City of Houston

Northeast Water Purification Plant Improvements

Transient Analysis Report

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Executive Summary

Lockwood, Andrews & Newnam, Inc. (LAN) was retained by CDM Smith, the design engineer, and the City of Houston Public Works and Engineering Department (City) to perform a transient study to support plant improvements at the Northeast Water Purification Plant (NEWPP). Two models were built to analyze transients: a small, detailed scale model (micro model) of the NEWPP High Service Pump Station (HSPS) and a larger scale model (macro model) of the Northeast Transmission System.

With the micro model of the NEWPP HSPS, all pumps failing, single pump failure, and normal pump start-up and shut down, both with and without the existing surge tanks in the system were simulated and analyzed. With the macro model of the Northeast Transmission System, the North Harris County Regional Water Authority (NHCRWA) emergency flow control valve closure was simulated and analyzed.

At the NEWPP HSPS, transients were an issue with the existing check valves on the pump discharge lines in the pump failure scenarios. The check valves slammed, causing pressure spikes over 200 psi in the discharge lines and the header. Without the surge tanks in the system, high pressure spikes were not an issue. Vapor cavities occurred in the pump discharge lines in the pump failure scenarios, both with and without the surge tanks.

One solution to mitigate the transient issues occurring with the existing check valves is to replace the check valves with different pump control valves. Three different types of pump control valves, selected by the design engineer, were modeled with the existing pump control valves remaining in service, but set in the open position. These included a 24-inch and 30-inch Golden Anderson Ball Valve, 24-inch and 30-inch Adams Disc Valve, and 30-inch Golden Anderson Wye Valve. Replacing the check valves with either the Adams Disc Valve or Golden Anderson Ball Valve, either 24-inch or 30-inch sizes, mitigate transients in all conditions modeled without the need for additional air valves or surge devices. The results for the Adams Disc Valve and the Golden Anderson Ball Valve are very similar. Results also do not change much between the 24-inch and the 30-inch valves. The Golden Anderson Checktronic Wye Valve creates high pressure spikes and vapor cavities in the All Pump Failure Scenario, because the valve's emergency closure is hydraulically controlled and can potentially slam. This valve is not recommended for this project.

In the existing system conditions Simultaneous All Pump Failure Scenario, the surge tanks emptied when the tanks were initially set to the current operations water level (65% full) and the NEWPP was modeled as an isolated system (i.e. East Water Purification Plant (EWPP) is inoperable or Hirsch Rd flow control valve is closed). According to information provided by the City Drinking Water Operations staff, when the NEWPP pump station is offline, the EWPP is able to maintain a system backpressure of approximately 40 psi. With the EWPP backpressure in the system, the surge tanks did not empty. Also, when the surge tanks were initially set to the Operations and Maintenance (O&M) Manual of 80% full, the surge tanks did not empty.

Under current conditions it is necessary to operate the surge tanks at the O&M manual recommended 80% full when the Hirsch Rd flow control valve is closed, to ensure the surge tanks do not empty. Once the proposed pump control valves have been installed, and assuming a 30 to 60 second valve closure time, the system can operate without the surge tanks, regardless of the EWPP backpressure.

In the macro model of the Northeast Transmission System, NHCRWA was modeled taking 44 MGD and closing their flow control valve at the currently defined emergency closure time of 90 seconds. The 90 second closure of the NHCRWA valve causes “line packing” to occur. Line packing is a condition that occurs in longer pipelines when flow is stopped at the downstream and the volume in the line increases due to pipe wall expansion. In the last 30-seconds of the valve closure, the pressures in the line rise quickly, creating a pressure transient that reflects through the system. The pumps at the NEWPP also continue to operate during the valve closure, causing the pump discharge pressure to rise while flow through the pumps is reduced. Pressures above 200 psi are seen throughout the NHCRWA water line and the City system.

Four 12-inch Golden Anderson Surge Relief valves, with a 120 psi setting to open, are recommended to be installed at the NHCRWA Spears Rd Pump Station. Until the surge relief valves can be installed, or as an alternative to the installation of these valves, it is recommended that NHCRWA adjust their flow control valve closure of 90 seconds no faster than 30 minutes. It is also recommended that NHCRWA notify the NEWPP before they begin closing their valve, so the NEWPP operators can adjust their pumping operations.

