff that will be filed with FERC for transportation on the Keystone XL pipeline will set forth the following specifications to govern the quality of the petroleum (i.e., crude oil) that shippers may tender for transportation:

- Reid Vapor Pressure shall not exceed one hundred and three kiloPascals (103kPa)
- sediment and water shall not exceed one-half of one percent (0.5%) of volume, as determined by the centrifuge method in accordance with ASTM D4007 standards (most current version) or by any other test that is generally accepted in the petroleum industry as may be implemented from time to time;
- the temperature at the Receipt Point shall not exceed thirty-eight degrees Celsius (38°C);
- the density at the Receipt Point shall not exceed nine hundred and forty kilograms per Cubic Meter (940 kg/m^3);
- the kinematic viscosity shall not exceed three hundred and fifty (350) square millimetres per second (mm^2/s) determined at the Carrier's reference line temperature as posted on Carrier's electronic bulletin board
- shall have no physical or chemical characteristics that may render such Petroleum not readily transportable by Carrier or that may materially affect the quality of other Petroleum transported by Carrier or that may otherwise cause disadvantage or harm to Carrier or the Pipeline System, or otherwise impair Carrier's ability to provide service on the Pipeline System.

Heavy Crude Quality Testing Project -- Typical Crude Properties

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
Access Western Blend														
	Average	3.95	22.1	70.98	192.70	10.67	0.64	8.61	81	236	308	500	683	717
	Upper	4.17	23.8	83.40	212.80	11.82	0.82	11.07	111	324	356	541	709	720
	Lower	3.72	20.4	58.55	172.60	9.51	0.46	6.15	51	148	260	459	656	715
Albian Heavy Synthetic														
	Average	2.53	19.5	43.12	90.40	10.88	1.57	2.97	156	264	306	447	584	713
	Upper	2.96	20.4	61.57	129.25	13.01	2.22	4.18	214	297	340	484	653	732
	Lower	2.09	18.6	24.67	51.54	8.74	0.93	1.75	98	232	271	411	515	694
Albian Residual Blend														
	Average	2.71	20.0	46.50	117.34	8.15	0.47	0.82	142	248	278	413	638	719
	Upper	3.12	21.0	55.35	135.05	9.91	1.04	1.53	251	258	306	488	651	721
	Lower	2.30	19.0	37.65	99.63	6.38	-0.11	0.10	33	238	249	339	625	717
Bow River North														
	Average	2.85	21.1	35.71	84.16	8.58	0.97	3.53	161	254	287	427	590	723
	Upper	3.20	23.3	45.80	103.00	9.66	1.68	4.92	214	290	320	468	656	742
	Lower	2.49	18.9	25.62	65.32	7.50	0.25	2.14	108	219	253	386	524	704
Bow River South														
	Average	2.79	23.3	30.55	82.01	8.20	0.96	3.00	148	233	267	416	582	720
	Upper	2.99	24.7	40.12	103.56	8.88	1.36	4.20	187	267	300	458	659	743
	Lower	2.59	21.9	20.98	60.46	7.52	0.57	1.81	108	199	234	375	506	697
Cold Lake														
	Average	3.60	20.7	62.33	160.50	10.62	1.00	6.79	109	248	291	457	634	721
	Upper	3.91	22.5	74.38	190.29	11.45	1.48	8.62	169	310	347	515	722	753
	Lower	3.30	19.0	50.29	130.70	9.80	0.53	4.96	49	186	235	399	546	689
Fosterton														
	Average	3.13	20.3	44.71	103.22	9.74	0.51	1.21	178	259	292	438	608	719
	Upper	3.30	21.4	52.96	122.75	10.78	1.11	1.90	207	284	316	468	666	736
	Lower	2.96	19.2	36.47	83.70	8.69	-0.10	0.51	148	233	267	407	551	702
Gibson Sour														
	Average	2.04	28.9	21.91	47.22	5.84	2.28	4.95	106	191	228	376	539	722
	Upper	2.32	31.4	29.86	64.11	7.04	3.37	7.09	159	256	285	418	612	756
	Lower	1.76	26.5	13.95	30.32	4.63	1.19	2.82	53	125	171	333	466	687

***Upper and Lower values reflect 2σ variability. The actual values will be between the noted Upper and Lower values 19 times out of 20**

Heavy Crude Quality Testing Project -- Typical Crude Properties

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
Light Sour Blend														
	Average	1.13	36.4	5.88	9.80	2.95	2.13	3.31	94	151	179	315	465	708
	Upper	1.49	39.0	10.17	18.46	4.07	2.78	4.18	109	198	232	383	549	723
	Lower	0.76	33.8	1.59	1.13	1.82	1.48	2.43	80	104	126	247	381	693
Lloyd Blend														
	Average	3.36	20.9	54.68	118.61	9.69	2.13	4.80	133	261	299	459	635	722
	Upper	3.59	22.5	66.02	143.40	10.50	2.65	6.01	198	295	328	510	718	743
	Lower	3.13	19.3	43.35	93.82	8.88	1.60	3.59	69	227	270	408	553	702
Lloyd Kerrobert														
	Average	3.08	20.6	43.88	98.05	9.39	2.93	4.35	156	268	302	451	623	721
	Upper	3.34	22.2	56.04	119.07	10.05	5.12	6.45	229	317	351	507	708	741
	Lower	2.81	19.0	31.72	77.02	8.72	0.73	2.24	82	219	254	396	538	702
Long Lake Heavy														
	Average	2.86	20.8	46.69	126.91	7.00	0.71	1.77	186	267	296	413	588	716
	Upper	3.35	23.2	55.19	151.88	8.41	1.05	2.75	226	297	323	441	658	722
	Lower	2.37	18.5	38.20	101.94	5.60	0.38	0.80	147	237	268	385	519	710
Mackay River														
	Average	2.78	19.6	43.32	112.34	6.93	1.03	1.64	197	278	303	394	545	718
	Upper	3.16	20.6	55.95	139.57	8.42	1.41	2.61	231	304	329	439	621	737
	Lower	2.41	18.6	30.70	85.11	5.44	0.66	0.67	164	253	277	350	468	698
Midale														
	Average	2.33	29.6	15.77	29.70	5.80	1.57	2.42	112	182	214	361	525	713
	Upper	2.67	30.9	20.94	39.24	6.67	1.96	3.09	146	212	246	400	591	744
	Lower	1.99	28.3	10.60	20.16	4.94	1.18	1.75	77	151	183	323	459	683
Mixed Sour Blend														
	Average	1.61	31.6	19.46	41.84	5.22	3.61	4.62	101	178	218	378	550	714
	Upper	2.06	36.2	29.30	61.25	6.51	5.41	8.19	141	234	272	420	610	722
	Lower	1.16	27.1	9.62	22.43	3.94	1.81	1.04	60	122	165	336	490	707
Peace River Heavy														
	Average	4.55	20.9	51.98	150.62	8.96	0.78	6.45	120	224	263	431	618	720
	Upper	5.51	22.6	68.46	205.49	10.74	1.20	9.78	173	293	336	505	716	737
	Lower	3.58	19.3	35.49	95.76	7.18	0.35	3.11	67	155	191	357	519	703

***Upper and Lower values reflect 2σ variability. The actual values will be between the noted Upper and Lower values 19 times out of 20**

Heavy Crude Quality Testing Project -- Typical Crude Properties

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
SE Saskatchewan														
	Average	1.48	34.6	6.33	9.90	3.67	1.97	3.00	102	160	189	322	469	704
	Upper	1.76	36.0	9.72	15.38	4.61	2.42	3.32	127	180	209	357	527	736
	Lower	1.21	33.2	2.94	4.41	2.73	1.51	2.67	76	140	168	287	411	672
Seal Heavy														
	Average	4.59	20.6	59.21	165.89	9.37	1.74	4.44	120	231	275	466	664	717
	Upper	4.88	21.9	71.09	199.99	10.36	2.71	5.43	149	261	303	504	715	720
	Lower	4.31	19.4	47.33	131.78	8.39	0.77	3.46	92	201	247	429	613	714
SHE														
	Average	1.65	34.8	15.67	42.84	3.77	1.76	4.17	101	153	181	324	486	710
	Upper	2.20	38.6	23.43	63.17	4.92	2.64	6.41	127	189	221	361	544	722
	Lower	1.09	31.1	7.91	22.51	2.63	0.88	1.93	75	117	141	286	427	698
SLE														
	Average	0.98	38.0	7.73	18.14	2.57	2.37	4.47	88	133	158	296	451	705
	Upper	1.29	41.3	15.28	37.38	3.81	3.98	6.45	109	153	182	329	495	721
	Lower	0.68	34.7	0.17	-1.10	1.32	0.77	2.49	67	112	134	262	408	689
Smiley-Coleville														
	Average	2.95	19.9	34.27	93.44	9.38	1.01	3.81	155	260	295	448	620	722
	Upper	3.12	21.3	40.83	107.19	9.98	1.51	4.71	199	294	328	487	693	739
	Lower	2.79	18.5	27.71	79.70	8.79	0.51	2.90	110	226	263	409	547	705
Suncor Synthetic H														
	Average	3.02	19.9	3.12	7.97	0.63	0.65	1.49	246	323	339	394	445	679
	Upper	3.14	20.6	6.43	15.38	1.32	1.01	2.02	282	331	345	400	451	742
	Lower	2.90	19.2	-0.19	0.56	-0.07	0.29	0.97	211	316	332	387	438	617
Surmont Heavy Blend														
	Average	2.88	19.8	49.09	133.01	7.09	0.82	1.33	197	270	297	413	593	716
	Upper	3.11	21.0	55.41	153.97	7.97	1.07	1.84	221	286	311	422	613	721
	Lower	2.66	18.6	42.77	112.05	6.20	0.57	0.83	173	255	284	404	572	711
Wabasca Heavy														
	Average	3.77	21.0	48.90	132.16	8.52	1.73	2.61	145	236	274	437	620	722
	Upper	4.26	22.9	59.80	156.85	9.27	2.99	3.51	184	280	314	486	698	741
	Lower	3.27	19.1	38.01	107.47	7.77	0.48	1.71	106	193	234	389	542	703

***Upper and Lower values reflect 2σ variability. The actual values will be between the noted Upper and Lower values 19 times out of 20**

Heavy Crude Quality Testing Project -- Typical Crude Properties

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
Western Canadian Blend														
	Average	3.03	20.6	44.27	92.00	8.68	0.77	3.42	167	263	296	445	625	721
	Upper	3.24	22.2	55.12	114.44	9.41	1.03	4.83	214	289	319	480	693	744
	Lower	2.81	19.1	33.41	69.56	7.94	0.50	2.01	121	236	273	411	557	699
Western Canadian Select														
	Average	3.32	20.5	53.57	129.84	9.35	2.03	3.91	161	268	303	451	632	717
	Upper	3.64	22.1	65.80	156.46	10.10	2.75	5.04	227	311	341	498	707	722
	Lower	3.00	19.0	41.34	103.22	8.59	1.30	2.78	94	225	265	404	556	712

***Upper and Lower values reflect 2σ variability. The actual values will be between the noted Upper and Lower values 19 times out of 20**

Light Crude Quality Testing Project -- Typical Crude Properties

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
BC Light														
	Average	0.57	40.5	1.65	5.09	0.98	1.75	2.43	104	146	167	282	413	688
	Upper	0.64	42.1	3.01	9.30	1.38	2.46	2.87	129	165	184	303	440	723
	Lower	0.50	39.0	0.28	0.87	0.59	1.04	1.99	79	126	150	260	386	653
Bonnie Glen														
	Average	0.39	42.3	2.70	6.31	1.45	3.29	3.93	80	119	141	265	430	703
	Upper	0.53	45.1	4.58	11.50	2.32	4.66	5.42	112	142	161	300	499	734
	Lower	0.25	39.5	0.83	1.11	0.57	1.92	2.44	48	96	120	229	361	672
Boundary Lake														
	Average	0.76	36.1	8.93	27.71	2.66	1.44	2.44	113	163	188	314	460	701
	Upper	0.84	37.4	11.09	32.46	3.21	1.89	2.85	126	174	202	330	483	715
	Lower	0.68	34.9	6.77	22.96	2.11	0.99	2.03	99	151	174	298	437	688
CNRL Light Sweet Synthetic														
	Average	0.04	34.9				1.32	2.68	135	190	210	279	342	545
	Upper	0.06	36.3				1.88	3.49	142	194	213	283	349	574
	Lower	0.02	33.5				0.77	1.88	128	186	208	274	335	516
Federated														
	Average	0.39	40.0	3.18	6.55	1.64	2.80	3.23	95	135	155	276	426	698
	Upper	0.47	41.7	5.32	10.98	2.15	4.18	4.35	122	157	176	308	473	735
	Lower	0.30	38.4	1.04	2.13	1.13	1.42	2.12	68	113	134	244	380	660
Gibson Light Sour														
	Average	1.16	37.7	18.42	47.61	4.09	4.37	5.69	71	115	141	340	533	709
	Upper	2.79	43.5	45.37	125.42	7.97	6.72	9.25	75	130	154	418	691	724
	Lower		31.9	0.00	0.00	0.20	2.01	2.13	66	100	129	263	376	694
Gibson Light Sweet														
	Average	0.42	41.3	3.74	7.31	1.72	3.69	4.94	78	121	143	284	438	702
	Upper	0.53	43.3	5.55	11.71	2.41	5.81	8.60	97	148	181	319	469	720
	Lower	0.31	39.3	1.94	2.91	1.03	1.57	1.28	60	93	106	250	407	685
Husky Synthetic Blend														
	Average	0.10	32.6	0.37	0.93	0.06	2.94	1.56	177	236	255	329	403	591
	Upper	0.14	34.0	0.93	1.81	0.17	3.66	2.18	196	251	269	342	416	656
	Lower	0.07	31.2	0.00	0.04	0.00	2.22	0.94	159	221	241	315	389	527

***Upper and Lower values reflect 2σ variability. The actual values will be between the noted Upper and Lower values 19 times out of 20**

Light Crude Quality Testing Project -- Typical Crude Properties

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
Joarcam														
	Average	0.41	39.2	3.88	8.36	2.11	2.09	7.34	86	142	173	320	474	711
	Upper	0.60	43.1	6.02	12.94	3.01	4.36	13.03	126	184	214	349	507	725
	Lower	0.23	35.3	1.73	3.79	1.20	0.00	1.64	46	100	132	291	441	697
Kerrobert Sweet														
	Average	0.29	36.8	4.26	5.65	2.34	2.93	2.93	101	155	183	318	467	708
	Upper	0.39	39.0	5.86	9.97	2.70	3.61	4.92	119	183	215	347	504	724
	Lower	0.18	34.5	2.65	1.34	1.99	2.25	0.94	83	127	152	289	430	692
Koch Alberta														
	Average	1.06	34.7	10.30	18.38	3.56	1.70	3.44	103	154	179	318	476	713
	Upper	1.24	38.5	14.57	27.61	4.29	3.48	6.34	138	192	218	358	530	734
	Lower	0.89	30.9	6.04	9.15	2.82	0.00	0.54	68	116	140	278	422	693
Long Lake Light Synthetic														
	Average	0.12	36.5	1.10	2.10	0.20	1.46	2.50	124	189	212	301	384	569
	Upper	0.23	37.2	1.10	2.10	0.20	1.99	2.84	124	189	212	301	384	569
	Lower	0.01	35.9	1.10	2.10	0.20	0.94	2.15	124	189	212	301	384	569
Mixed Sweet Blend														
	Average	0.45	39.2	4.07	7.68	1.97	2.61	3.75	95	140	164	298	449	704
	Upper	0.50	40.6	6.05	10.66	2.43	3.80	4.75	121	161	185	324	494	730
	Lower	0.39	37.8	2.08	4.69	1.51	1.42	2.76	68	119	144	272	404	679
Peace														
	Average	0.43	39.8	3.47	6.39	1.71	1.87	3.44	99	139	161	287	440	697
	Upper	0.50	41.8	5.28	10.14	2.14	2.41	4.38	126	161	183	325	502	733
	Lower	0.36	37.8	1.66	2.64	1.28	1.32	2.49	72	118	138	249	378	661
Peace River Sour														
	Average	1.69	34.6	16.24	45.15	3.79	1.49	3.30	108	161	188	329	502	712
	Upper	2.36	39.2	25.29	71.55	5.21	2.09	4.74	134	190	220	369	559	723
	Lower	1.03	30.0	7.20	18.74	2.38	0.88	1.86	83	132	156	290	446	701
Pembina														
	Average	0.42	38.8	3.40	7.05	1.93	2.02	3.39	97	140	162	299	457	704
	Upper	0.49	40.8	5.09	10.40	2.46	3.57	4.29	122	162	186	332	501	732
	Lower	0.34	36.8	1.71	3.69	1.39	0.46	2.49	72	118	139	267	414	676

***Upper and Lower values reflect 2σ variability. The actual values will be between the noted Upper and Lower values 19 times out of 20**

Light Crude Quality Testing Project -- Typical Crude Properties

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
Pembina Light Sour														
	Average	0.75	40.2	2.17	5.45	1.47	3.34	2.90	95	135	155	273	423	700
	Upper	0.84	41.1	4.02	8.71	2.01	4.64	3.43	106	148	169	294	450	724
	Lower	0.65	39.3	0.32	2.19	0.93	2.05	2.37	84	122	141	253	397	676
Premium Albian Synthetic														
	Average	0.10	33.5	2.22	4.30	0.20	0.34	0.52	163	203	217	279	337	561
	Upper	0.34	35.5	5.00	9.25	0.64	0.64	1.13	191	227	242	307	371	679
	Lower		31.5	0.00	0.00	0.00	0.04	0.00	135	178	193	250	303	444
Rainbow														
	Average	0.47	38.7	4.84	8.60	2.29	2.95	3.46	101	150	173	303	459	706
	Upper	0.60	40.4	7.77	15.08	2.80	3.86	4.29	130	173	195	337	519	731
	Lower	0.33	37.1	1.91	2.13	1.78	2.03	2.64	71	127	150	269	399	681
Redwater														
	Average	0.45	35.1	10.23	5.15	3.34	1.74	2.93	106	166	195	338	500	712
	Upper	0.52	37.9	18.97	10.12	3.96	2.49	5.08	134	192	226	379	595	735
	Lower	0.38	32.2	1.48	0.17	2.72	1.00	0.78	77	141	165	298	406	690
Shell Synthetic Light														
	Average	0.10	33.7		1.30	0.14	0.46	0.94	125	235	269	348	407	589
	Upper	0.14	35.8		1.50	0.27	0.81	1.49	141	239	272	355	417	614
	Lower	0.05	31.7		1.10	0.02	0.11	0.38	110	231	266	341	397	563
Suncor Synthetic A														
	Average	0.19	33.1	0.57	1.49	0.02	1.81	2.97	134	197	225	315	382	573
	Upper	0.25	35.4	2.52	4.14	0.13	2.66	3.90	157	220	247	331	396	636
	Lower	0.14	30.9	0.00	0.00	0.00	0.97	2.03	111	174	202	300	367	511
Syncrude Synthetic														
	Average	0.13	31.5	0.36	0.79	0.05	1.90	2.42	148	212	235	321	401	602
	Upper	0.20	33.6	1.07	1.50	0.16	2.51	3.08	172	233	256	341	422	658
	Lower	0.06	29.4	0.00	0.07	0.00	1.29	1.76	125	191	214	301	380	545
Tundra Sweet														
	Average	0.42	39.9	4.90	2.00	1.74	2.92	2.47	97	138	160	269	403	693
	Upper	0.55	41.1	7.15	3.53	2.16	3.96	2.93	105	149	169	282	425	721
	Lower	0.30	38.8	2.65	0.47	1.33	1.88	2.01	90	127	151	257	381	664

***Upper and Lower values reflect 2σ variability. The actual values will be between the noted Upper and Lower values 19 times out of 20**

Are there any elements in the crude oil content that can be detrimental to the public if released? If so, what are they, what are risks/impact to the public with that particular content, and what are the company specific emergency response procedures to address?

Response:

The composition of crude oil varies widely, depending on the source and processing. Crude oils are complex mixtures of hundreds of organic (and a few inorganic) compounds. These compounds differ in their solubility, toxicity, persistence, and other properties that profoundly affect their impact on the environment. The effects of a specific crude oil cannot be thoroughly understood without taking its composition into account.

For the purposes of this analysis, transportation of two crude oil types will be assumed: synthetic crude oil and diluted bitumen. This analysis assumes that the pipeline will contain segregated batches of these two products. The primary classes of compounds found in crude oil are alkanes (hydrocarbon chains), cycloalkanes (hydrocarbons containing saturated carbon rings), and aromatics (hydrocarbons with unsaturated carbon rings). Most crude oils are more than 95 percent carbon and hydrogen, with small amounts of sulfur, nitrogen, oxygen, and traces of other elements. Crude oils contain lightweight straight-chained alkanes (e.g., hexane, heptane); cycloalkanes (e.g., cyclyohexane); aromatics (e.g., benzene, toluene); cycloalkanes; and heavy aromatic hydrocarbons (e.g., polycyclic aromatic hydrocarbons [PAHs], asphaltines). Straight-chained alkanes are more easily degraded in the environment than branched alkanes. Cycloalkanes are extremely resistant to biodegradation. Aromatics (i.e., benzene, toluene, ethylbenzene, xylenes compounds) pose the most potential for environmental concern because of their lower molecular weight, they are more soluble in water than alkanes and cycloalkanes.

Overall, the environmental fate of crude oil is controlled by many factors and persistence is difficult to predict with great accuracy. Major factors affecting the environmental fate include spill volume, type of crude oil, dispersal rate of the crude oil, terrain, receiving media, and weather. The speed and efficiency of emergency response containment and cleanup largely dictates the fate and extent of transport within the environment.

The emergency response procedures (ERP) are not based on a specific component in crude oil but developed to address the entire range of crude oil content and type to be transported. The equipment, response and clean up techniques do not differ.

An evaluation of the potential impacts resulting from the accidental release of crude oil into the environment is discussed by environmental resource below.

Soils

Because pipelines are buried, soil absorption of spilled crude oil could occur, thus impacting the soils. Subsurface releases to soil tend to disperse slowly and are generally located within a contiguous and discrete area, often limited to the less consolidated soils (lower soil bulk density) within the pipeline trench. Effects to soils can be quite slow to develop, allowing time for emergency response and cleanup actions to mitigate effects to potential receptors.