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1.0 Introduction

Lockwood, Andrews & Newnam, Inc. (LAN) was retained by CDM Smith, the design engineer, and the City of Houston Public Works and Engineering Department (City) to perform a transient study to support plant improvements at the Northeast Water Purification Plant (NEWPP).

This transient study included the development of a detailed transient analysis model of the City's NEWPP high service pump station. The detailed model was used to simulate normal pump start-up and shut down, and emergency condition scenarios at the NEWPP. The simulation results were used to evaluate normal pump start-up and shut down procedures, recommend control valve opening and closure times, and provide recommendations for surge protection equipment. Worst case emergency conditions were also evaluated to determine performance of new control valve alternatives that could be used to minimize pump backflow and the size and future role of the existing surge tanks.

LAN conducted the NEWPP transient analysis study in two phases.

1. Simulated and analyzed the existing system for all pumps failing, single pump failure, and normal pump start-up and shut down, both with and without the existing surge tanks in the system.
2. Simulated and analyzed the same scenarios with the proposed pump control valves, surge tanks and proposed surge mitigation devices.

An existing macro model of the Northeast transmission system was modified to include the North Harris County Regional Water Authority's (NHCRWA) 54-inch water line. The model includes the line from the City 66-inch water line to the Spears Pump Station, ending at the flow control valve before the storage tanks. An exhibit of the lines modeled can be seen in Appendix B, Exhibit 2. The model was used to simulate a NHCRWA peak hour emergency flow control valve closure, to determine the effects on the City's transmission lines and at the NEWPP.

2.0 Transient Events

A transient event, also referred to as a surge or water hammer, is a series of pressure fluctuations above or below the normal operating pressure of the pipe in an unsteady state flow condition. Transient events generally occur whenever flow conditions in the pipe are quickly altered.

Pressure increases, or "up-surges", are commonly the result of rapid valve closure, pump start-ups, and pump shut downs. In the case of rapid valve closure, when water is flowing in a pipe at a certain velocity and is stopped in a short period of time, the energy from the water flow is forced to reverse as it reflects off the closed valve. The energy then propagates as a transient high pressure wave through the pipeline. The pressure increase is independent of the working pressure of the system and is instead dependent on the properties of the fluid, and the size and material properties of the pipe. The high pressure transient wave stresses the pipe, which may damage the pipe or potentially lead to a failure.

Negative (vacuum) pressures, or "down-surges", are commonly the result of pump shut down or failure, the rapid opening of a valve, and pipe breaks. Negative pressure in the pipeline without adequate protection can lead to the collapsing of the pipe. If the negative pressure caused by the transient event falls to the vapor pressure of the liquid (i.e., -14.7 psi for water), the creation of vapor pockets inside the pipeline result. The collapse of these vapor pockets and subsequent rush

of fluid to fill the void may produce high pressure spikes and propagate a high pressure transient wave through the pipeline, further stressing the pipe.

Computer modeling of all transient event scenarios through the NEWPP system pumps, valves, surge protection devices, and pipelines was performed using the Liquid Transient, or LIQT©, computer program.

3.0 Data Collection and Model Development

This study required the development of a detailed micro model of the NEWPP High Service Pump Station (HSPS), which the following:

- HSPS pumps, control valves (butterfly valves), check valves, existing combination air and vacuum valves, surge tanks, and flow meters.
- Discharge piping connecting the NEWPP HSPS pumps to the existing 84-inch transmission main out to Beltway 8.
- Headloss associated with pipe material, pipe bends, tees, valves and flow meters
- Mid-way through the project, the Lake Houston Cost Share 36-inch transmission main was added, and associated demand and headloss.

The suction side piping for the NEWPP was not included in the micro model. Also, the node elevations used in the model are top of pipe elevations.