In the event of a spill, a portion of the released materials would enter the surrounding soil and disperse both vertically and horizontally in the soil. The extent of dispersal would depend on a number of factors, including speed and success of emergency containment and cleanup, size and rate of release, topography of the release site, vegetative cover, soil moisture, bulk density, and soil porosity. High rates of release from the buried pipeline would result in a greater likelihood that released materials would escape the trench and reach the ground surface.

If a release were to occur in sandy soils encountered along the Project route, it is likely that the horizontal and vertical extent of the contamination would be greater than in areas containing more organic soils. Crude oil released into sandy soils would likely become visible to aerial surveillance due to product on the soils surface or discoloration of nearby vegetation, which will facilitate emergency response and soil remediation efforts. If present, soil moisture and moisture from precipitation would increase the dispersion and migration of crude oil.

The majority of the Project alignment is located in relatively flat or moderately rolling terrain. In these areas, the oil would generally begin dispersing horizontally within the pipeline trench, and with sufficient spill volume or flow, then the oil could move out of the trench onto the soils surface, generally moving toward low lying areas. If the spill were to occur on a steep slope where trench breakers had been installed during construction, then crude oil would pool primarily within the trench behind any trench breakers. If sufficient volume existed, the crude oil would breach the soil's surface as it extended over the top of the trench breaker. In either case, once on the soil's surface, the release would be more apparent to leak surveillance patrols, facilitating emergency response and remediation.

Both on the surface and in the subsurface, rapid attenuation of light, volatile constituents (due to evaporation) would quickly reduce the total volume of crude oil, while heavier constituents would be more persistent. Except in rare cases of high rate and high total volume releases with environmental settings characterized by steep topography or karst terrain, soil impacts would be confined to a relatively small, contiguous, and easily defined area, facilitating cleanup and remediation. Within a relatively short time, lateral migration would generally stabilize. Downward vertical migration would begin at the onset of a spill, with rates governed by soil permeability. For example, in soils with moderately high permeability, water may penetrate 2.5 inches per hour, while penetration rates for soils of low permeability may occur at 0.05 inch per hour. Crude oil is more viscous than water, therefore, permeability of crude oil would be slower.

In accordance with federal and state regulations, Keystone would be responsible for cleanup of contaminated soils and would be required to meet applicable cleanup levels. Soil cleanup levels for benzene from petroleum hydrocarbon releases vary by state (Montana: 0.04 part per million [ppm]; South Dakota: 17 ppm; Nebraska: 3.63 ppm; Kansas: 9.8 ppm; Oklahoma: no value; Texas: 38 ppm). While Oklahoma has no benzene soil cleanup standard, other risk-based screening values exist for petroleum hydrocarbons and, consequently, soils would still be remediated to ensure human health and environmental quality. Once remedial cleanup levels were achieved in the soils, no adverse or long-term impacts would be expected.

It is difficult to estimate the volume of soil that might be contaminated in the event of a spill. Site-specific environmental conditions (e.g., soil type, weather conditions) and release dynamics (e.g., leak rate, leak duration) would result in substantially different surface spreading and infiltration rates, which in turn, affect the final volume of affected soil to be remediated. Based on historical data (PHMSA 2008), soil remediation involved 100 cubic yards of soil or less at the majority of spill sites where soil contamination occurred, and only 3 percent of the spill sites required remediation of 10,000 cubic yards or more (PHMSA 2008).

Vegetation

Crude oil released to the soil's surface could potentially produce localized effects on plant populations. While a release of crude oil could result in the contamination of soils, resulting in potential effects to vegetation. Keystone will be responsible for cleanup of contaminated soils. Once remedial cleanup levels were achieved in the soils, no adverse or long-term impacts to vegetation would be expected.

Water Resources

Crude oil could be released to water resources if the pipeline is breached or leaks occur. As part of project planning and in recognition of the environmental sensitivity of waterbodies, the Project routing process attempted to minimize the number waterbodies crossed, including groundwater aquifers. Furthermore, valves have been strategically located along the Project route to help reduce the amount of crude oil that could potentially spill into waterbodies, if such an event were to occur. The location of valves, spill containment measures, and implementing actions in the Project Emergency Response Plan would mitigate adverse effects to both surface water and groundwater.

Groundwater

Multiple groundwater aquifers underlie the proposed Project. Vulnerability of these aquifers is a function of the depth to groundwater and the permeability of the overlying soils. While routine operation of the Project would not affect groundwater, there is the possibility that a release could migrate through the overlying surface materials and enter a groundwater system.

In general, the potential for groundwater contamination following a spill would be more probable in locations where a release into or on the surface of soils has occurred:

- Where a relatively shallow water table is present (as opposed to locations where a deeper, confined aquifer system is present);
- Where soils with high permeability are present throughout the unsaturated zone; and
- Where, in cooperation with federal and state agencies, the PHMSA (in cooperation with the US Geological Service [USGS] and other federal and state agencies) has identified specific groundwater resources that are particularly vulnerable to contamination. These resources are designated by PHMSA as HCAs

Depending on soil properties, the depth to groundwater, and the amount of crude oil in the unsaturated zone, localized groundwater contamination can result from the presence of free crude oil and the migration of its dissolved constituents. Crude oil is less dense than water and would tend to form a floating pool after reaching the groundwater surface. Movement of crude oil is generally quite limited due to adherence with soil particles, groundwater flow rates, and natural attenuation (i.e., microbial degradation) (Freeze and Cherry 1979; Fetter 1993). Those compounds in the crude oil that are soluble in water will form a larger, dissolved “plume.” This plume would tend to migrate laterally in the direction of groundwater flow.

Movement of dissolved constituents typically extends for greater distances than movement of pure crude oil in the subsurface, but is still relatively limited. Unlike chemicals with high environmental persistence (e.g., trichloroethylene, pesticides), the aerial extent of the dissolved constituents will stabilize over time due to natural attenuation processes. Natural biodegradation through metabolism by naturally occurring microorganisms is often an effective mechanism for reducing the volume of crude oil and its constituents. Natural attenuation will reduce most toxic compounds into non-toxic metabolic byproducts, typically carbon dioxide and water (Minnesota Pollution Control Agency 2005). Field investigations of more than 600 historical petroleum hydrocarbon release sites indicate the migration of dissolved constituents typically stabilize within several hundred feet of the crude oil source area (Newell and Conner 1998; USGS 1998). Over a longer period, the area of the contaminant plume may begin to reduce due to natural biodegradation. Removal of crude oil contamination will eliminate the source of dissolved constituents impacting the groundwater.

Most crude oil constituents are not water soluble. For those constituents that are water soluble (e.g., benzene) the dissolved concentration is not controlled by the amount of oil in contact with the water, but by the concentration of the specific constituent in the oil (Charbeneau et al. 2000;

Charbeneau 2003; Freeze and Cherry 1979). Studies of 69 crude oils found that benzene was the only aromatic or PAH compound tested that is capable of exceeding groundwater protection values for drinking water (i.e., maximum contaminant levels [MCLs] or Water Health Based Limits) (Kerr et al. 1999 as cited in O'Reilly et al. 2001).

If exposure to humans or other important resources would be possible from a release into groundwater, then regulatory standards, such as drinking water criteria (MCL) would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. For human health protection, the national MCL is an enforceable standard established by the USEPA and is designed to protect long-term human health. The promulgated drinking water standards for humans vary by several orders of magnitude for crude oil constituents. Of the various crude oil constituents, benzene has the lowest national MCL at 0.005 ppm[1] and, therefore, it was used to evaluate impacts on drinking water supplies, whether from surface water or groundwater. However, emergency response and remediation efforts have the potential for appreciable adverse environmental effects from construction/cleanup equipment. If no active remediation activities were undertaken, natural biodegradation and attenuation would ultimately allow a return to preexisting conditions in both soil and groundwater. Depending on the amount of crude oil reaching the groundwater and natural attenuation rates, this would likely require up to tens of years. Keystone will utilize the most appropriate cleanup procedure as determined in cooperation with the applicable federal and state agencies.

Flowing Surface Waters

Keystone has evaluated impacts to downstream drinking water sources by comparing projected surface water benzene concentrations with the national MCL for benzene. Like other pipelines already in existence, the Project will cross hundreds of perennial, intermittent, and ephemeral streams.

The following extremely conservative assumptions were developed to over-estimate potential spill effects for planning purposes.

- The entire volume of a spill reaches the large waterbody, regardless of downstream distance;
- Benzene instantaneously reaches its maximum solubility (less than 1.2 mg/L[2]) within the water column.

Under the actual conditions of a crude oil release, the spill volume capable of reaching the large waterbody and benzene concentration outlined by these assumptions are not expected to occur at the very high levels described.

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[1] All affected states along the Project route use the national MCL value of 0.005 ppm.

[2] Solubility of benzene is limited by the concentration of benzene within the crude oil. This analysis used the US Environmental Protection Agency's (2009) solubility limit of 1.2 mg/L, a value appropriate for diesel fuel with a higher benzene content than crude oils. Thus, this analysis overestimates the amount of benzene likely to be dissolved within the water column.

Based on ultra-conservative assumptions, results suggest that most spills that enter a waterbody could result in exceedence of the national MCL for benzene. Although the assumptions used are highly conservative and, thus, overestimate potential benzene water concentrations, the analysis indicates the need for rapid notification of managers of municipal water intakes downstream of a spill so that any potentially affected drinking water intakes could be closed to bypass river water containing crude oil.

Risk also must consider the likelihood of an event occurring. Conservative occurrence intervals for a spill at any representative stream ranges from about 22,000 years for a large waterbody to over 830,000 years for a small waterbody (less likely to occur in any single small waterbody than any single large waterbody). If any release did occur, it is likely that the total release volume of a spill would be 3 barrels or less, based on PHMSA data for historical spill volumes.

In summary, while a release of crude oil directly into any given waterbody would likely cause an exceedence of drinking water standards under the highly conservative assumptions used in this analysis, the frequency of such an event would be very low. Nevertheless, streams and rivers with downstream drinking water intakes represent sensitive environmental resources and could be temporarily impacted by a crude oil release. Keystone's Emergency Response Plan contains provisions for protecting and mitigating potential impacts to drinking water.

Pipeline and Hazardous Materials Safety Administration
Docket Number PHMSA 2008-0285
TransCanada Keystone Pipeline, L.P.
Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to PHMSA

A portion of the EA and draft Special Permit Analysis and findings is related to providing some information on compliance history. Can you help clarify if the below operators are all under the TransCanada name (at least that are reportable to PHMSA)? Also, can you at least help provide a month/day when you took them over?

STATUS_ CODE	OPERATOR _ID	UPPER(A.OPERATOR_NAME)	UPPER (MOE.OWNER_NAME)
A	405	ANR PIPELINE CO	TRANSCANADA
A	6660	GREAT LAKES GAS TRANSMISSION CO	TRANSCANADA
A	13769	NORTHERN BORDER PIPELINE COMPANY	TRANSCANADA
A	15014	GAS TRANSMISSION NORTHWEST CORPORATION (GTN)	TRANSCANADA
A	30838	TUSCARORA GAS TRANSMISSION COMPANY	TRANSCANADA
A	31145	PORTLAND NATURAL GAS TRANSMISSION SYSTEM	TRANSCANADA
A	31891	NORTH BAJA PIPELINE LLC	TRANSCANADA
A	32334	TC OIL PIPELINE OPERATIONS INC	TRANSCANADA

Response:

TransCanada is the operator of all of the aforementioned pipeline systems. The official dates these companies were incorporated into TransCanada are cited below:

TC OIL PIPELINE OPERATIONS INC
- Incorporated on December 12, 2007

NORTH BAJA PIPELINE LLP
- November 2, 2004

PORTLAND NATURAL GAS TRANSMISSIONS SYSTEM
- August 3, 2004

TUSCARORA GAS TRANSMISSION COMPANY
- December 19, 2006

GAS TRANSMISSION NORTHWEST CORPORATION (GTN)
- November 2, 2004

Response

NORTHERN BORDER PIPELINE CORPORATION

- April 1, 2007

GREAT LAKES GAS TRANSMISSION CO

- February 22, 2007

ANR PIPELINE CO

- February 22, 2007

"We need answers for the following on crude oil quality and how it affects internal corrosion and environmentally to people and the environment, if Keystone should have a leak or spill. We do not see the below information in documents that Keystone has submitted. It needs to be included in the PHMSA Analysis and Findings document that will be referenced in the Federal Register Notice for the pipeline.

PHMSA requested additional information on relevant documentation and content numbers (or at least maximum accepted limits) for the following:

- Volatile Organic Compounds (VOCs) Content
- H2S Content
- Sulfur Content
- CO2 Content
- API gravity limits
- free water limits – BS&W – 0.5% solids and water content – "proposed" tariff"

Response:

The tariff that will be filed with FERC for transportation on the Keystone XL pipeline will set forth the following specifications to govern the quality of the petroleum (i.e., crude oil) that shippers may tender for transportation:

ARTICLE 4
QUALITY

4.1 **Permitted Petroleum**. Only that Petroleum having properties that conform to the specifications of Petroleum described in Sections 4.2, 4.3 and 4.4 will be permitted in the Pipeline System. Shipper will not Tender to Carrier, and Carrier will have no obligation to accept, transport or Deliver Petroleum which does not meet said specifications.

4.2 **Specifications of Petroleum**. For the purposes of Section 4.1, the specifications of the Petroleum shall be as follows: (i) Reid Vapor Pressure shall not exceed one hundred and three kiloPascals (103kPa); (ii) sediment and water shall not exceed one-half of one percent (0.5%) of volume, as determined by the centrifuge method in accordance with ASTM D4007 standards (most current version) or by any other test that is generally accepted in the petroleum industry as may be implemented from time to time; (iii) the temperature at the Receipt Point shall not exceed thirty-eight degrees Celsius (38°C); (iv) the density at the Receipt Point shall not exceed nine hundred and forty kilograms per Cubic Meter (940 kg/m^3); (v) the kinematic viscosity shall not exceed three hundred and fifty (350) square millimetres per second (mm^2/s) determined at the

Response

Carrier's reference line temperature as posted on Carrier's electronic bulletin board; and (vi) shall have no physical or chemical characteristics that may render such Petroleum not readily transportable by Carrier or that may materially affect the quality of other Petroleum transported by Carrier or that may otherwise cause disadvantage or harm to Carrier or the Pipeline System, or otherwise impair Carrier's ability to provide service on the Pipeline System.

4.3 **Modifications to Specifications**. Notwithstanding Sections 4.1 and 4.2, or any other provision in these Rules and Regulations to the contrary, Carrier shall have the right to make any reasonable changes to the specifications under Section 4.2 from time to time to ensure measurement accuracy and to protect Carrier, the Pipeline System or Carrier's personnel, provided that Carrier shall give Shipper reasonable notice of such changes prior to filing.

4.4 **Freedom from Objectionable Matter**. Petroleum shall not contain sand, dust, dirt, gums, impurities or other objectionable substances in quantities that may be injurious to Carrier, the Pipeline System or downstream facilities, or which may otherwise interfere with the transportation of Petroleum in the Pipeline System.

The Keystone XL pipeline is expected to transport primarily heavy crude oils. Below are the Material Safety Data Sheets (MSDS) for two of the most popular and largest heavy crude oils produced in Western Canada - Cold Lake and Western Canadian Select. These crudes are a blend of many different producers' products and thus provide a good basis for comparison with regards to heavy crude types. Between the MSDS and the information captured from crude monitor, all of contents in question can be addressed with exception to CO_2. There has been no record of a noteworthy presence of carbon dioxide in heavy crudes emanating from the WSCB. TransCanada expects that the crude transported by Keystone will contain little to no carbon dioxide and thus it's presence in the crude stream is negligible.

Crude		Sulphur (wt%)	API Gravity	Nickel (mg/L)	Vanadium (mg/L)	MCR (mass%)	TotalC4's (vol%)	TotalC5's (vol%)	Distillation Profile (%off at oC) 10%	20%	25%	50%	75%	FBP
Cold Lake														
	Average	3.60	20.7	62.33	160.50	10.62	1.00	6.79	109	248	291	457	634	721
	Upper	3.91	22.5	74.38	190.29	11.45	1.48	8.62	169	310	347	515	722	753
	Lower	3.30	19.0	50.29	130.70	9.80	0.53	4.96	49	186	235	399	546	689
Western Canadian Select														
	Average	3.32	20.5	53.57	129.84	9.35	2.03	3.91	161	268	303	451	632	717
	Upper	3.64	22.1	65.80	156.46	10.10	2.75	5.04	227	311	341	498	707	722
	Lower	3.00	19.0	41.34	103.22	8.59	1.30	2.78	94	225	265	404	556	712

SECTION 1 – MATERIAL IDENTIFICATION AND USE

Material Name: HEAVY CRUDE OIL/DILUENT MIX (CHRISTINA LAKE/FOSTER CREEK)
Use: Process stream, fuels and lubricants production
WHMIS Classification: Class B, Div. 2, Class D, Div. 2, Sub-Div. A and B
NFPA: Fire: 2 **Reactivity**: 0 **Health**: 3
TDG: **UN:** 1267 **Class:** 3
Packing Group: I (boiling point less than 35 deg. C)
II (boiling point 35 deg. C or above, and flash point less than 23 deg. C)
Manufacturer/Supplier: ENCANA CORPORATION
#1800, 855 - 2nd Street S.W., P.O. BOX 2850,
CALGARY, ALBERTA, T2P 2S5
Emergency Telephone: 403-645-3333
Chemical Family: Crude oil/condensate mix

SECTION 2 – HAZARDOUS INGREDIENTS OF MATERIAL

Hazardous Ingredients	**Approximate Concentrations (%)**	**C.A.S. Nos.**	**LD50/LC50 Specify Species & Route**	**Exposure Limits**
Crude oil	50 - 70	8002-05-9	LD50,rat, skin,>2 g/kg	5 mg/m3 (OEL,TLV)
Hydrocarbon Diluent	30 - 50	N.Av.	N.Av.	900 mg/m3 (OEL)*
Benzene	0.05 - 0.1	71-43-2	LD50,rat,oral,930 mg/kg LC50,rat,4 hr,13200 ppm	1 ppm (OEL), 0.5 ppm (TLV)
Hydrogen Sulphide	<20 ppm	7783-06-04	LC50, rat, 4 hrs, 444 ppm	10 ppm (OEL,TLV)

OEL = 8 hr. Alberta Occupational Exposure Limit; TLV = Threshold Limit Value (8 hrs) *OEL for gasoline

SECTION 3 – PHYSICAL DATA FOR MATERIAL

Physical State: Liquid
Specific Gravity: 0.92 – 0.94
Vapour Density (air=1): 2.5 -5.0
Percent Volatiles, by volume: 20 - 30 (estimated)
pH: N.Av.
Vapour Pressure (mmHg): approx. 300 @ 20C
Odour Threshold (ppm): N.Av.
Evaporation Rate: N.Av.
Boiling Pt. (deg.C): initial B.Pt. variable (16 – 30C)
Freezing Pt. **(deg.C**): <0
Coefficient of Water/Oil Distribution: <0.1
Odour & Appearance: Brown/black liquid, hydrocarbon odour
(N.Av. = not available N.App. = not applicable)

SECTION 4 – FIRE AND EXPLOSION

Flammability: Yes **Conditions**: Material will ignite at normal temperatures.
Means of Extinction: Foam, CO2, dry chemical. Explosive accumulations can build up in areas of poor ventilation.
Special Procedures: Use water spray to cool fire-exposed containers, and to disperse vapors if spill has not ignited. Cut off fuel and allow flame to burn out.
Flash Point (deg.C) & Method: <-35 (PMCC)
Upper Explosive Limit (% by vol.): 8 (estimated) **Sensitivity to Impact**: No
Lower Explosive Limit (% by vol.): 0.8 (estimated) **Sensitivity to Static Discharge**: Yes, at elevated temperatures
Auto-Ignition Temp. (deg.C): 250 (estimated) **TDG Flammability Classification**: N.App.
Hazardous Combustion Products: Carbon monoxide, carbon dioxide, sulphur oxides

SECTION 5 – REACTIVITY DATA

Chemical Stability: Stable **Conditions**: Heat
Incompatibility: Yes **Substances**: Oxidizing agents (e.g. chlorine)
Reactivity: Yes **Conditions**: Heat, strong sunlight
Hazardous Decomposition Products: Carbon monoxide, carbon dioxide, sulphur oxides

SECTION 6 – TOXICOLOGICAL PROPERTIES OF PRODUCT

Routes of Entry:
Skin Absorption: Yes **Skin Contact**: Yes **Eye Contact**: Yes
Inhalation: **Acute**: Yes **Chronic**: Yes **Ingestion**: Yes
Effects of Acute Exposure: Vapour may cause irritation of eyes, nose and throat, dizziness and drowsiness. Contact with skin may cause irritation and possibly dermatitis. Contact of liquid with eyes may cause severe irritation/burns.
Effects of Chronic Exposure: Due to presence of benzene, long term exposure may increase the risk of anaemia and leukemia. Repeated skin contact may increase the risk of skin cancer.
Sensitization to Product: No.
Exposure Limits of Product: 1 ppm (Alberta 8 hr OEL for benzene)
Irritancy: Yes
Synergistic Materials: None reported
Carcinogenicity: Yes **Reproductive Effects**: Possibly **Teratogenicity**: Possibly **Mutagenicity**: Possibly

SECTION 7 – PREVENTIVE MEASURES

Personal Protective Equipment: Use positive pressure self-contained breathing apparatus, supplied air breathing apparatus or cartridge air purifying respirator approved for organic vapours where concentrations may exceed exposure limits (note: cartridge respirator not suitable for oxygen deficiency or IDLH situations).
Gloves: Viton (nitrile adequate for short exposure to liquid)
Eye: Chemical splash goggles. **Footwear**: As per safety policy **Clothing**: As per fire protection policy
Engineering Controls: Use only in well ventilated areas. Mechanical ventilation required in confined areas. Equipment must be explosion proof.
Leaks & Spills: Stop leak if safe to do so. Use personal protective equipment. Use water spray to cool containers. Remove all ignition sources. Provide explosion-proof clearing ventilation, if possible. Prevent from entering confined spaces. Dyke and pump into containers for recycling or disposal. Notify appropriate regulatory authorities.
Waste Disposal: Contact appropriate regulatory authorities for disposal requirements.
Handling Procedures & Equipment: Avoid contact with liquid. Avoid inhalation. Bond and ground all transfers. Avoid sparking conditions.
Storage Requirements: Store in a cool, dry, well ventilated area away from heat, strong sunlight, and ignition sources.
Special Shipping Provisions: N.App.

SECTION 8 – FIRST AID MEASURES

Skin: Flush skin with water, removing contaminated clothing. Get medical attention if irritation persists or large area of contact. Decontaminate clothing before re-use.

Eye: Immediately flush with large amounts of luke warm water for 15 minutes, lifting upper and lower lids at intervals. Seek medical attention if irritation persists.

Inhalation: Ensure own safety. Remove victim to fresh air. Give oxygen, artificial respiration, or CPR if needed. Seek medical attention immediately.

Ingestion: Give 2-3 glasses of milk or water to drink. DO NOT INDUCE VOMITING. Keep warm and at rest. Get immediate medical attention.

SECTION 9 – PREPARATION DATE OF MSDS

Prepared By: EnCana Environment, Health and Safety (EHS)
Phone Number: (403) 645-2000 Preparation Date: August 19, 2009 Expiry Date: August 19, 2012

Husky Energy

Material Safety Data Sheet

WHMIS	Personal Protection	TDG Road/Rail

Section I. Product Identification and Uses

Common/Trade name	**Western Canadian Select (WCS)**
Synonyms	Not available.
Chemical family	Blend of Heavy Petroleum Crude, Medium Sweet Crude and Synthetic Crude.
Supplier	Husky Oil Operations Limited PO Box 6525 Station 'D' Calgary, Alberta T2P 3G7 403-298-6111
CAS #	8002-05-09
DSL	On the DSL list.
Manufacturer	Husky Oil Operations Limited PO Box 6525 Station 'D' Calgary, Alberta T2P 3G7 403-298-6111
Material uses	Chemical feedstock

Section 2. First Aid Measures

Eye contact	Flush eyes for at least 15 minutes with clean water. Patch lightly, allowing drainage. Seek medical attention.
Skin contact	Remove contaminated clothing. Wash skin thoroughly with soap and water. Seek medical attention if irritation develops.
Inhalation	Protect rescuer. Move exposed person to fresh air. If breathing has stopped apply artificial respiration. Seek medical attention.
Ingestion	If swallowed, do not induce vomiting or give liquids. Seek immediate medical attention.

Section 3. Hazardous Ingredients

		Exposure Limits						
Name	**CAS #**	**TWA (ppm)**	**TWA (Mg/M3)**	**STEL (ppm)**	**STEL (Mg/M3)**	**CEIL (ppm)**	**CEIL (Mg/M3)**	**% by Weight**
Crude Oil (Hydrocarbons C5 and C6 Rich)	8002-05-09	100	n/av	n/av	n/av	n/av	n/av	100
Hydrogen Sulphide	7783-06-4	10	14	15	21	n/av	n/av	<0.5
Benzene	71-43-2	0.5	n/av	2.5	n/av			0.1-1
Toluene	108-88-3	20	n/av					1-5
Xylene	1330-20-7	100	n/av	150	n/av			1-30

Toxicity values of the hazardous ingredients

Crude oil (Hydrocarbons C5 and C6 Rich) LD50:4,300 mg/Kg (Rat). LC50: Not available.
Hydrogen Sulphide (H2S) LC50 Inhalation Mouse = 673 ppm 1 hour. LC50 Inhalation Rat = 444 ppm for 4 hours
Benzene. LD50 Oral rat= 930-5600 mg/Kg. LC50 Inhalation rat = 13,700 ppm for 4 hrs.
Xylene. LD50 Oral rat= 4300 mg/Kg. LC50 Inhalation rat= 6700 ppm for 4 hrs. LD50 Dermal rabbit >2000 mg/Kg.
Toluene. LD50 Oral rat= 5000 mg/Kg. LC50 Inhalation rat= 8000 ppm for n4 hrs. LD50 Dermal rabbit= 14000 mg/Kg.

Continued on Next Page

Section 4. Physical Data

Physical state and appearance	Liquid. Black/Brown.
Odor	Petroleum Odour
pH (1% soln/water)	Not applicable.
Odor threshold	O.13 ppm H2S
Evaporation rate	Not available.
Freezing point	Not available.
Boiling point	10°C - 1000°C
Specific gravity	0.92 -0.94 (Water = 1)
Volatility	100 (%vol)
Vapor density	Not available.
Vapor pressure	Not available.
Water/oil dist. coeff.	Not available.
Solubility	Not available.
Molecular Weight	Not applicable.
Melting Point	Not available.
Density	Not available.

Section 5. Fire and Explosion Data

Auto-ignition temperature	Not available.
Flash points	CLOSED CUP: -40°C (-40°F)
Flammable limits	Not available.
Extinguishing Media	Use DRY chemicals, CO2, or foam to extinguish fire. Water may not be an effective medium to extinguish fire. Cool containing vessels with water jet in order to prevent pressure build-up, autoignition or explosion.
Special fire fighting procedures	Use supplied air or self contained breathing apparatus (SCBA) for large fires or for fires in enclosed areas.
Flammability	Highly flammable liquid. Released vapours may form flammable/explosive mixtures at or above the flash point. Vapours may travel considerable distances to ignition sources and cause a flash fire. All storage containers and pumping equipment must be grounded. **Remark** No additional remark.
Risks of explosion	This material is sensitive to static discharge. This product is not sensitive to mechanical impact. **Remark** No additional remark.

Section 6. Reactivity Data

Stability	The product is stable.
Hazardous decomp. products	Carbon monoxide, carbon dioxide and irritant fumes and gases including sulphur oxides, nitrogen oxides and aldehydes.
Reactivity	Incompatible material: Strong acids, strong oxidizers, chlorine. Hazardous polymerization: Will not occur. **Remark** No additional remark.

Continued on Next Page

Section 7. Toxicological Properties

Routes of entry	Ingestion. Inhalation. Eye contact. Skin contact.
TLV	TLV-TWA 100 PPM (525 mg/m3) for stoddard solvent from ACGIH. Hydrogen Sulfide: TWA: 10 ppm, STEL: 15 ppm, from ACGIH Benzene TWA:0.5 ppm, STEL: 2.5 ppm, from ACGIH, SKIN Toluene TWA: 20 ppm, from ACGIH Consult local authorities for acceptable exposure limits.
Toxicity to animals	**Hydrocarbons C5 and C6 Rich** LD50: Not available. LC50: Not available. **Hydrogen Sulphide (H2S)** **LC50 Inhalation Mouse = 673 ppm 1 hour** **LC50 Inhalation Rat = 444 ppm for 4 hours** **Remark** No additional remark.
Chronic effects	This product may contain benzene. Benzene has been classified by the international agency for research on cancer as a group 1 product indicating sufficent evidence of carcinogenicity. Studies exist which report a link to crude oil and reproductive effects including fetal tumors and menstrual disorders. This product contains small quantities of xylene. High exposure to xylene has produced fetotoxic effects in animal studies. This product contains small quantities of polycylic aromatic hydrocarbons. Prolonged contact with these compound has been associated with the induction of skin and lung tumours. This product may contain toluene which is known to cause visual impairment, narcosis, anxiety, muscle fatigue, insomnia, dermatitis, parathesis, liver and kidney damage and to affect reproduction. **Remark** No additional remark.
Acute effects	Sensitizing Capabiltiy: No effects known. Irritancy: Skin, eye and upper respiratory tract irritant.
Ingestion	Pulmonary aspiration hazard if swallowed and vomitting occurs.
Skin	Prolonged skin contact can cause defatting of the skin resulting in dry cracked skin and dermatitis.
Eyes	Eye contact with product or product vapours may result in eye irritation.
Inhalation	May cause headache, dizziness, loss of appetite and loss of consiousness. Product vapours are irritating to the respiratory tract. **Remark** This product contains small quantities of hydrogen sulphide (H2S) gas which may collect in confined spaces. Acute effects vary with concentration of H2S released from mild eye, nose and throat irritation at approximately 100 ppm to sudden unconsciousness or death at 500 ppm.
Synergistic materials	Not available.

Section 8. Preventive Measures

Waste disposal	Dispose of in accordance with all federal, provincial and local regulations.
Storage	Keep away from all ignition sources. Maintain temperature below the flash point. Head spaces in storage containers may contain hydrocarbon vapours and toxic hydrogen sulphide gas.
Ventilation	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value.
Spill and leak	Evacuate unecessary personnel. Eliminate all ignition sources. Be alert to the potential for the presence of hydrogen sulphide gas and don appropriate protective equipment. Stop leak if safe to do so. Contain spill and absorb with inert absorbent. Large spills should be removed with explosion proof vacuum equipment. Large pools may be covered with foam to prevent vapour evolution. Comply with federal, provincial, and local requirements for spill notification.

Continued on Next Page

Section 9. Classification/Regulatory Information

TDG road / rail

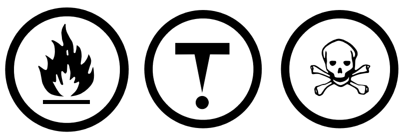
TDG CLASS 3: Flammable liquid with a flash point less than or equal to 60.5 C (140.9 F). Closed cup test method.

PIN: 1267 - PETROLEUM CRUDE OIL

Remark
No additional remark.

WHMIS

WHMIS CLASS B-2: Flammable liquid with a flash point lower than 37.8°C (100°F).
WHMIS CLASS D-2A: Material causing other toxic effects (VERY TOXIC).
WHMIS CLASS D-2B: Material causing other toxic effects (TOXIC).



Remark
No additional remark.

Other

This product is on the Domestic Substances List (DSL). TSCA (Toxic Substance Control Act): This product is listed on the TSCA Inventory.
Refer to federal, provincial, and local legislation for further requirements.

Section 10. Protective Clothing

Eye

Non-vented chemical goggles to prevent eye irritation from the solvent vapours.

Skin

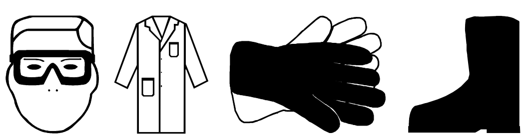
Impervious gloves and clothing should be worn as appropriate to protect against skin contact. Neoprene or nitrile material is suggested.

Respiratory

Respiratory protection may be required in poorly ventilated areas. Properly fitted air purifying masks equipped with organic vapour filters will provide protection at low concentrations. Air supplied respirators or positive pressure self contained breathing apparatus is required when atmospheric concentrations of hydrocarbon vapours are likely to exceed 10X the occupational exposure limit or when high concentrations of H2S may be present.

Other

As required by the situation according to your companies policies and procedures. Contact your supervisor for direction.



Section 11. Preparation Information

References

-Provisional Domestic Substances List, Canadian Ennvironmental Protection Act, Volume 1-Registry Number Index, April 1990; Environment Canada. -SAX, N.I. Dangerous Properties of Industrial Materials. Toronto, Van Nostrand Reinold, 6e ed. 1984. CCOHS (Chem advi)
CCOHS(Cheminfo) Doccumentation of the Threshold Limit Values and Biological Exposure Indices (ACGIH)
Pocket Guide to Chemical Hazards (NIOSH)
Transportation of Dangerous Goods Shedule II List II

MSDS Status

Acronyms: TLV = Threshold Limit Value N/AP = Not applicable N/AV = Not Available COC = Cleveland Open Cup PMCC = Pensky Martens Closed Cup

Validated by Husky Corporate Hygiene on 3/19/2009.	**Verified by Husky Corporate Hygiene.**
Supersedes: 11/28/2005	**Printed 3/9/2009.**

Continued on Next Page

Emergency Phone # 403-262-2111

While the company believes the data set forth herein are accurate as of the date hereof, the company makes no warranty with respect thereto and expressly disclaims all liability for reliance thereon. Such data are offered solely for your consideration, investigation and verification.

Pipeline and Hazardous Materials Safety Administration
Docket Number PHMSA 2008-0285
TransCanada Keystone Pipeline, L.P.
Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to PHMSA

“Please ask Keystone to add English Units.”

Response:

Please find attached hydraulic profile charts in English Units. These are the same profiles presented in appendix A and appendix B submitted to PHMSA on November 19, 2009 in response to the query regarding hydraulic modeling and valve closure scenarios.

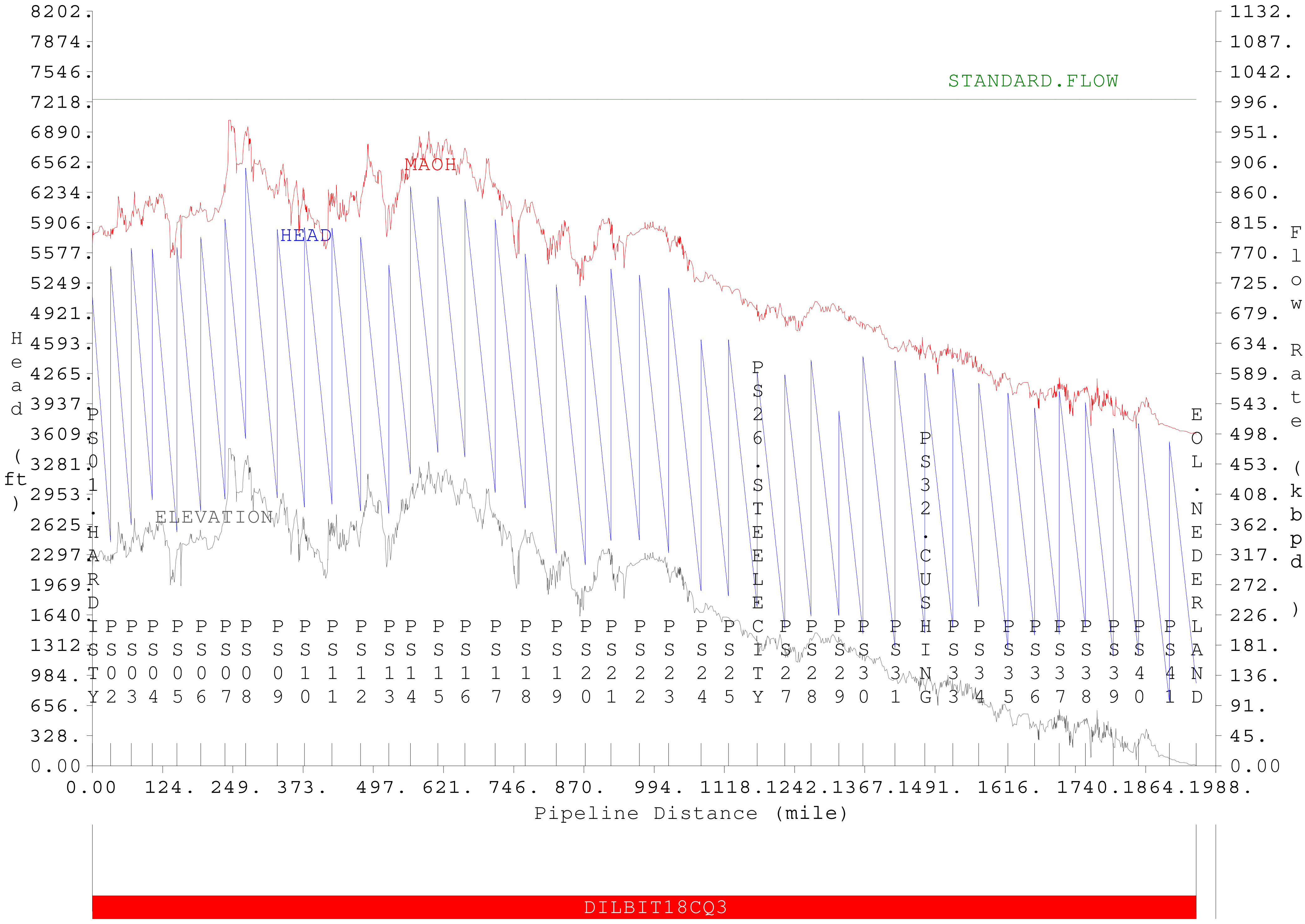
Appendix A

Steady State Pressure Profile

TIME = 05/07 00:52:46
STEP = 00:14:54

TIME =   05/07 00:52:46
STEP =   00:14:54

KXL Update: Head and Flow Profiles (Dilbit Q3 at 1000 kbpd)