Information related to the design and operations of the NEWPP was collected, reviewed and used to develop the micro model, including:

- As-built drawings for the NEWPP, Phases 1 and 2
- As-built drawings for the Lake Houston Cost Share 36-/24-/20-inch water line
- Submittals, information and Operations and Maintenance (O&M) Manuals for the existing NEWPP 20 MGD pumps
- Shop drawings and O&M Manuals for the existing NEWPP surge tanks
- Information and O&M Manuals for the existing 30-inch pump control valves (butterfly valves)
- Information for the existing 30-inch globe style silent check valves on the pump discharge lines
- Information for the existing 8-inch and 6-inch combination air vacuum valves on the pump discharge lines

Information and O&M manuals for the surge tanks, globe style silent check valves, combination air vacuum valves and pump control valves are provided in Appendix A. In addition to reviewing NEWPP related data, preliminary meetings with City staff to discuss the various scenarios were conducted. Several site visits to the NEWPP HSPS were also conducted. One site visit included a meeting with the plant operator to witness and time existing control valves for normal pump start-up and shut down, and to verify pump discharge pressures and water levels in the surge tanks during operations. A table with the findings from the visit can be seen in Appendix A.

There was some debate at progress meetings held with the City about the rated capacity of the pumps at the HSPS. When the plant was built, four 27 MGD vertical turbine pumps (Pumps 1-4) and an 8 MGD emergency diesel pump (Pump 5) were installed at the HSPS. During a site visit conducted in July 2013, it was noted the nameplates for Pumps 1-4 indicated a rating of 27 MGD at 117-ft TDH. However, according to the pump manufacturer, Floway, the original pumps (Pumps

1-5) were rebowled in 2005 when Pumps 6-8 were installed, and the nameplates were not replaced. It is believed that all pumps, including the diesel driven emergency pump, are now rated 20 MGD at 191-ft TDH. See Appendix A for pump submittals and pump curves for the existing pumps. Table 1shows the rated conditions for the existing pumps at the NEWPP HSPS.

Table 1 - Pump Information

Pump	Rated Flow	Rated Head	Rated Speed	Motor/Engine
Pump 1	20 MGD	191 ft	890 rpm	Induction Motor
Pump 2	20 MGD	191 ft	890 rpm	Induction Motor
Pump 3	20 MGD	191 ft	890 rpm	Induction Motor
Pump 4	20 MGD	191 ft	890 rpm	Induction Motor
Pump 6	20 MGD	191 ft	890 rpm	Induction Motor
Pump 7	20 MGD	191 ft	890 rpm	Induction Motor
Pump 8	20 MGD	191 ft	890 rpm	Induction Motor
Pump 5 (Emergency Pump)	20 MGD	191 ft	890 rpm	Diesel Engine

The study also required a macro model, a larger scale model of the Northeast transmission system. The macro model includes:

- HSPS pumps, pump control valves, existing combination air vacuum valves and surge tanks
- 84-inch water line from NEWPP to Smith Rd
- 66-inch water line along Greens Road from Smith Rd to Greenspoint Dr
- 42-inch water line along Hirsch Road from Smith Rd to Little York Rd
- NHCRWA 54-inch water line
- All air/vacuum valves located along the existing lines
- Headloss associated with pipe material

An existing model from a previous study of the Northeast system was used as a starting point for this macro model. Information reviewed to add to and update the model includes:

- Drawings for the NHCRWA 54-inch water line to Spears Road Pump Station.
- NHCRWA Stealth Energy Dissipating flow control valve (NHCRWA flow control valve). Information on the valve is provided in Appendix C.
- Drawings for the Lake Houston Cost Share 36-/24-/20-inch water line.
- Customer demand information for NHCRWA and other customers along the Northeast transmission mains.

Specific information regarding the closure profile of the NHCRWA flow control valve could not be obtained. Instead, a closure profile of a similar Pratt Sleeve Valve was used.

An exhibit and schematic of the macro model can be seen in Appendix B. The demands in the model changed mid-way through the project, represented in the “Revised Demands” exhibit in Appendix B. The revision in demands is further discussed in Section 7.3.

The LIQT software analyzes the system in sections based on the defined analysis timestep. A smaller timestep allows the section length and overall system length analyzed to be smaller for more details. For the micro model, a timestep of 0.0035 seconds was selected to allow analysis of pipe lengths as short as 12 feet. However, the macro model consists of 21 miles of pipe. It was not feasible to model and analyze the transmission system with lengths as short as 12 feet because of

the resulting size of the model, and time for the model to run. Therefore, a more appropriate timestep of 0.05 seconds corresponding to a minimum pipe length of 141 feet was used.