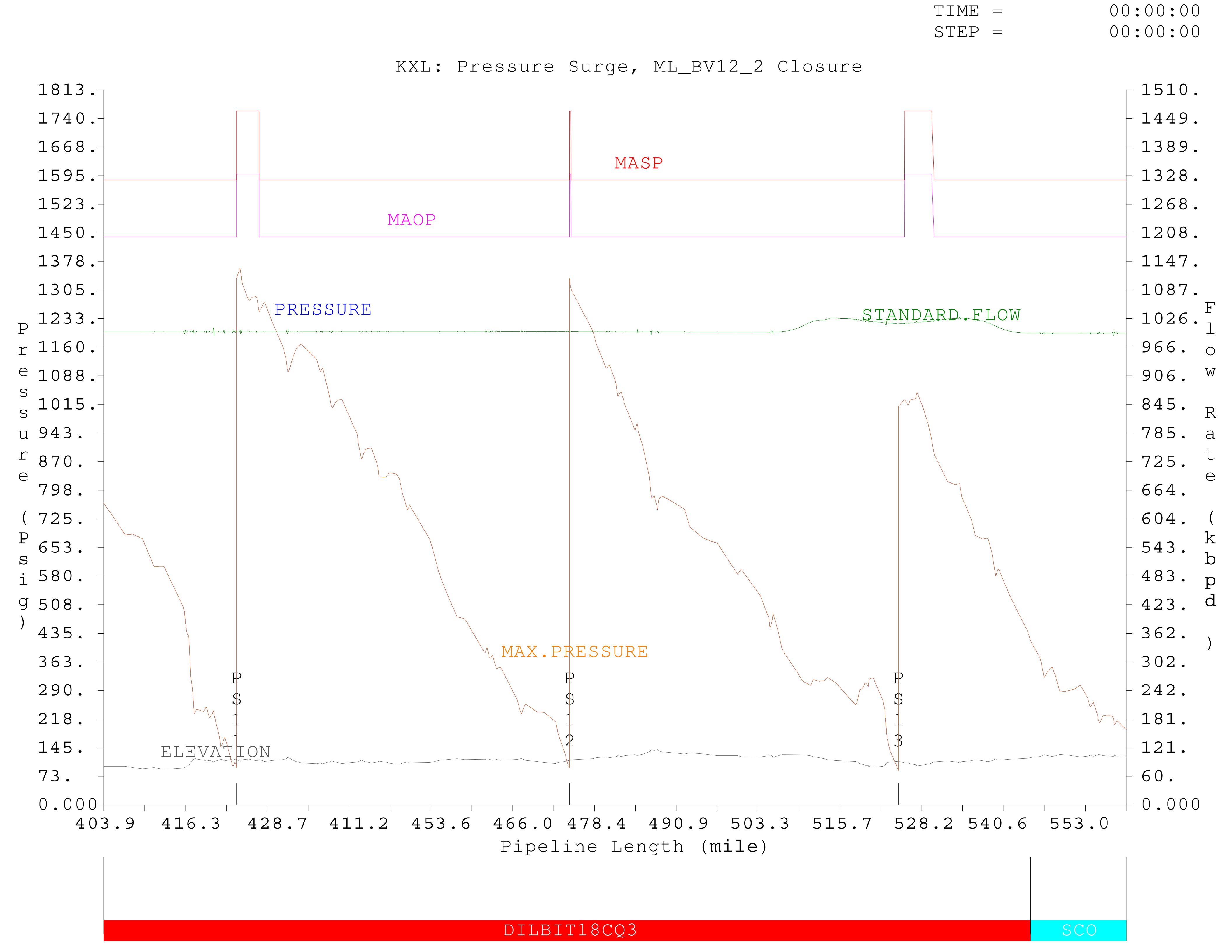


Appendix B

Transient Pressure Profiles

Scenario I

Mainline Valve at Suction Side of a Pump Station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MASP
MAOP
PRESSURE
STANDARD.FLOW
MAX.PRESSURE
ELEVATION
PS11
PS12
PS13
Pressure (psig)
Flow Rate (kbpd)
Pipeline Length (mile)
1813. 1740. 1668. 1595. 1523. 1450. 1378. 1305. 1233. 1160. 1088. 1015. 943. 870. 798. 725. 653. 580. 508. 435. 363. 290. 218. 145. 73. 0.000
1510. 1449. 1389. 1328. 1268. 1208. 1147. 1087. 1026. 966. 906. 845. 785. 725. 664. 604. 543. 483. 423. 362. 302. 242. 181. 121. 60. 0.000
403.9 416.3 428.7 411.2 453.6 466.0 478.4 490.9 503.3 515.7 528.2 540.6 553.0
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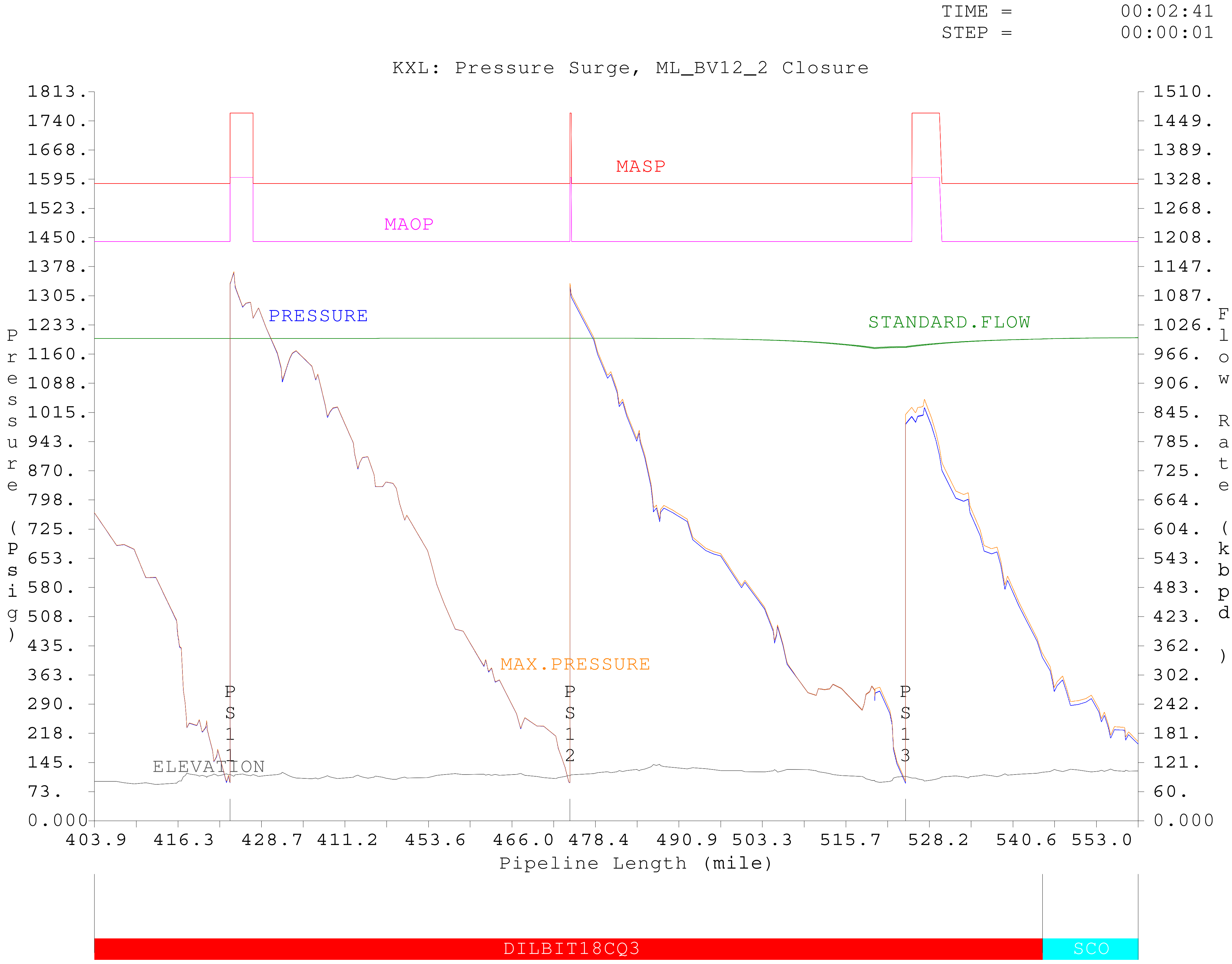
SCO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MAOP
PRESSURE
STANDARD.FLOW
MAX.PRESSURE
ELEVATION
PS11
PS12
PS13
Pressure (psig)
Flow Rate (kbpd)
Pipeline Length (mile)
1813. 1740. 1668. 1595. 1523. 1450. 1378. 1305. 1233. 1160. 1088. 1015. 943. 870. 798. 725. 653. 580. 508. 435. 363. 290. 218. 145. 73. 0.000
1510. 1449. 1389. 1328. 1268. 1208. 1147. 1087. 1026. 966. 906. 845. 785. 725. 664. 604. 543. 483. 423. 362. 302. 242. 181. 121. 60. 0.000
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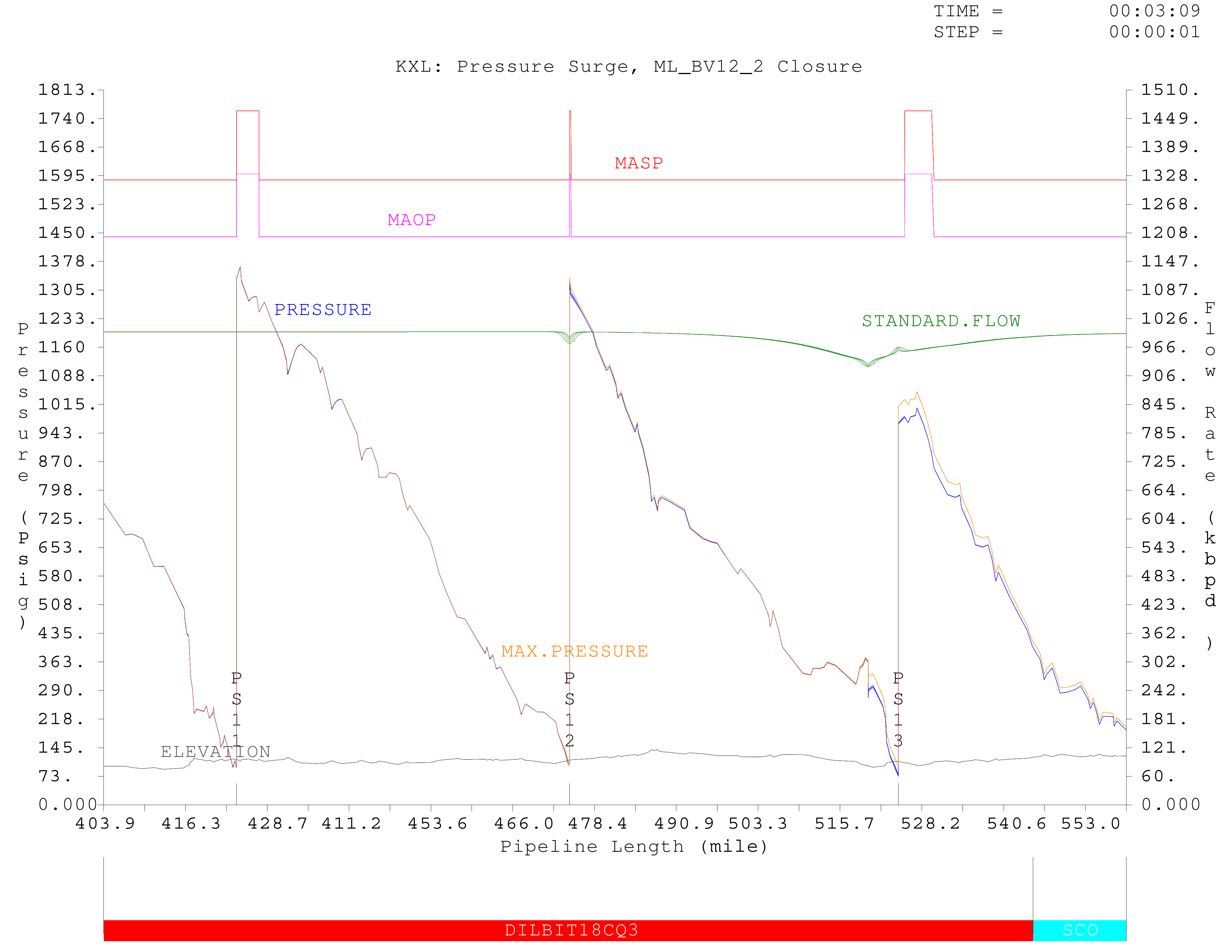
DILBIT18CQ3
SCO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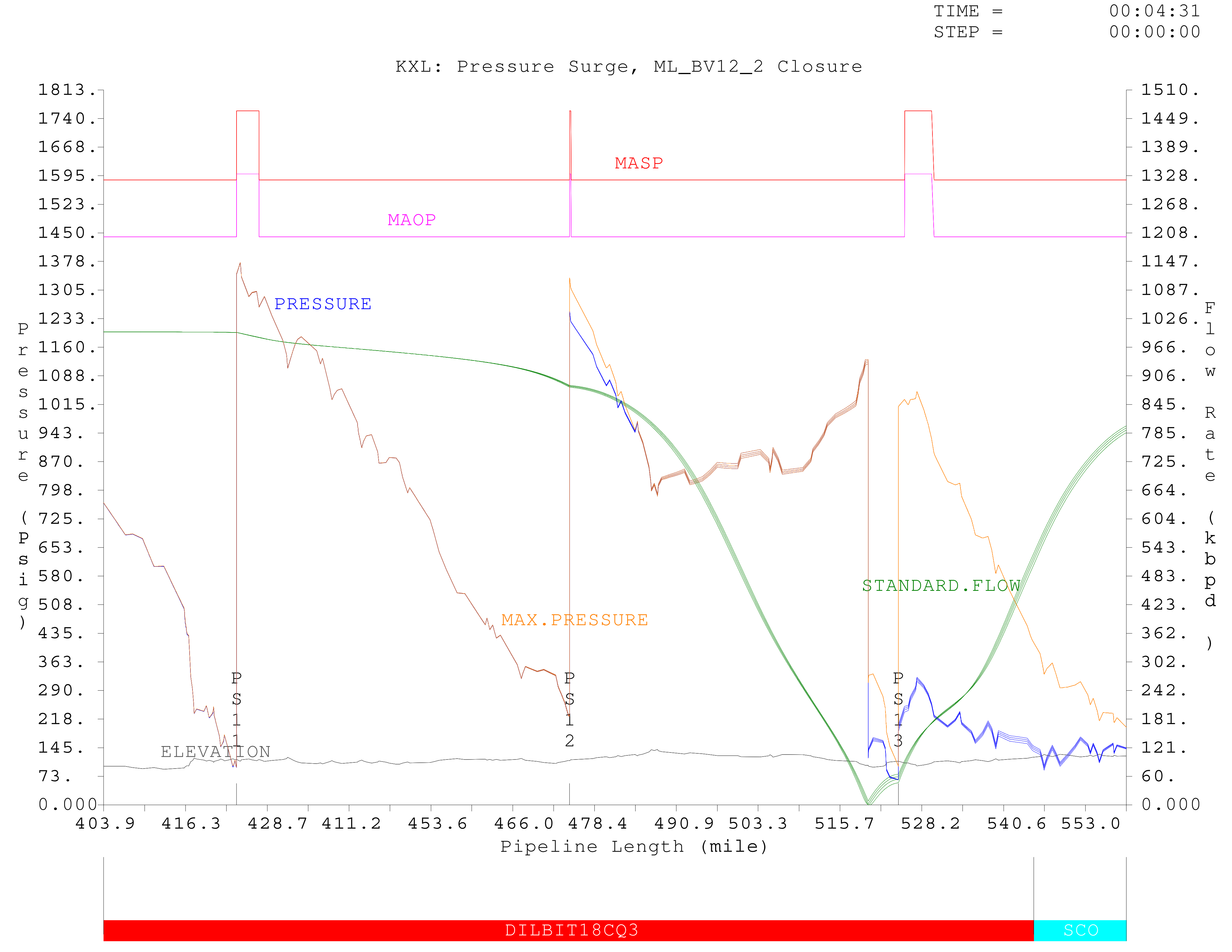
MASP
MAOP
PRESSURE
STANDARD.FLOW
MAX.PRESSURE
ELEVATION
PS11
PS12
PS13
Pressure (Psig)
Flow Rate (kbpd)
1813. 1740. 1668. 1595. 1523. 1450. 1378. 1305. 1233. 1160. 1088. 1015. 943. 870. 798. 725. 653. 580. 508. 435. 363. 290. 218. 145. 73. 0.000
1510. 1449. 1389. 1328. 1268. 1208. 1147. 1087. 1026. 966. 906. 845. 785. 725. 664. 604. 543. 483. 423. 362. 302. 242. 181. 121. 60. 0.000
403.9 416.3 428.7 411.2 453.6 466.0 478.4 490.9 503.3 515.7 528.2 540.6 553.0
Pipeline Length (mile)
DILBIT18CQ3
SCO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1668.
1595.
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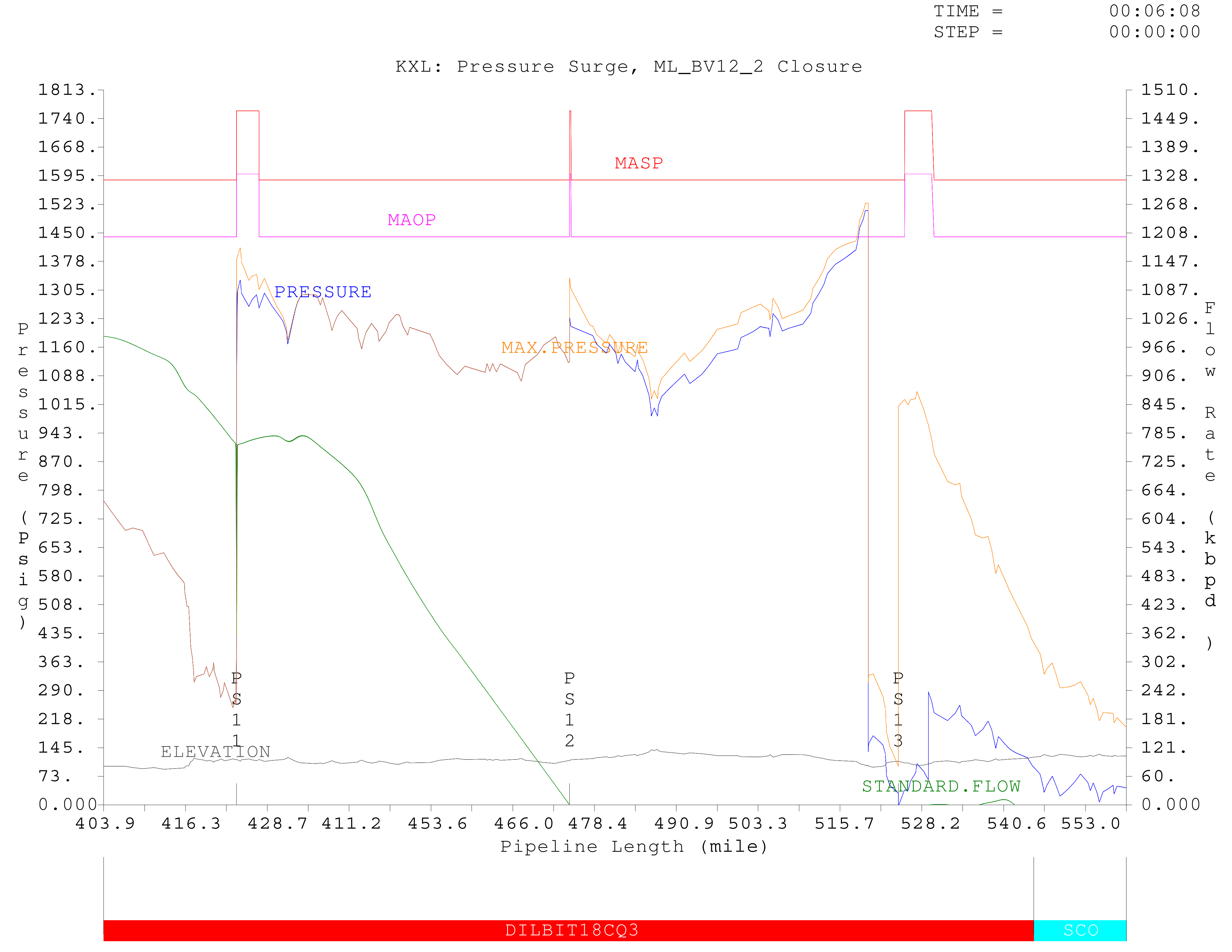
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.000
Pressure (Psig)
1510.
1449.
1389.
1328.
1268.
1208.
1147.
1087.
1026.
966.
906.
845.
785.
725.
664.
604.
543.
483.
423.
362.
302.
242.
181.
121.
60.
0.000
Flow Rate (kbpd)
MASP
MAOP
PRESSURE
MAX.PRESSURE
STANDARD.FLOW
ELEVATION
PS11
PS12
PS13
403.9
416.3
428.7
411.2
453.6
466.0
478.4
490.9
503.3
515.7
528.2
540.6
553.0
Pipeline Length (mile)
DILBIT18CQ3
SCO



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Flow Rate (kbpd)
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1668.
1595.
1523.
1450.
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1305.
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1160.
1088.
1015.
943.
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MASP
MAOP
PRESSURE
MAX.PRESSURE
ELEVATION
STANDARD.FLOW
PS11
PS12
PS13
403.9
416.3
428.7
411.2
453.6
466.0
478.4
490.9
503.3
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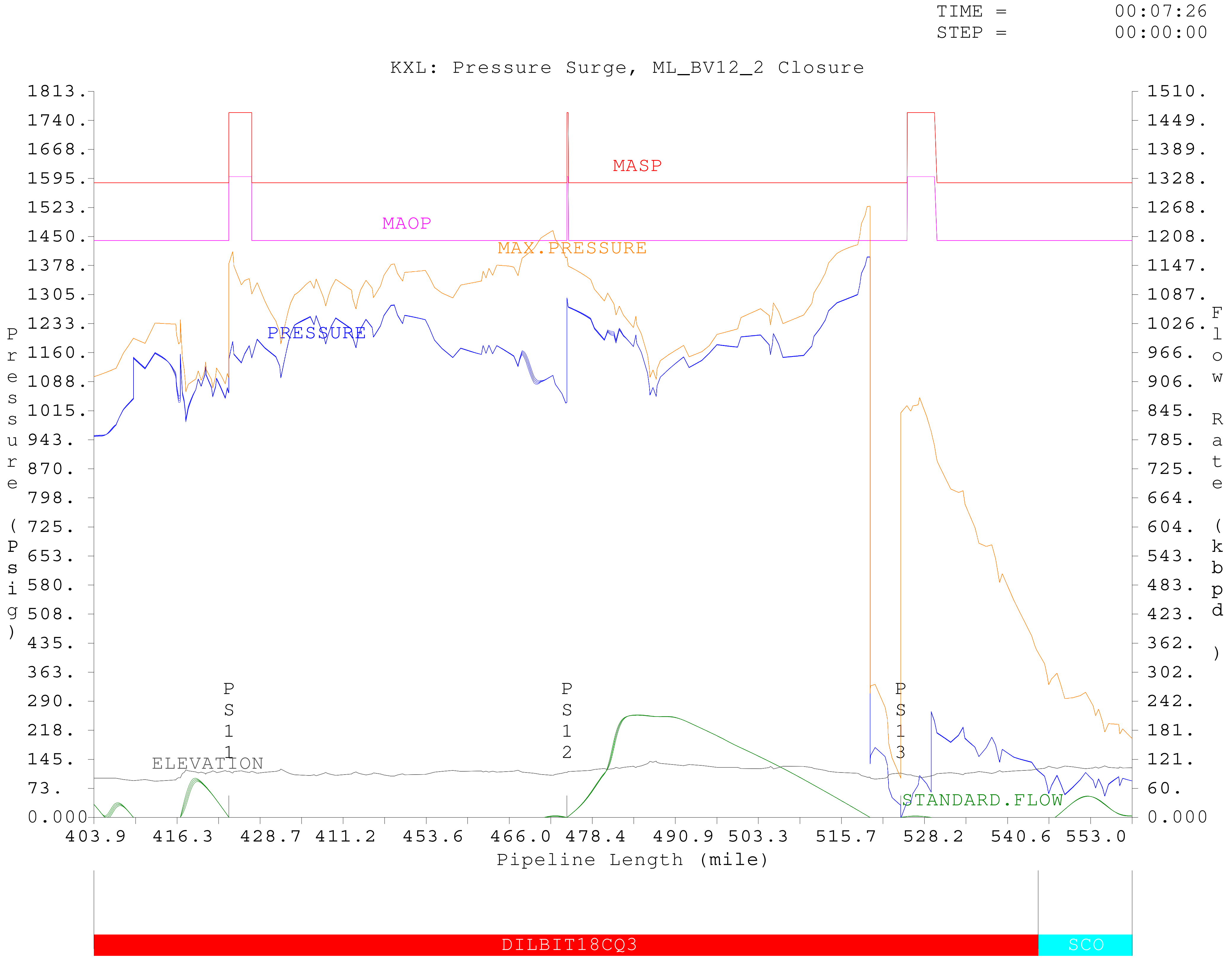
528.2
540.6
553.0
Pipeline Length (mile)
DILBIT18CQ3
SCO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Pressure (Psig)
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1595.
1523.
1450.
1378.
1305.
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1160.
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1015.
943.
870.
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580.
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363.
290.
218.
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73.
0.000
Flow Rate (kbpd)
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1389.
1328.
1268.
1208.
1147.
1087.
1026.
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725.
664.
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483.
423.
362.
302.
242.
181.
121.
60.
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MASP
MAOP
MAX.PRESSURE
PRESSURE
ELEVATION
STANDARD.FLOW
PS11
PS12
PS13
403.9
416.3
428.7
411.2
453.6
466.0
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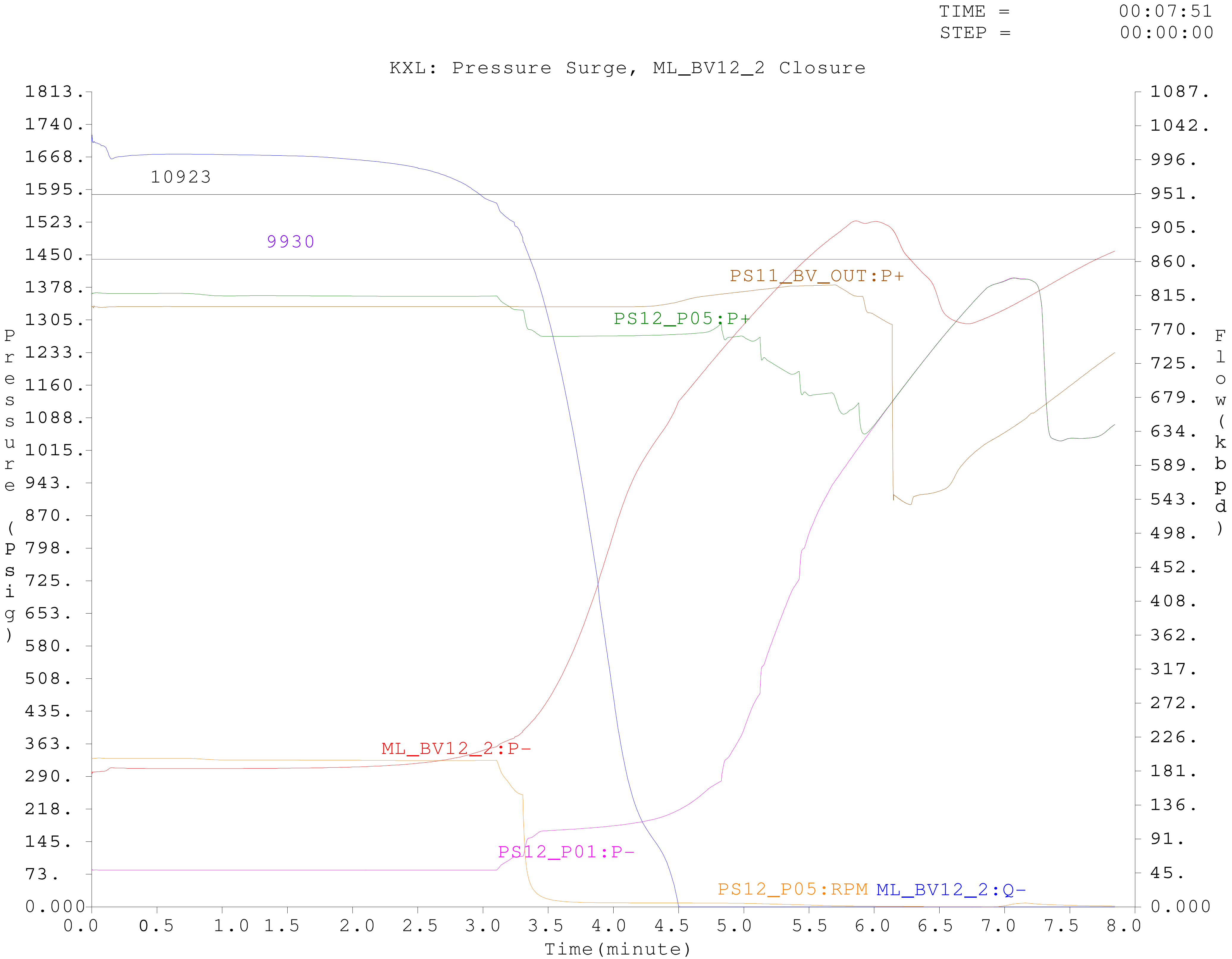
Pipeline Length (mile)
DILBIT18CQ3
SCO

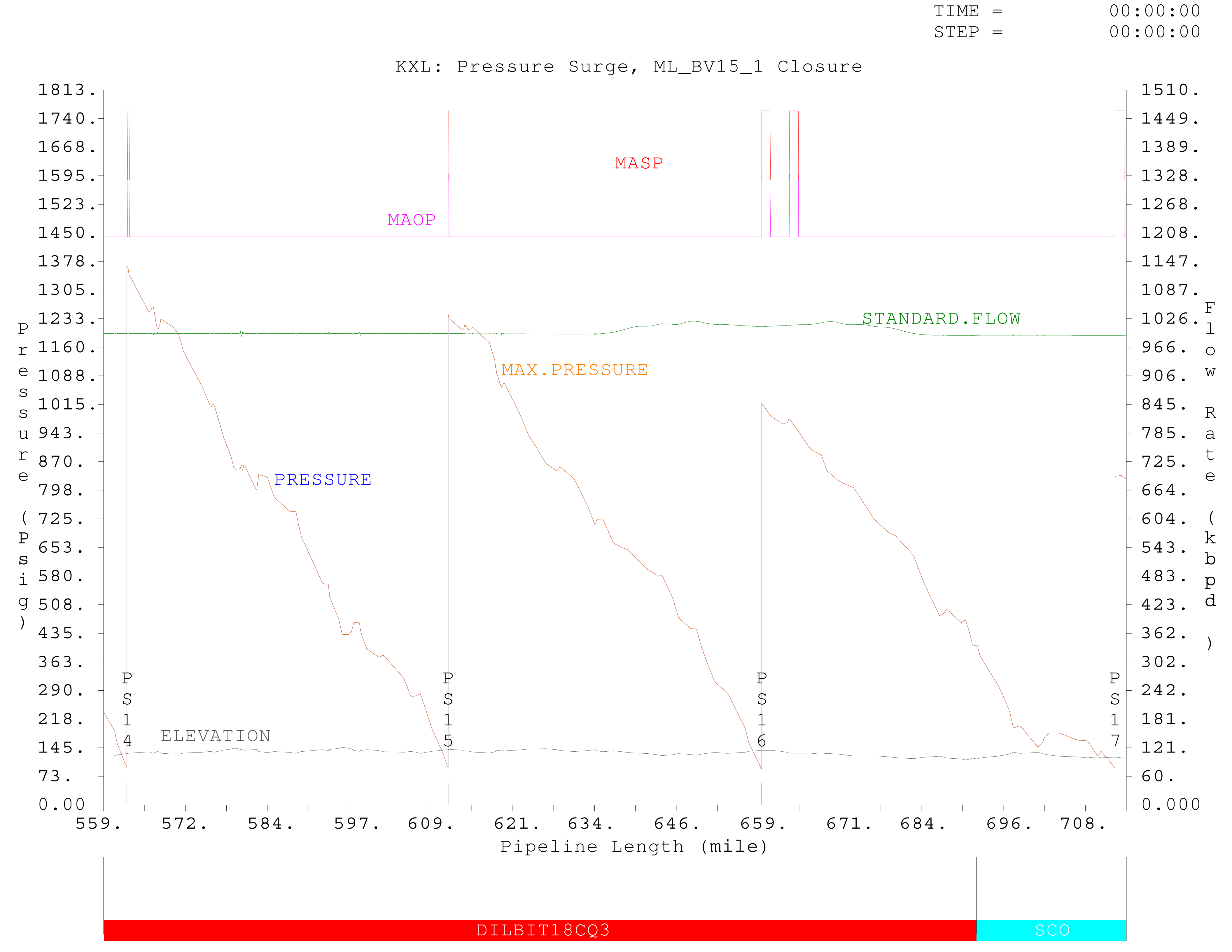

TIME = 00:07:51
STEP = 00:00:00
KXL: Pressure Surge, ML_BV12_2 Closure
Pressure (psig)
Flow (kbpd)
Time(minute)
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.000
1087.
1042.
996.
951.
905.
860.
815.
770.
725.
679.
634.
589.
543.
498.
452.
408.
362.
317.
272.
226.
181.
136.
91.
45.
0.000
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
10923
9930
PS11_BV_OUT:P+
PS12_P05:P+
ML_BV12_2:P-
PS12_P01:P-
PS12_P05:RPM
ML_BV12_2:Q-

Appendix B

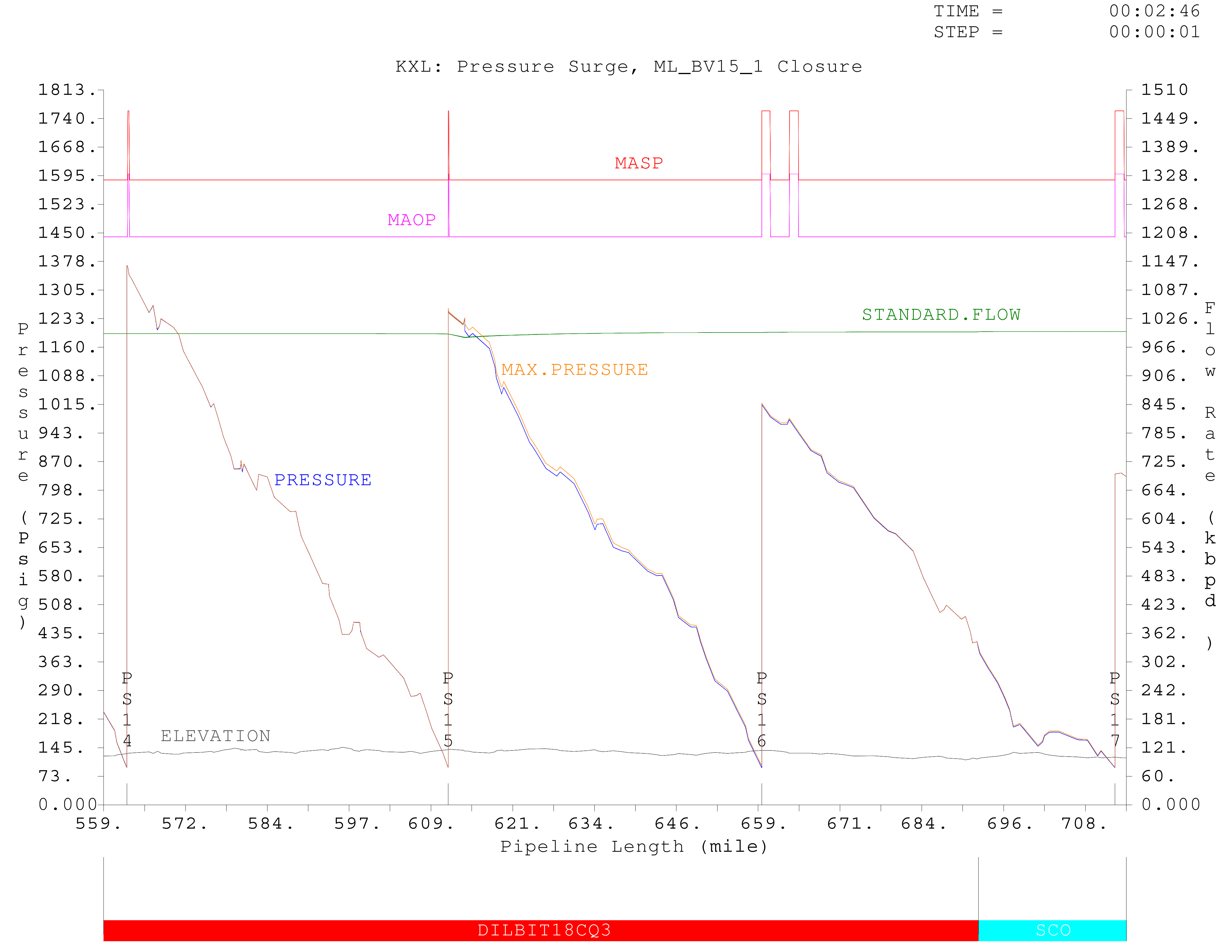
Transient Pressure Profiles

Scenario II

Mainline Valve at Discharge Side of a Pump Station



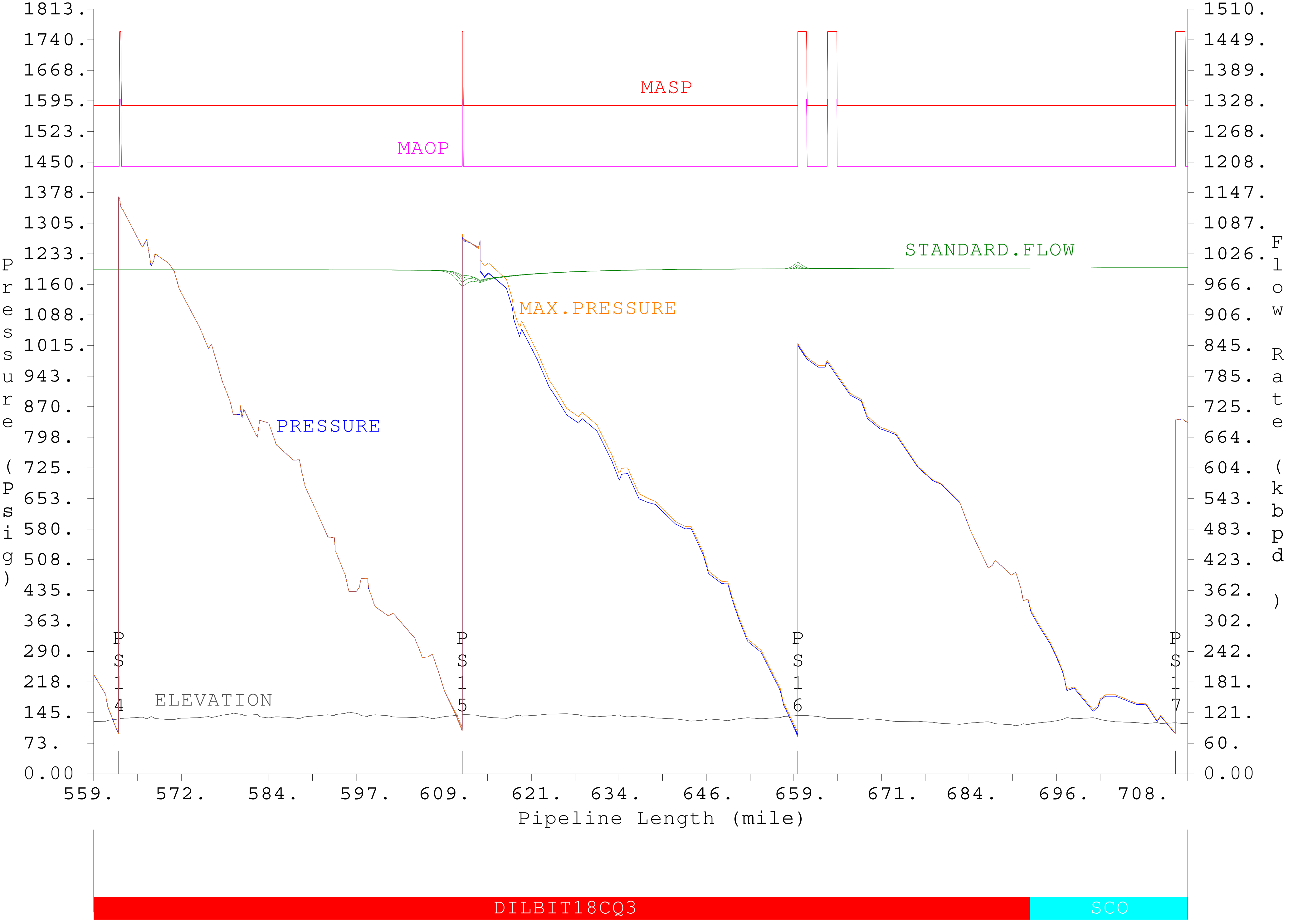
TIME = 00:00:00
STEP = 00:00:00
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
PS14
PS15
PS16
PS17
Pressure (psig)
Flow Rate (kbpd)
Pipeline Length (mile)
DILBIT18CQ3
SCO

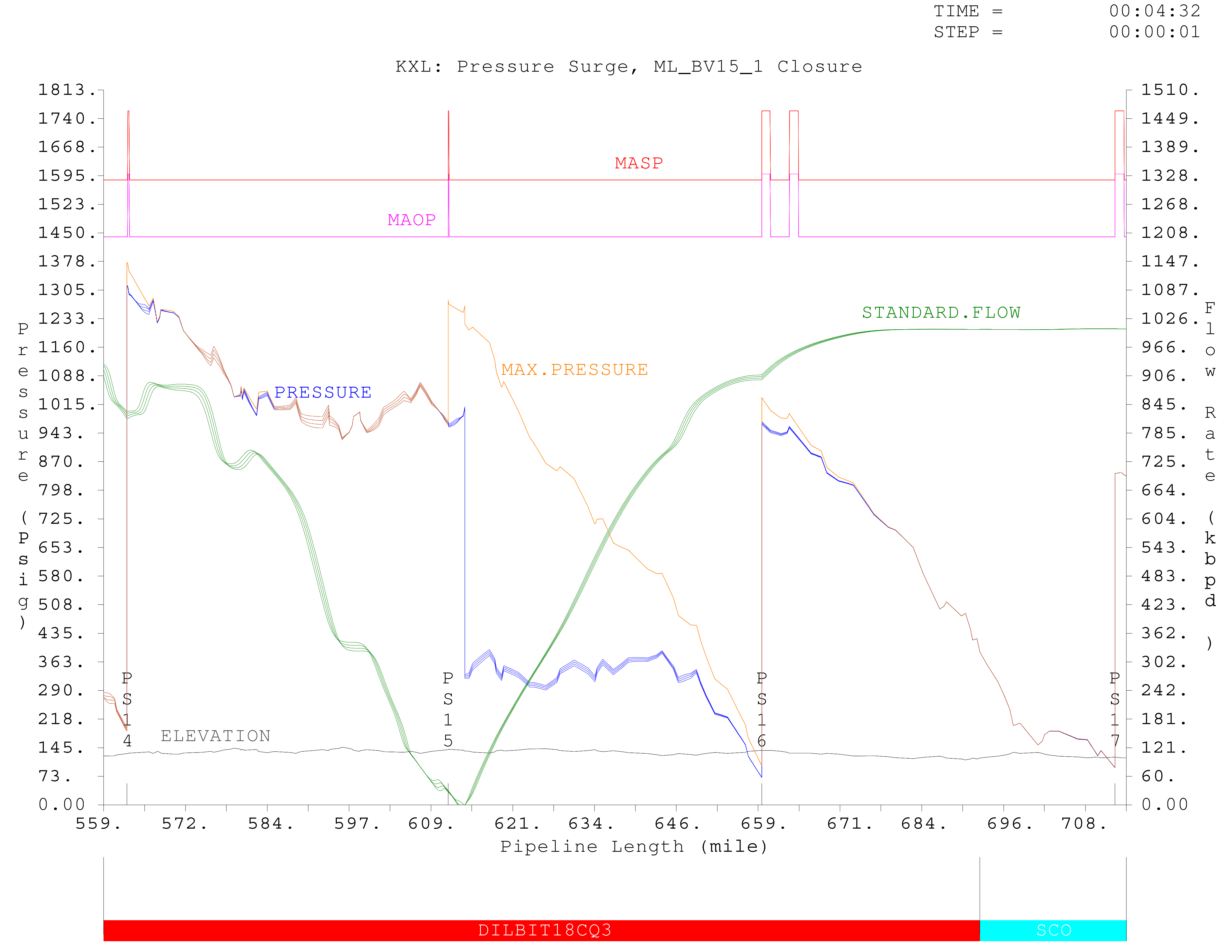


TIME = 00:02:46
STEP = 00:00:01
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
Pressure (psig)
Flow Rate (kbpd)
PS14
PS15
PS16
PS17
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.000
1510
1449.
1389.
1328.
1268.
1208.
1147.
1087.
1026.
966.
906.
845.
785.
725.
664.
604.
543.
483.
423.
362.
302.
242.
181.
121.
60.
0.000
559. 572. 584. 597. 609. 621. 634. 646. 659. 671. 684. 696. 708.
Pipeline Length (mile)
DILBIT18CQ3
SCO

TIME = 00:03:03
STEP = 00:00:01

KXL: Pressure Surge, ML_BV15_1 Closure

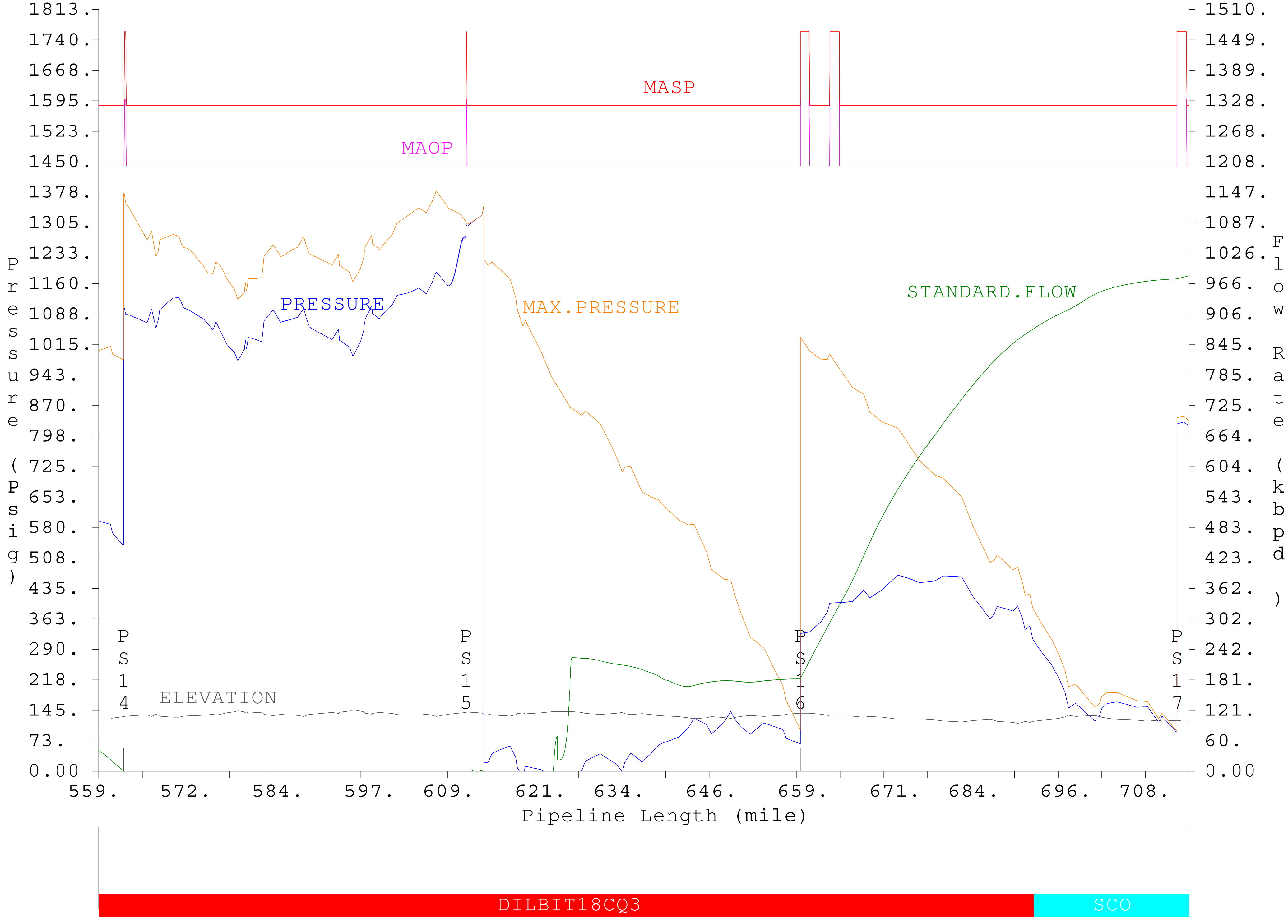


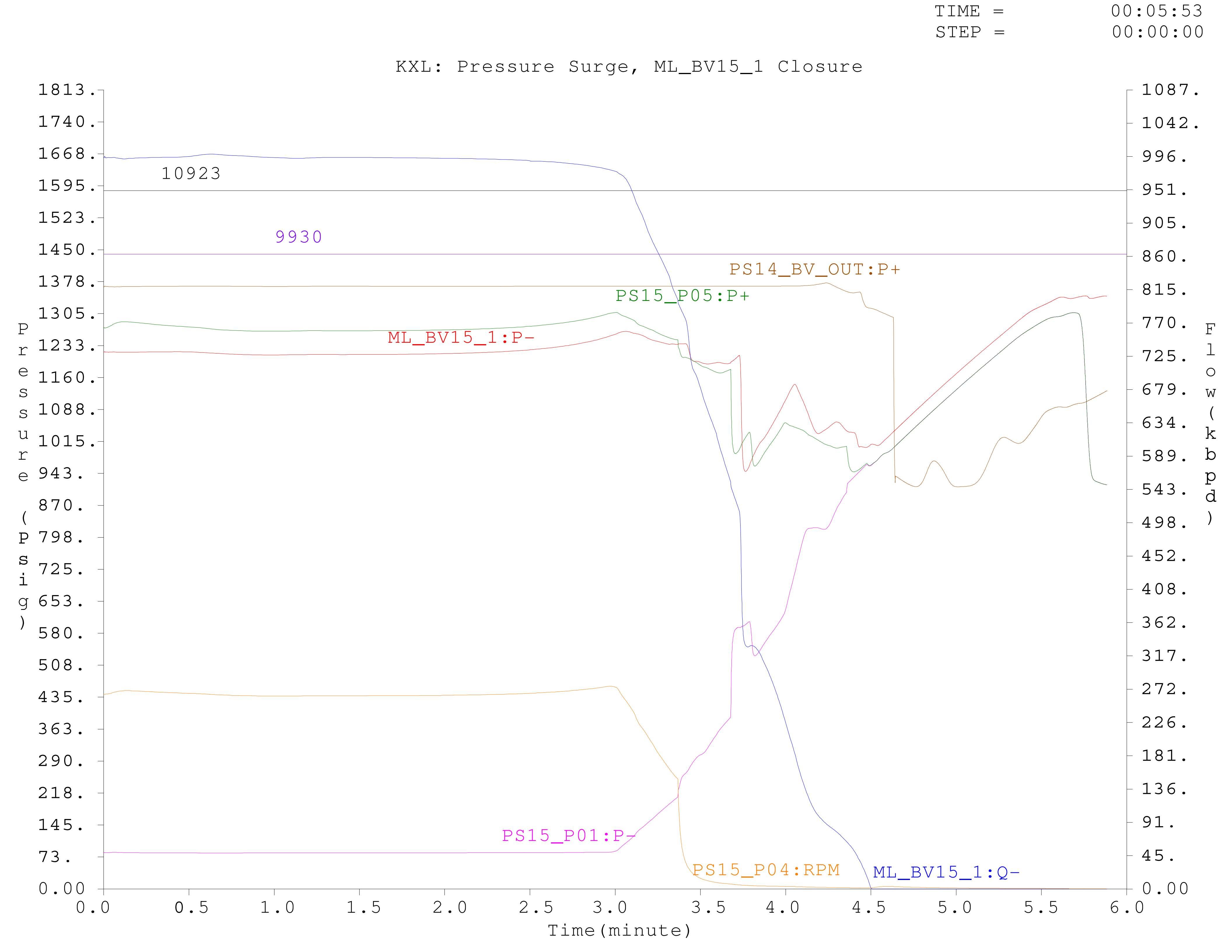

TIME = 00:04:32
STEP = 00:00:01
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
MAX.PRESSURE
PRESSURE
STANDARD.FLOW
ELEVATION
PS14
PS15
PS16
PS17
Pressure (psig)
Flow Rate (kbpd)
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.00
1510.
1449.
1389.
1328.
1268.
1208.
1147.
1087.
1026.
966.
906.
845.
785.
725.
664.
604.
543.
483.
423.
362.
302.
242.
181.
121.
60.
0.00
559.
572.
584.
597.
609.
621.
634.
646.
659.
671.
684.
696.
708.
Pipeline Length (mile)
DILBIT18CQ3
SCO