4.0 Assumptions and Criteria

The transient analysis was performed using the maximum firm pumping capacity of the NEWPP of 120 MGD. (Note: Firm pumping capacity is a pump station's total pumping capacity with the largest pump out of service.) The emergency pump (Pump 5) is not run as part of normal operations, and therefore not considered in the determination of the firm capacity. The analysis of the existing system used the following initial assumptions and criteria:

- All pumps at the NEWPP are rated 20 MGD at 191 TDH.
- Firm pumping capacity (6 pumps running) of 120 MGD was used (Pumps 1 and 5 are offline).
- The EWPP is able to maintain a system back pressure of 40 psi at the NEWPP when the NEWPP is shut down and the Hirsch 42-inch valve is open. The Hirsch 42-inch valve is open in all scenarios unless noted.
- All combination air valves in the NEWPP and along the transmission lines are operational.
- The combination air/vacuum valves open at 0 psi.
- The 30-inch globe style silent check valves on the pump discharge lines are operational.
- The 30-inch globe style silent check valves on all the pump discharge lines open in 0.5 seconds, and close in 0.4 seconds, as recommended by Val-Matic.
- The 30-inch globe style silent check valves begin to close immediately upon backflow through the valve.
- The surge tanks initial water level for all existing system scenarios is 6.5 ft (65% full), as witnessed in field visits.
- The pump control valves (butterfly valves) are fully open and fail in current position.
- The existing pump control valves for Pumps 6, 7 and 8 open and close in 120 seconds, based on pump witness testing conducted September 18th, 2013.
- The existing pump control valves for Pumps 1 through 4 open and close in 40 seconds, based on pump witness testing conducted September 18th, 2013.
- A Hazen Williams coefficient (C-value) of 120 was used for water lines less than 36-inches diameter, and 130 for water lines equal to or greater than 36-inches diameter.
- The allowable, or safe, surge pressure range is -10 psi to 150 psi.
- All elevations are top-of-pipe.

The pressure wave speed for each pipe size was calculated as part of this analysis. The wave speed is important because the propagation of a transient event is directly related to the wave speed. The speed of a pressure wave is independent of the working pressure of the system but dependent on the fluid properties, the size, and material of the pipe. All other factors being equal, and ignoring surge control devices, a higher wave speed will result in a higher surge pressure. A summary of the pipe sizes, material assumptions, and corresponding wave speeds is provided in Table 2.

Table 2: Pressure Wave Speeds Used

Pipe Diameter (in)	Pipe Material	Wave Velocity (feet per second)
20	Steel	3,930
24	Steel	3,850
30	Steel	3,365
36	Steel	3,520
42	Steel	3,385
54	Steel	3,115
66	Steel	3,115
84	Steel	3,015

5.0 Scenarios

The transient analysis for the micro model of the NEWPP was based on the following set of Scenarios:

- Scenario 1 – Simultaneous All Pump Failure
- Scenario 2 – Normal Pump Shut Down
- Scenario 3 – Normal Pump Start Up
- Scenario 4 – Single Pump Failure with Five Remaining Pumps Running
- Scenario 5 – Emergency Pump 5 Shut Down Five Pumps Running
- Scenario 6 – Emergency Pump 5 Start Up with All Pumps Shut Down

For the problem definition phase, these Scenarios 1-4 were modeled under existing system conditions both with and without surge tanks. The Scenarios 1-4 were also modeled with proposed pump control valves, provided by the design engineer, with surge tanks. With the proposed pump control valves, Scenario 1 was also modeled without surge tanks, to determine the effects of the surge tanks on the system. Scenarios 5 and 6 were used as confirmation scenarios, once the proposed pump control valves were selected and other surge protection recommendations identified.

The Scenarios for the macro model of the Northeast Transmission System included:

- Scenario 7 – NHCRWA Emergency Flow Control Valve Closure
- Scenario 8 - Simultaneous Pump Failure at the NEWPP

The Simultaneous Pump Failure at the NEWPP Scenario was used as a confirmation scenario once the proposed pump control valves were selected, to ensure the existing combination air vacuum valves on the transmission lines adequately mitigate transients.

6.0 Phase 1 - Existing System Results

6.1 Scenario 1 – Simultaneous Pump Failure

Scenario 1 evaluated the failure of all pumps at the NEWPP. A simulation time of 180 seconds, with the pumps failing after 5 seconds was used for this Scenario. The Scenario was performed both with and without the surge tanks. Table 3 shows the results for Scenario 1a with surge tanks online.