TIME = 00:04:38
STEP = 00:00:00
KXL: Pressure Surge, ML_BV15_1 Closure
MASP
MAOP
PRESSURE
MAX.PRESSURE
STANDARD.FLOW
ELEVATION
Pressure (Psig)
Flow Rate (kbpd)
PS14
PS15
PS16
PS17
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.00
1510.
1449.
1389.
1328.
1268.
1208.
1147.
1087.
1026.
966.
906.
845.
785.
725.
664.
604.
543.
483.
423.
362.
302.
242.
181.
121.
60.
0.00
559.
572.
584.
597.
609.
621.
634.
646.
659.
671.
684.
696.
708.
Pipeline Length (mile)
DILBIT18CQ3
SCO

TIME = 00:05:44
STEP = 00:00:00

KXL: Pressure Surge, ML_BV15_1 Closure





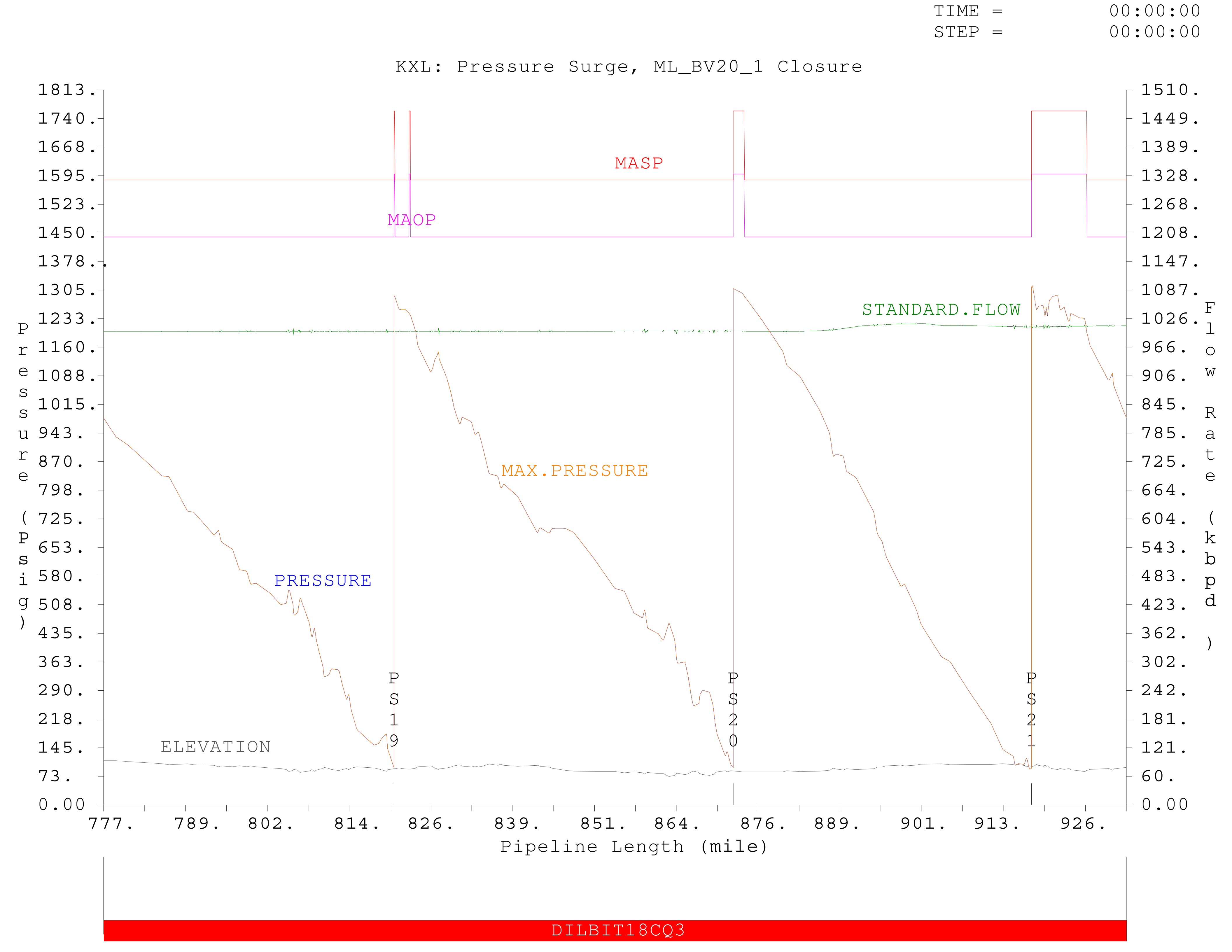
TIME = 00:05:53
STEP = 00:00:00
KXL: Pressure Surge, ML_BV15_1 Closure
10923
9930
PS14_BV_OUT:P+
PS15_P05:P+
ML_BV15_1:P-
PS15_P01:P-
PS15_P04:RPM
ML_BV15_1:Q-
Pressure (Psig)
Flow (kbpd)
Time(minute)
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.00
1087.
1042.
996.
951.
905.
860.
815.
770.
725.
679.
634.
589.
543.
498.
452.
408.
362.
317.
272.
226.
181.
136.
91.
45.
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0

Appendix B

Transient Pressure Profiles

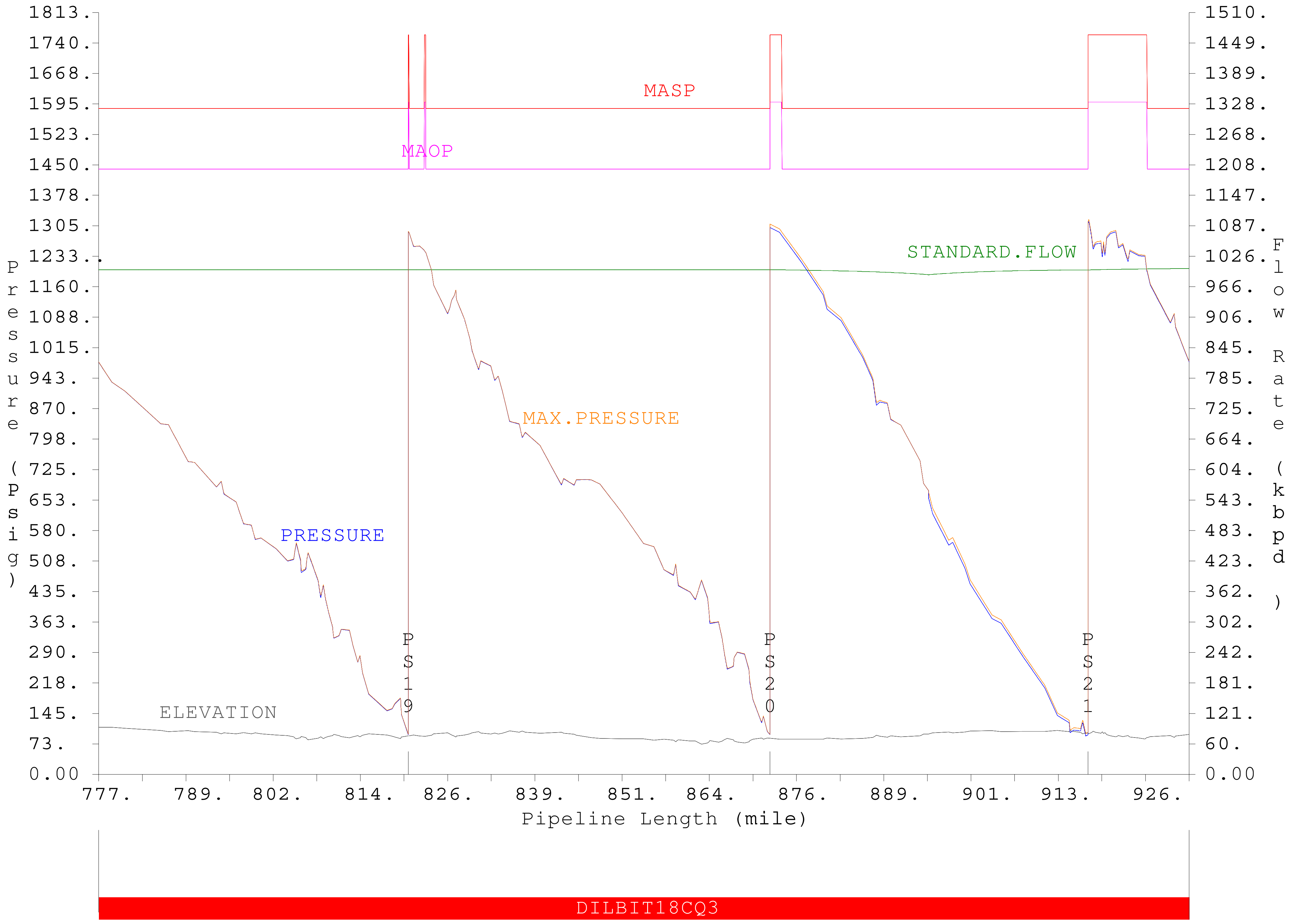
Scenario III

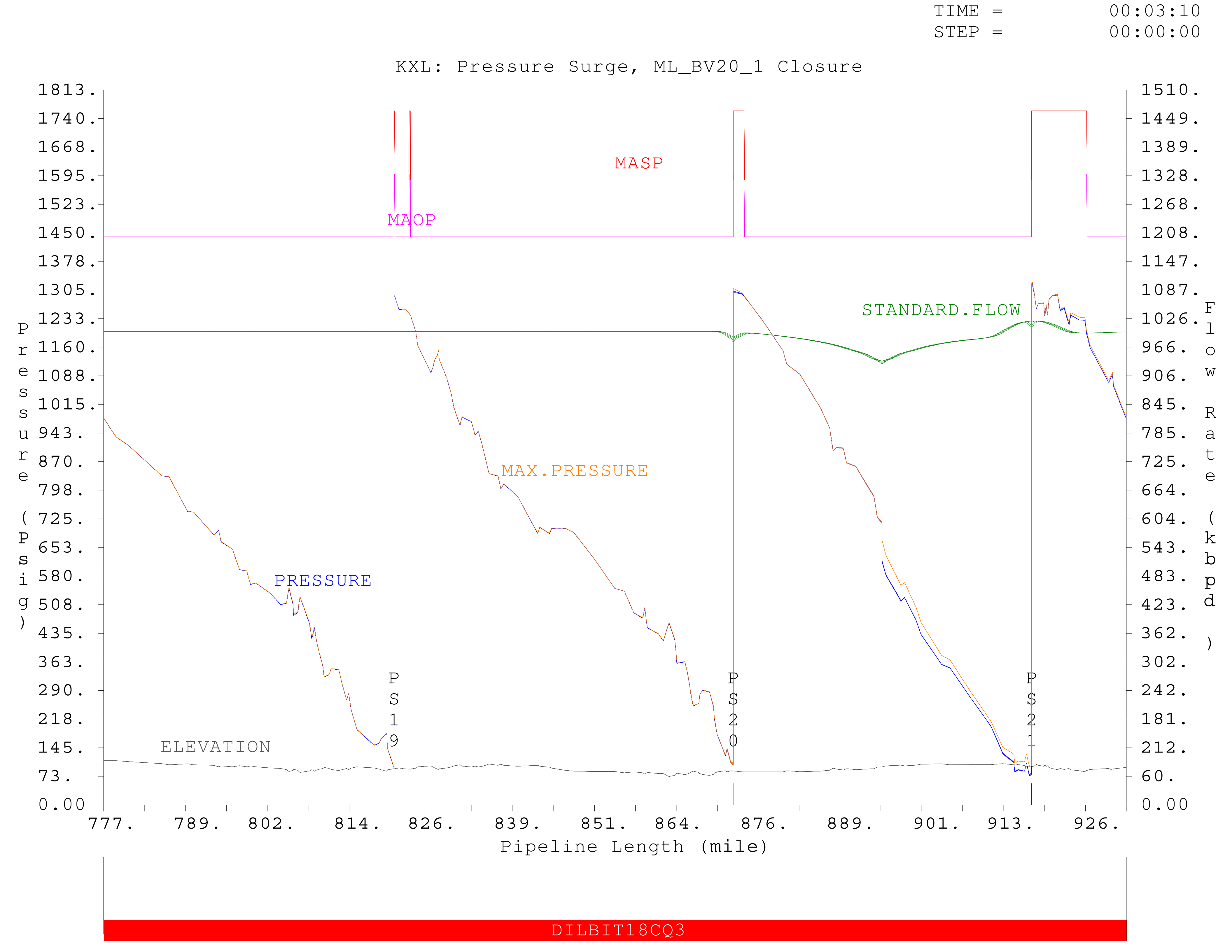
Mainline Valve at the Midpoint between Two Pump Stations


TIME = 00:00:00
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
Pressure (psig)
Flow Rate (kbpd)
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
PS19
PS20
PS21
Pipeline Length (mile)
DILBIT18CQ3

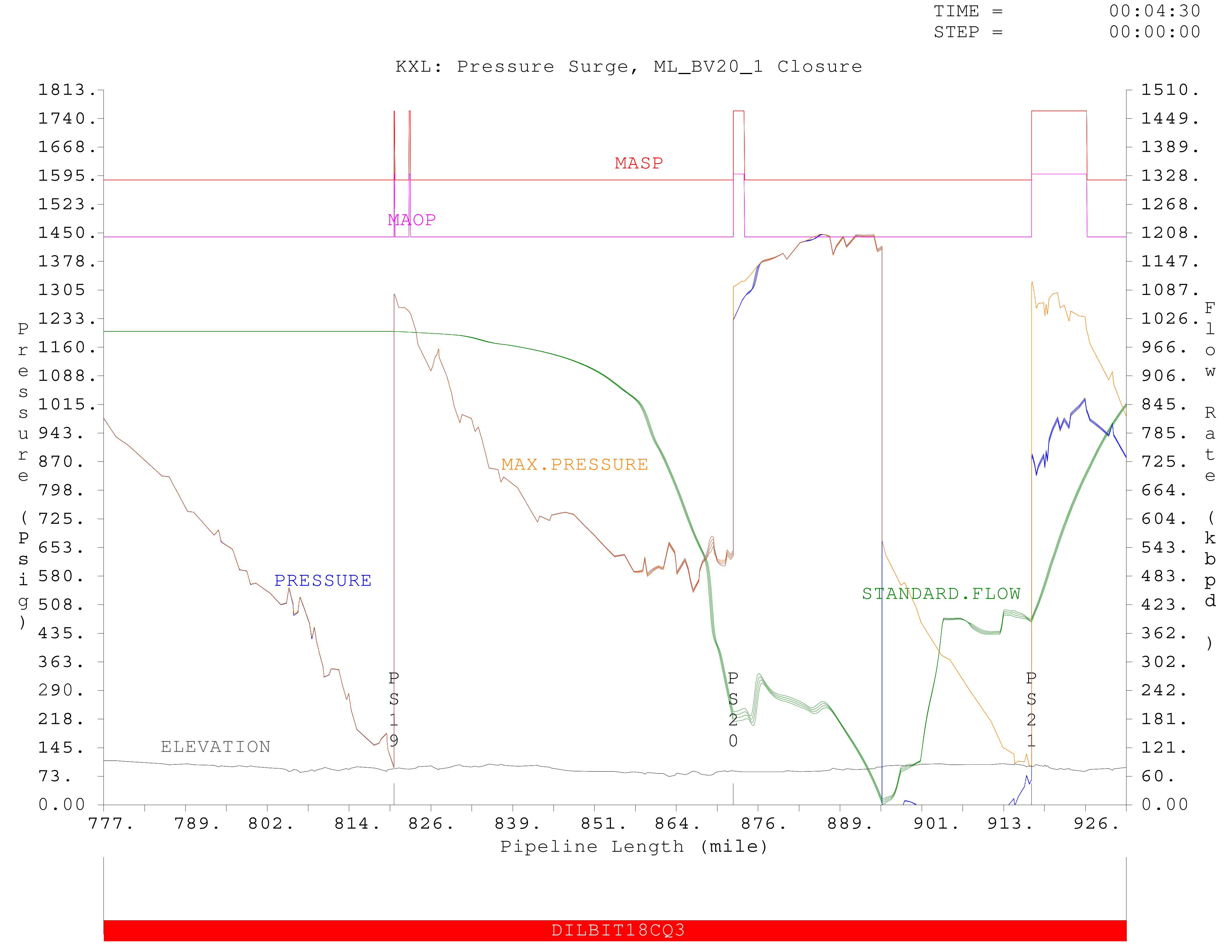
TIME = 00:02:30
STEP = 00:00:00

KXL: Pressure Surge, ML_BV20_1 Closure

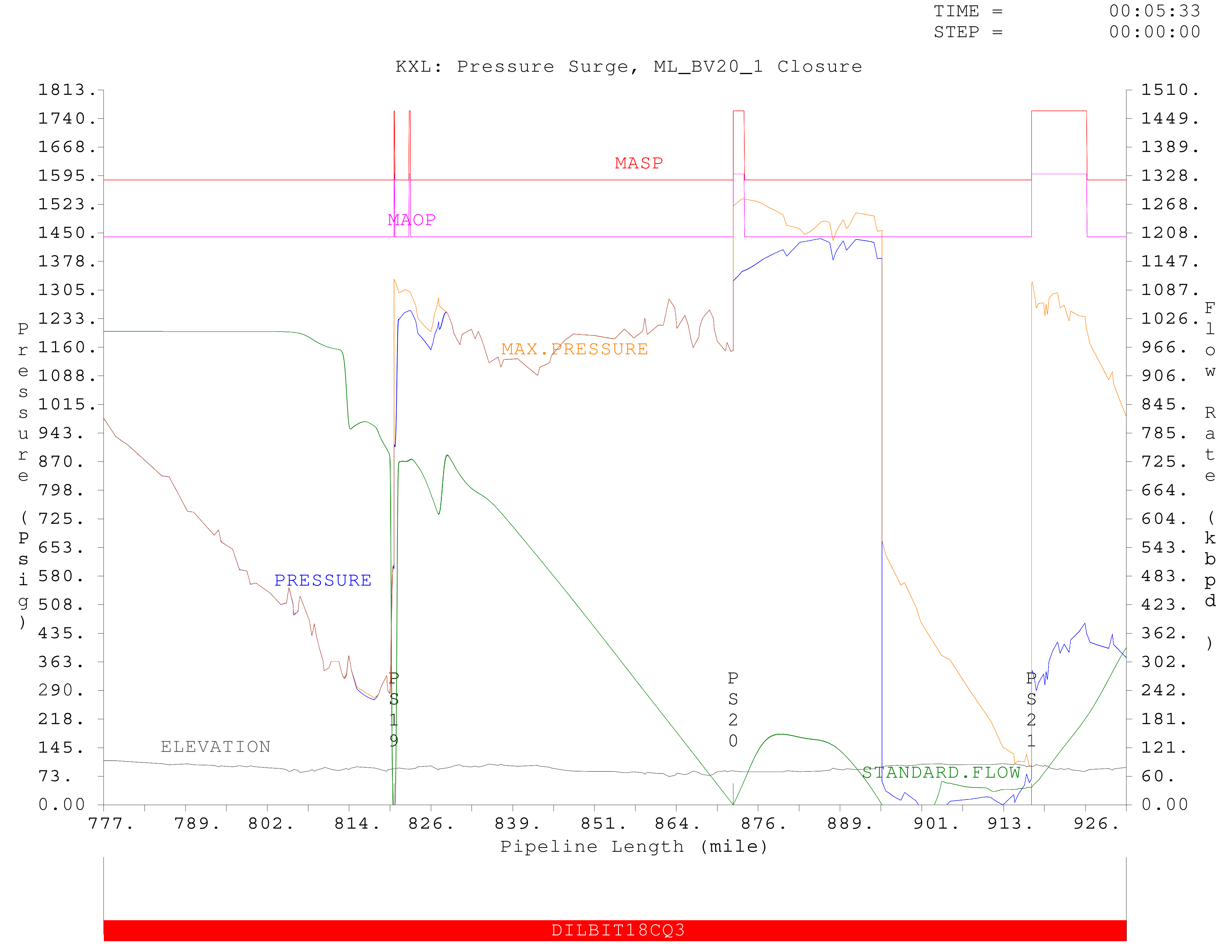




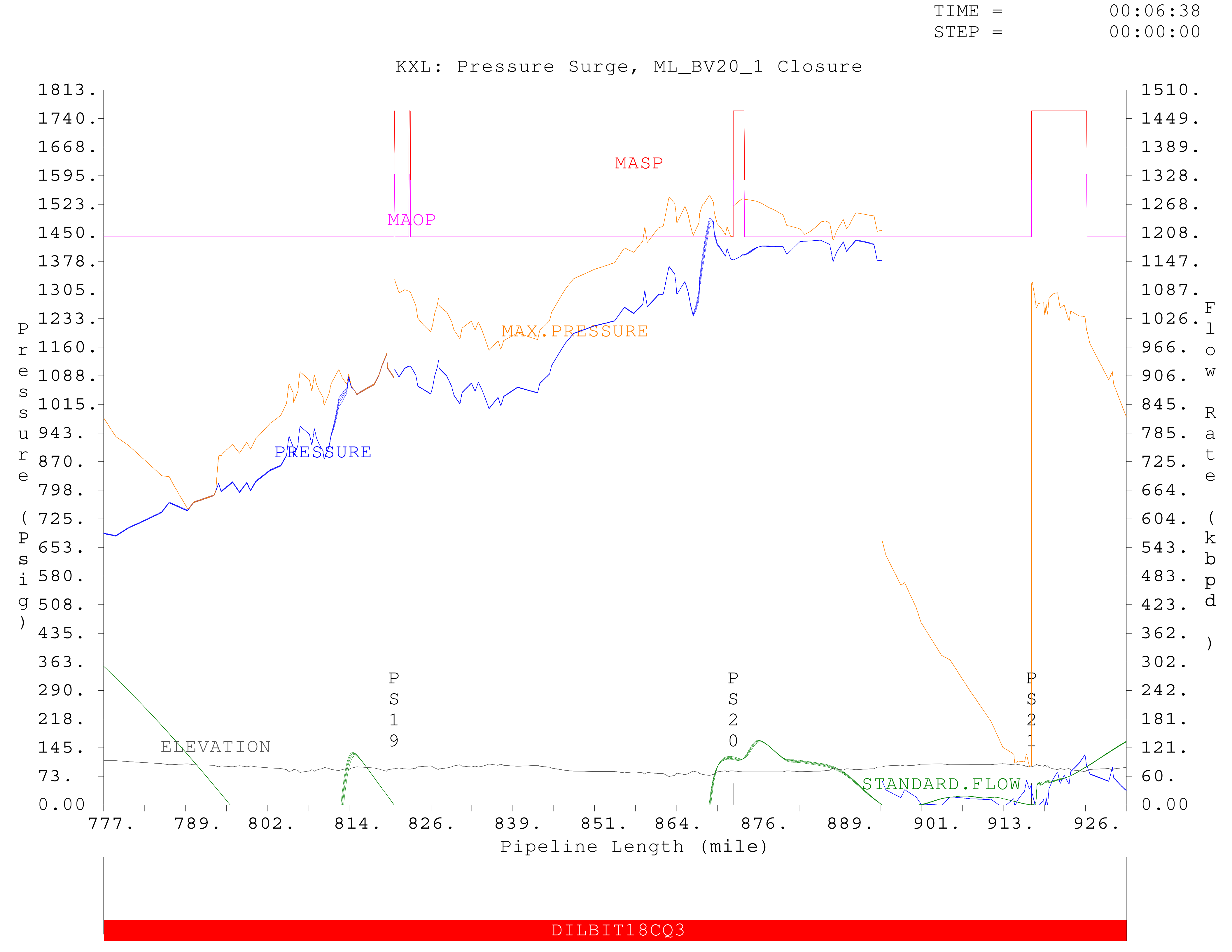
TIME = 00:03:10
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
PS19
PS20
PS21
Pressure (psig)
Flow Rate (kbpd)
1813. 1740. 1668. 1595. 1523. 1450. 1378. 1305. 1233. 1160. 1088. 1015. 943. 870. 798. 725. 653. 580. 508. 435. 363. 290. 218. 145. 73. 0.00
1510. 1449. 1389. 1328. 1268. 1208. 1147. 1087. 1026. 966. 906. 845. 785. 725. 664. 604. 543. 483. 423. 362. 302. 242. 181. 212. 60. 0.00
777. 789. 802. 814. 826. 839. 851. 864. 876. 889. 901. 913. 926.
Pipeline Length (mile)
DILBIT18CQ3

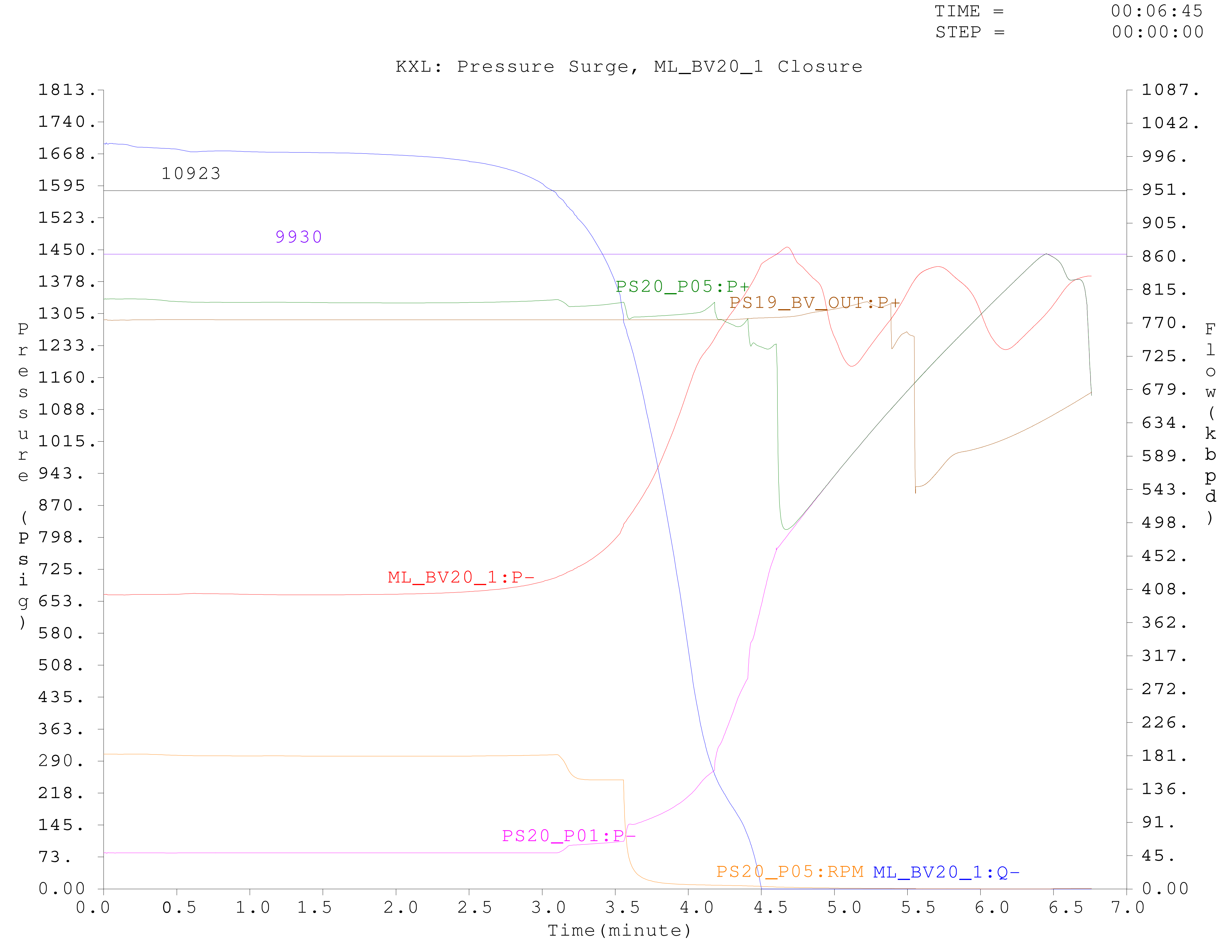


TIME = 00:04:30
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
Pressure (Psig)
Flow Rate (kbpd)
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.00
1510.
1449.
1389.
1328.
1268.
1208.
1147.
1087.
1026.
966.
906.
845.
785.
725.
664.
604.
543.
483.
423.
362.
302.
242.
181.
121.
60.
0.00
MASP
MAOP
MAX.PRESSURE
PRESSURE
STANDARD.FLOW
ELEVATION
PS19
PS20
PS21
777.
789.
802.
814.
826.
839.
851.
864.
876.
889.
901.
913.
926.
Pipeline Length (mile)
DILBIT18CQ3



TIME = 00:05:33
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
MASP
MAOP
MAX.PRESSURE
PRESSURE
ELEVATION
STANDARD.FLOW
PS19
PS20
PS21
Pressure (Psig)
Flow Rate (kbpd)
1813. 1740. 1668. 1595. 1523. 1450. 1378. 1305. 1233. 1160. 1088. 1015. 943. 870. 798. 725. 653. 580. 508. 435. 363. 290. 218. 145. 73. 0.00
1510. 1449. 1389. 1328. 1268. 1208. 1147. 1087. 1026. 966. 906. 845. 785. 725. 664. 604. 543. 483. 423. 362. 302. 242. 181. 121. 60. 0.00
777. 789. 802. 814. 826. 839. 851. 864. 876. 889. 901. 913. 926.
Pipeline Length (mile)
DILBIT18CQ3


TIME = 00:06:38
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
Pressure (psig)
Flow Rate (kbpd)
MASP
MAOP
MAX.PRESSURE
PRESSURE
ELEVATION
STANDARD.FLOW
PS19
PS20
PS21
Pipeline Length (mile)
DILBIT18CQ3


TIME = 00:06:45
STEP = 00:00:00
KXL: Pressure Surge, ML_BV20_1 Closure
Pressure (psig)
Flow (kbpd)
Time(minute)
10923
9930
PS20_P05:P+
PS19_BV_OUT:P+
ML_BV20_1:P-
PS20_P01:P-
PS20_P05:RPM
ML_BV20_1:Q-
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.00
1087.
1042.
996.
951.
905.
860.
815.
770.
725.
679.
634.
589.
543.
498.
452.
408.
362.
317.
272.
226.
181.
136.
91.
45.
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0

Pipeline and Hazardous Materials Safety Administration
Docket Number PHMSA 2008-0285
TransCanada Keystone Pipeline, L.P.
Application to Design, Construct and Operate the Keystone XL Oil Pipeline at 80% Specified Minimum Yield Strength (SMYS)
Response to PHMSA

"Will any areas go over 1440psi, if so where. If they have some intermediate pipe areas with design/operating pressures over 1440 psi, how will they monitor pressure/pressure control at the pipe spec change point?

Response:

As explained in "pipe segments downstream of pump stations" response dated November 19, 2009, Keystone is designing heavier wall pipe into the pipeline system, which will be rated to an MOP of 1600 psig. This pipe will be located at certain low elevation points in close proximity to the discharge of a pump station. As explained in the November 19^{th} response, under normal operating circumstances no pipeline segment, including the segments referenced above, will exceed 1440 psig. It is important to note that Keystone is not requesting that the special permit apply to these areas. The intent of these intermediate heavy wall pipe segments is to ensure that an overpressure due to a surge event is properly mitigated from a pipeline design perspective. This is yet another redundant form of protection that serves to supplement the pressure control and over pressure protection system that will be implemented on the pipeline.

There is no monitoring directly at the points where the 1440 psig pipeline meets the intermediate segments that utilize pipe rated to a higher MOP. Control and monitoring of these segments will be achieved through the use of the SCADA system and proven design. As with other liquid service pipelines, design profiles are monitored and simulated to ensure that no segment of the pipeline ever exceeds MOP. In cases where the elevation profile of the pipeline could cause increased hydraulic gradients, the discharge of upstream pump stations is controlled to a below set maximum pressure calculated by the hydraulic simulation. This ensures there is no risk of overpressure.

That same control and monitoring is used on liquid pipeline systems that use a heavier wall pipe as additional mitigation against overpressure. The simulation calculates the set point of any upstream station at risk of higher hydraulic gradients. This maximum pressure is used to control the pump station discharge pressure. In the case of the Keystone XL pipeline system, these pressure set points will be based on the entire pipeline being 1440 psig MOP. Installing pipe rated to a higher MOP in those segments identified as having the greatest risk to surge due to hydraulic gradients, allows for a redundancy to the level of protection and thus further reducing the risk that surge events pose to the pipeline system.

"We would like to know if the "hydraulic modeling scenarios" – have the worst case examples?"

Response:

The hydraulic modeling scenarios presented in previous responses are based on a conservative approach to modeling. They indicate the worse case scenarios for all pipeline segments.

"What is the max. surge pressure that they expect, under what conditions, where is it located?"

Response:

The following transient simulation case captures the worst-case scenario where simultaneous failures modes and maximum operating conditions are present. In the unlikely event of multiple failure events occurring coincidentally such as maximum design flow rate is present, the station communication system experiences a failure, and an un-commanded valve closure occurs, the resulting pressure surge would not exceed the maximum allowed surge pressure limit. Under the current Keystone XL over pressure and pressure protection philosophy, in case of communication failure at a pump station, the pressure discharge setting will be reduced therefore enforcing a safer condition by decreasing both flow rate and pressure.

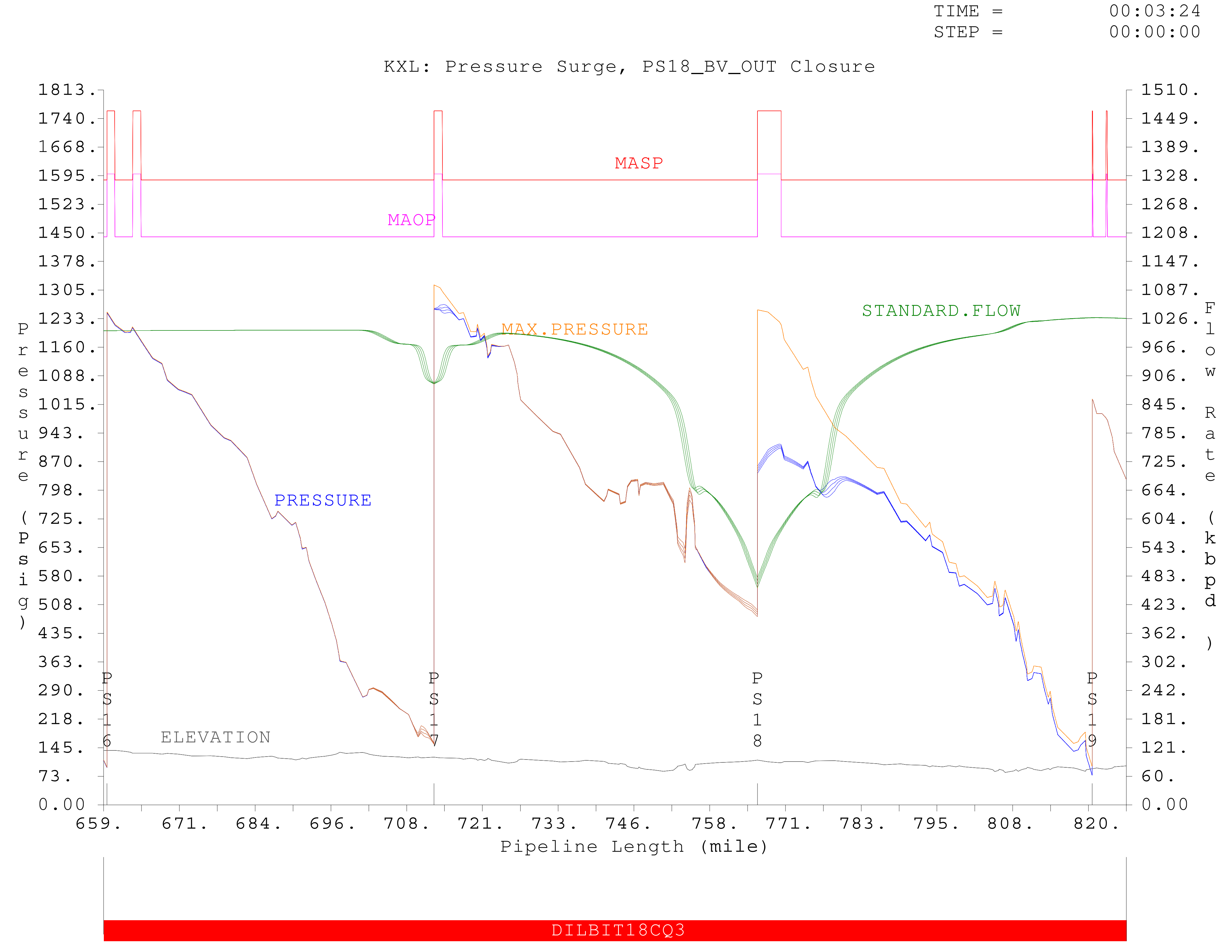
KXL Transient Pressure Profiles

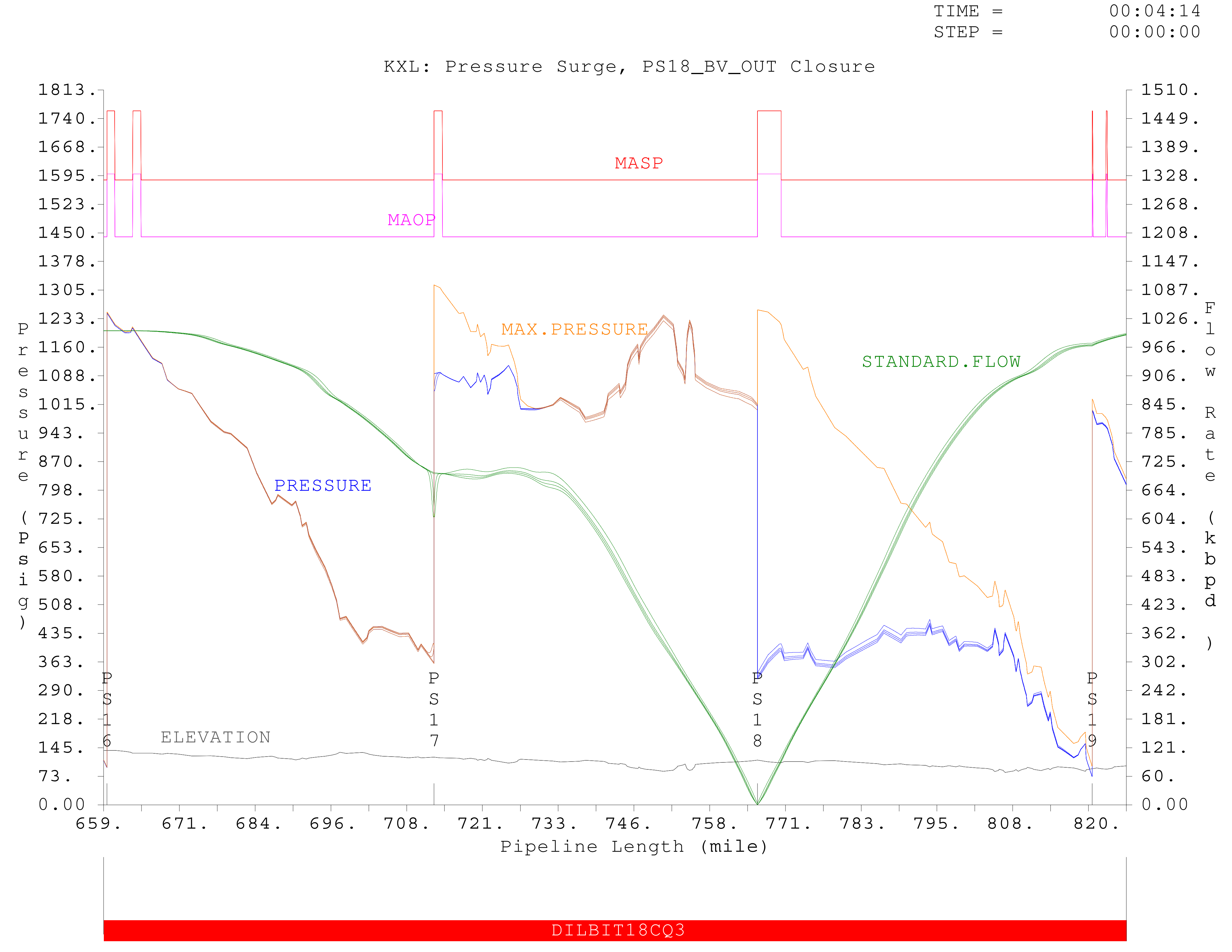
Maximum Surge Pressure Case

The worst case surge pressure is experienced downstream of Haakon pump station in South Dakota. It occurs when the discharge valve of the station is triggered to close during communication outage while the system is operating at maximum design flow.

TIME = 00:00:00
STEP = 00:00:00
KXL: Pressure Surge, PS18_BV_OUT Closure
MASP
MAOP
MAX.PRESSURE
STANDARD.FLOW
PRESSURE
ELEVATION
PS16
PS17
PS18
PS19
Pressure (psig)
Flow Rate (kbpd)
1813. 1740. 1668. 1595. 1523. 1450. 1378. 1305. 1233. 1160. 1088. 1015. 943. 870. 798. 725. 653. 580. 508. 435. 363. 290. 218. 145. 73. 0.00
1510. 1449. 1389. 1328. 1268. 1208. 1147. 1087. 1026. 966. 906. 845. 785. 725. 664. 604. 543. 483. 423. 362. 302. 242. 181. 121. 60. 0.00
659. 671. 684. 696. 708. 721. 733. 746. 758. 771. 783. 795. 808. 820.
Pipeline Length (mile)
DILBIT18CQ3

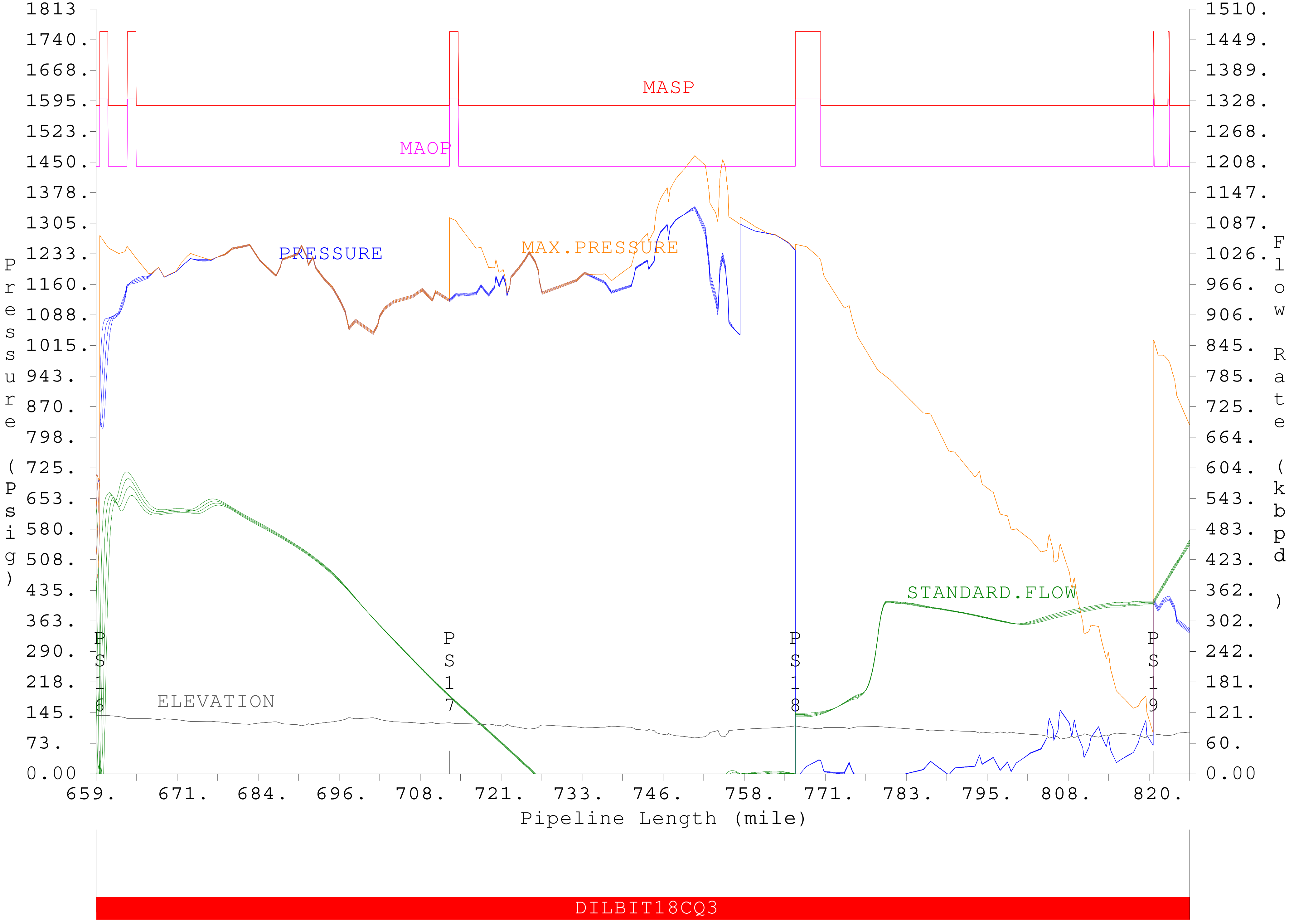

TIME = 00:02:27
STEP = 00:00:01
KXL: Pressure Surge, PS18_BV_OUT Closure
MASP
MAOP
STANDARD.FLOW
MAX.PRESSURE
PRESSURE
ELEVATION
Pressure (Psig)
Flow Rate (kbpd)
PS16
PS17
PS18
PS19
Pipeline Length (mile)
DILBIT18CQ3


TIME = 00:03:24
STEP = 00:00:00
KXL: Pressure Surge, PS18_BV_OUT Closure
MASP
MAOP
MAX.PRESSURE
STANDARD.FLOW
PRESSURE
ELEVATION
PS16
PS17
PS18
PS19
Pressure (Psig)
Flow Rate (kbpd)
Pipeline Length (mile)
DILBIT18CQ3

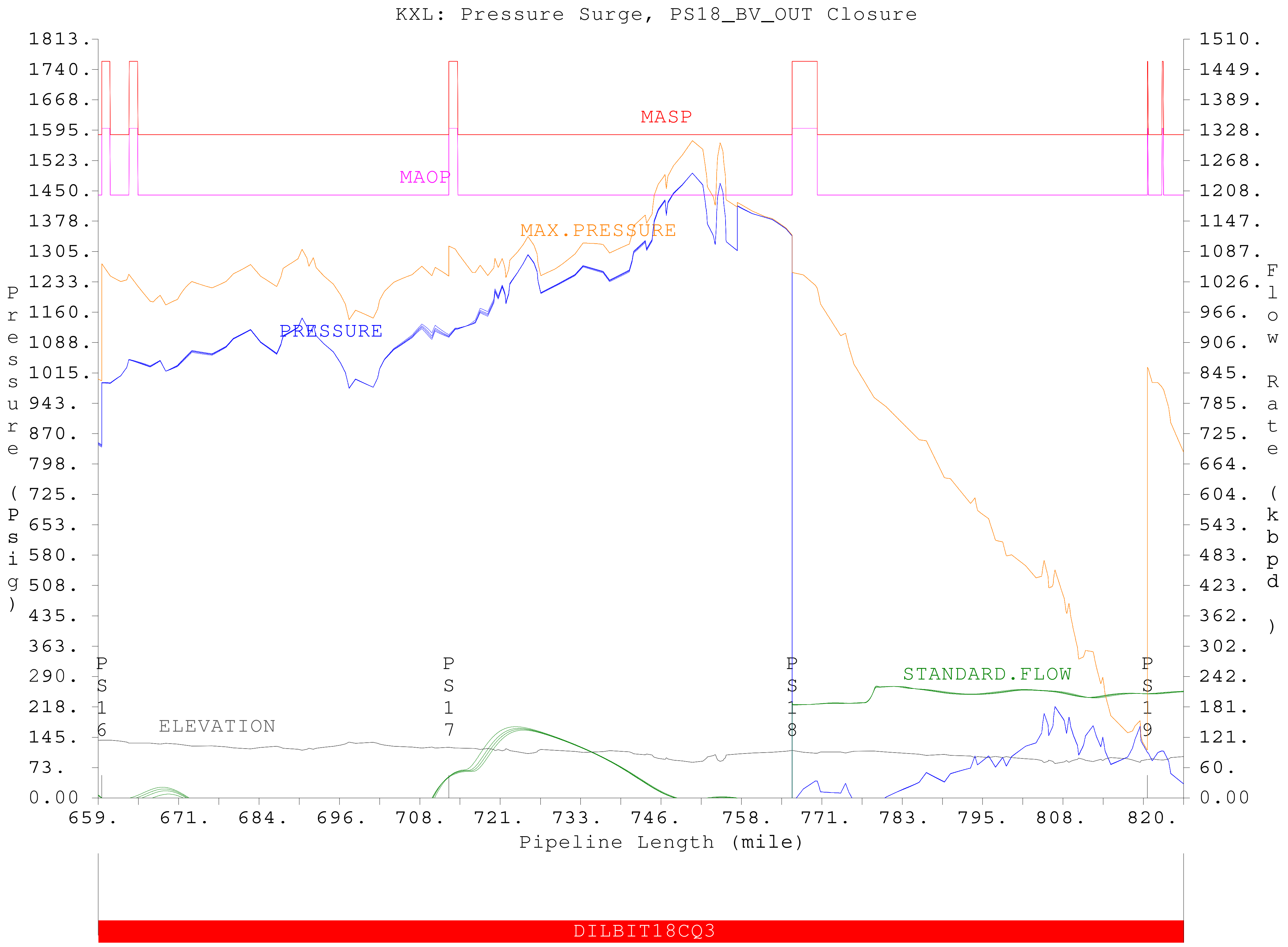

TIME = 00:04:14
STEP = 00:00:00
KXL: Pressure Surge, PS18_BV_OUT Closure
Pressure (Psig)
Flow Rate (kbpd)
MASP
MAOP
MAX.PRESSURE
STANDARD.FLOW
PRESSURE
ELEVATION
PS16
PS17
PS18
PS19
1813.
1740.
1668.
1595.
1523.
1450.
1378.
1305.
1233.
1160.
1088.
1015.
943.
870.
798.
725.
653.
580.
508.
435.
363.
290.
218.
145.
73.
0.00
1510.
1449.
1389.
1328.
1268.
1208.
1147.
1087.
1026.
966.
906.
845.
785.
725.
664.
604.
543.
483.
423.
362.
302.
242.
181.
121.
60.
0.00
659.
671.
684.
696.
708.
721.
733.
746.
758.
771.
783.
795.
808.
820.
Pipeline Length (mile)
DILBIT18CQ3

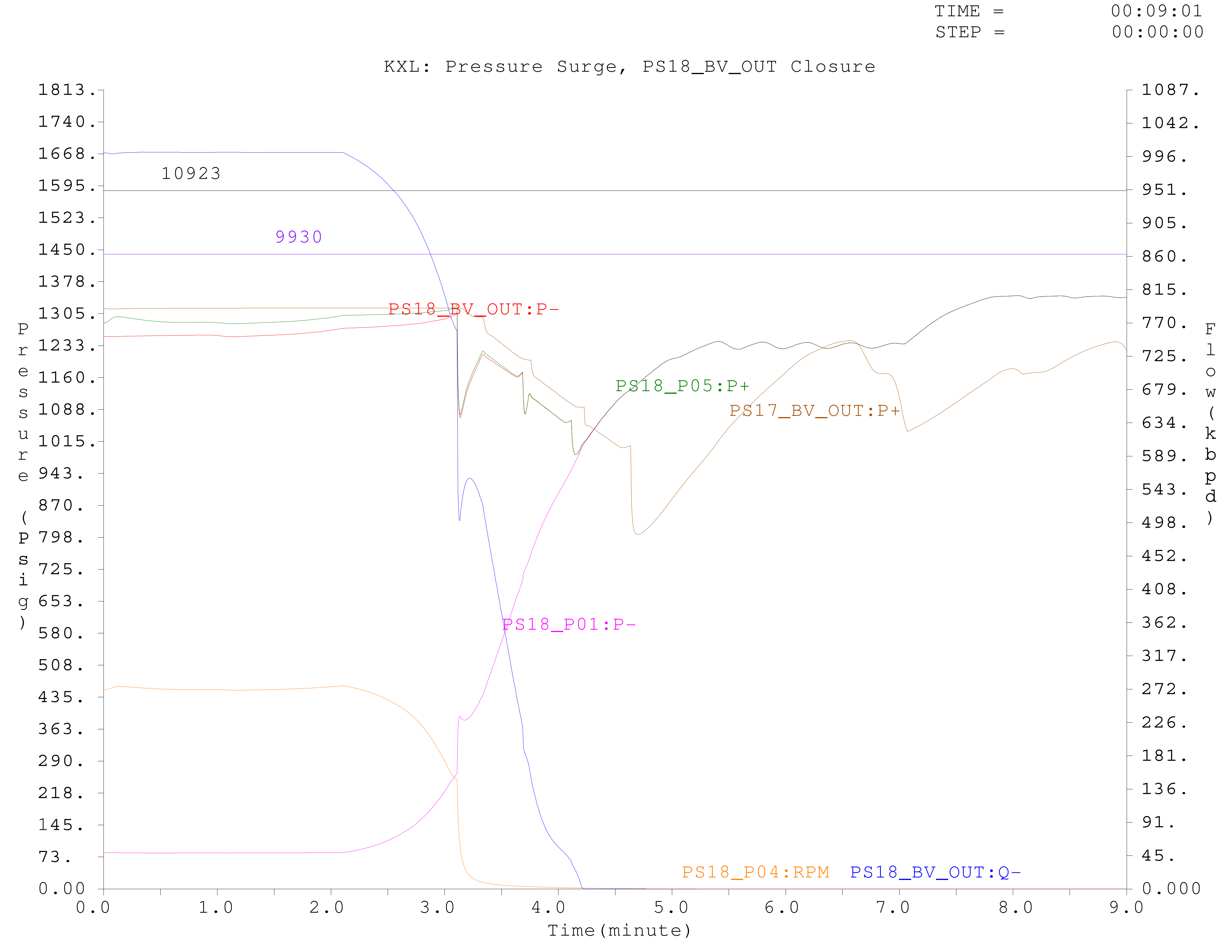
TIME = 00:05:47
STEP = 00:00:00

KXL: Pressure Surge, PS18_BV_OUT Closure



TIME = 00:09:06
STEP = 00:00:00




TIME = 00:09:01
STEP = 00:00:00
KXL: Pressure Surge, PS18_BV_OUT Closure
10923
9930
PS18_BV_OUT:P-
PS18_P05:P+
PS17_BV_OUT:P+
PS18_P01:P-
PS18_P04:RPM
PS18_BV_OUT:Q-
Pressure (Psig)
Flow (kbpd)
Time(minute)
1813. 1740. 1668. 1595. 1523. 1450. 1378. 1305. 1233. 1160. 1088. 1015. 943. 870. 798. 725. 653. 580. 508. 435. 363. 290. 218. 145. 73. 0.00
1087. 1042. 996. 951. 905. 860. 815. 770. 725. 679. 634. 589. 543. 498. 452. 408. 362. 317. 272. 226. 181. 136. 91. 45. 0.000
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0

"Please review and provide a response to Mr. Wesley James' comment PHMSA-2008-0285-0017, and where possible provide a side-by-side comparison with data and calculations provided in Mr. James' comment with the discussion paper Keystone provided. PHMSA is specifically looking for review/comment on any areas in data, calculations, and conclusions that may be in conflict between the two, as well as the areas where the two agree with one another."

Response:

Comment on Item 1 in PHMSA-2008-0285-0017

"The pressure in a gas pipeline is provided by compressors while the pressure in a crude oil pipeline is provided by centrifugal pumps. The cut pressure (pressure at zero discharge) for a centrifugal pump is typically 30% greater than the operating pressure. If a valve in the discharge line is closed while the pumps are running, the pressure in the discharge line would increase to 1950 psi and the pipeline would fail."

- All operating centrifugal pumps will increase in pressure when a discharge valve is closed. No centrifugal pump generates the same amount of head at zero flow. For the pumps that will be utilized on the Keystone XL pipeline, zero flow or shut off head is only 17% above the normal operating pressure as opposed to 30% as indicated by Mr. James.

- Any pipeline system that does not implement Pressure Control (PC) & Over-Pressure (OP) Protection Control systems would be at risk of over pressuring the pipeline. The Keystone XL pipeline will utilize both PC and OP protection systems. The station control system maintains the station discharge pressure within the acceptable boundaries by implementing a number of discharge pressure set points to ensure normal operating pressures are not exceeded and redundantly implements OP protection during any upset condition.

- Examples of PC and OP protection systems are:
  - A dramatic increase in pump discharge pressure will be dependant on the increase or shut down of one pump or the shutdown of the entire pump station.
  - Loss of communications between the operational control center and any Intermediate mainline valve will trigger a safe mode at the corresponding upstream pump station thereby slowing down the flow to a predetermined acceptable level.

Response

Comment on Item 2 in PHMSA-2008-0285-0017

"Because the density of the crude oil is greater than the density of the gas, unsteady flow surges are greater in a crude oil pipeline. Some common causes of surges in a pipeline are pump startup, power failure, valve movement, column separation and air removal. Pressure surges as much as 300 psi can occur in this pipeline resulting in a total pressure of 2250 psi. The bursting pressure for this pipeline is 2070 psi."

- Crude oil pipelines are more prone to surge situations than gas pipelines. Many operating conditions can trigger a surge such as power outages, valve movement, etc. Un-mitigated surges could pose a risk to overpressure. Implementation of specific OP and PC pipeline protection control system as designed into the Keystone XL system solves and adverts these problems.

- Keystone has conducted several transient hydraulic studies considering all the possible events and potential upset scenarios which could be considered potential sources of pressure surges within the system. These studies include intermediate mainline valve closure, intermediate mainline valve closure with two consecutive station shutdowns, pump station valve closure, PCV failure or closure, VFD failure, pump station shutdown or power failure, in-line tool stoppage and communication link failure. With specific OP and PC pipeline protection control systems in place there is no event and/or condition found where the total system pressure including the surges go beyond the allowable of 110% of the system's MOP (1.1 x 1440 = 1584 psig).

- Please refer to the data response entitled "Maximum Surge Scenario". Keystone examined a worst-case scenario transient simulation at the most vulnerable area along the pipeline to illustrate that the surge would not exceed 110% MOP (1584 psig).

- Keystone will be utilizing pipe that meets or exceeds the requirements of API 5L PSL 2. The required minimum tensile strength associated with this pipe is 82.7 ksi. From this we are able to determine that plastic deformation of the pipeline would not occur until the pressure was increased to 2136 psig. Given the fact that the worst case surge scenario would not allow the pressure to exceed 110% MOP (1584 psig, based on the extensive SCADA and operation control related features and procedures explained above), and that the pipeline will be successfully hydrostatically tested to 125% MOP (1800 psig), it is Keystone's opinion that its system design offers a level of safety equal to or greater than existing regulations in the unlikely event of a pressure surge along the pipeline.

Response

Comment on Item 3 in PHMSA-2008-0285-0017

"A study of major Canadian pipeline ruptures (Jeglic, 2004) have found that during the first ten years of operation, stress cracking was the most common cause of pipeline ruptures while during the next ten years of operation, external corrosion was the most common cause of pipeline ruptures. Both causes of ruptures are time dependent and will be a major concern with the Keystone Pipeline because there is no extra steel in the walls of the pipe to compensate for pipeline deterioration. Research (Kiefher, 2001) has shown that a longitudinal stress crack 16 inches long and less than 1/16 inch deep will cause the pipeline to rupture at the normal operating pressure of 1500 psi."

- The mechanism for the onset of external and internal corrosion does not change with an increase in operating stress level. Corrosion growth is also not affected by an increase in stress level. Safeguards are in place to minimize the potential of external corrosion on the pipeline. These safeguards include using high performance external coating (FBE), installing cathodic protection systems, conducting interference current surveys, and conducting close interval surveys

- Stress corrosion cracking (SCC) refers to localized pipe damage (cracks) caused by the combined influence of a susceptible pipeline coating, conducive environment (e.g., corrosive soils), operational stresses, and to a limited extent, temperature of the pipe. The coating system to be used on the Project is a high performance FBE. This coating system provides excellent protection against SCC due to the performance of the primer and the durability of the applied epoxy coating. According to Canadian Energy Pipeline Association Recommended Practices 2nd Edition Section 5.1.1.1, Coating Type and Coating Condition, "No SCC has been documented in association with FBE, field applied epoxy or epoxy urethanes, or extruded polyethylene" and according to PHMSA Fact Sheet on Stress Corrosion Cracking 120604 http://primis.phmsa.dot.gov, "applying special coatings (fusion bonded epoxy) will protect the pipeline from the occurrence of SCC." Additionally, the cathodic protection system will be monitored to prevent cathodic protection overcharging, which could promote SCC growth. Consequently, SCC is not considered to be a viable threat for the Project.

- It is not common practice to employ corrosion allowance in the design of North American onshore transmission pipelines.

Comment on Spray Calculation in PHMSA-2008-0285-0017:

- The spray calculation conducted by Mr. James is not applicable to below ground pipelines. In no case would a rupture from a buried pipeline result in a spray consistent with the calculated spray zone in PHMSA-2008-0285-0017. The pipeline will be buried 48 inches below the grounds surface, which in a release situation, would provide damping and absorption of all or most of the kinetic energy. Industry experience

Response

demonstrates that oil flowing through a pipeline buried at this depth would simply pool on the surface in the immediate area of the release. The Keystone XL pipeline will be buried to a depth of 4 feet. The anticipated worst case spray zone for an exposed or above ground pipeline is anticipated to be consistent with industry experience, i.e. in the 75 to 394 foot range. The following are examples of similar pipeline ruptures that support this theory. It should be noted that, while the pipelines in the first two examples operated at a lower pressure than the pressure for the Keystone XL pipeline, those pipelines were buried at a depth less than the 48-inches of cover that will apply to the Keystone XL pipeline.

Lakehead Pipe Line Co. - Bemidji, Minnesota (August 20, 1979)
On August 20, 1979, Lakehead Pipe Line Co. experienced a seam weld related rupture of their NPS 34 pipeline near Bemidji, Minnesota. The cause of the failure was determined to be a failure of the pipeline's long seam. The operating pressure of the pipeline at the time of the incident was approximately 500 psi. The oil spray covered a distance of approximately 394 feet from the rupture site.

Kinder Morgan Canada – Burnaby, British Columbia (Jul 24, 2007)
On July 24, 2007, a NPS 24 pipeline operated by Kinder Morgan Canada was punctured by a third party excavator. This caused oil to be released in the form of a geyser from the excavation site. The height of the spray of oil was approximately 49 – 66 feet high. It should be noted that the extent of the spray was worsened by the closure of the downstream isolating valve which caused the pressure of the pipeline to rise from 75 psi to 250 psi. The oil spray covered a distance of approximately 197 feet from the rupture site.

Trans-Alaska Pipeline – Fairbanks, Alaska (October 4, 2001)
On October 4, 2001, operators of the Trans-Alaska Pipeline detected a leak in the pipeline via helicopter patrol. The Trans-Alaska pipeline is an **above ground** pipeline that transports crude oil from Prudhoe Bay, Alaska to Valdez, Alaska. Upon investigation, it was determined that the oil leak was a result of a bullet puncture on the side of the pipeline slightly above the horizontal axis of the pipeline. The puncture resulted in a spray of crude oil to the surrounding environment. The operating pressure of the pipeline at the time of the incident was 525 psi. The oil spray covered a distance of approximately 75 feet from the puncture site.