Table 3 - Scenario 1a Results with Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	244.6	5.73	5.2	5.85
DH-8	Discharge Header at Pump 8	234.8	5.73	15.2	5.86
VL2-I	Flow Meter	189.3	5.74	11.0	8.38
VL3-I	Flow Meter	216.0	5.74	0.6	8.34
PL-END	Fence line of Plant	178.5	6.16	38.2	164.25
HAWC-4	84-inch line at Beltway 8	144.2	7.06	38.5	177.57
BFV8-O	Max System Pressure- Pump 8 Butterfly Valve	375.5	5.73	-14.7(2)	6.08

(1) See Exhibit 4, Appendix B for Node location
(2) Minimum system pressure of -14.7 psi occurs at multiple locations.

The maximum system pressure is 375.5 psi, occurring against the closed pump discharge valve for Pump 8, and exceeds the maximum allowable surge pressure (MASP) of 150 psi. The minimum system pressure is -14.7 psi, which occurs at the check valves and directly downstream of the check valves. The check valves on the pump discharge lines close at 5.67 seconds, causing pressure spikes and vapor cavities in the lines. The surge tanks drain but do not empty in this Scenario. Instead, the pressures in the surge tanks reach equilibrium with the system at 35.5 psi, and have a final water volume of 1,660 cu ft (33.2% full). Backflow is able to pass through the pump discharge line check valves before they close, causing backflow through the pumps. However, the pumps are equipped with ratchet devices, preventing the pumps from back spin. A graph showing the flow through the pumps in this Scenario can be seen in Appendix D.

The Scenario was also run without the backpressure from the EWPP (i.e. Hirsch Rd flow control valve closed). With the surge tanks initially at 65% full and without backpressure from the EWPP, the surge tanks empty and vapor cavities form in the piping to the surge tanks.

Table 4 shows the results for Scenario 1b without the surge tanks.

Table 4 - Scenario 1b Results without Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	105.8	0.00	6.0	13.14
DH-8	Discharge Header at Pump 8	105.8	0.00	5.4	24.62
VL2-I	Flow Meter	105.8	0.00	4.5	71.96
VL3-I	Flow Meter	105.8	0.00	5.0	145.34
PL-END	Fence line of Plant	107.4	0.00	12.1	12.74
HAWC-4	84-inch line at Beltway 8	106.7	0.00	14.3	15.30
ST-1	Max System Pressure – Surge Tank 1 Piping	115.4	0.00	13.3	59.86
BFV8-O	Min System Pressure – Pump 8 BFV	106.9	0.00	-14.7(2)	17.60

(1) See Exhibit 4, Appendix B for Node location
(2) Minimum system pressure of -14.7 psi occurs at multiple locations.

The maximum system pressure for this Scenario is 115.4 psi, which does not exceed the MASP of 150 psi. The minimum system pressure is -14.7 psi, which occurs on the downstream sides of the check valves on the pump discharge lines. The check valves on the discharge lines close between 9.09 and 10.9 seconds. Without the surge tanks, the max pressures in the system are significantly lower than Scenario 1a with the surge tanks. However, vapor cavities form in both Scenario 1a and 1b. Backflow through the pumps is not as much of an issue in this scenario, compared to Scenario 1a. In this scenario, the surge tanks are not online and, therefore, do not release water back into the header and discharge lines upon power failure. A graph showing the backflow through the pumps in this Scenario can be seen in Appendix D.

Graphs for Scenario 1 existing system results can be found in Appendix D.

6.2 Scenario 2 – Normal Pump Shut Down

In Scenario 2, normal shut down of the existing system was assessed. The pumps are assumed to shut down in reverse order (Pump 8 first, and Pump 2 last). Normal operations from the O&M manual state the pump control valves begin to close, and once they are fully closed, the pumps are taken offline. The pump discharge valves for Pumps 6 through 8 close in 120 seconds, while the pump control valves for Pumps 2 through 4 close in 40 seconds. The model was run for 4800 seconds with a single pump taken offline every 15 minutes. The Scenario was performed both with and without the surge tanks. Table 5 shows the results for Scenario 2a with the surge tanks online.

Table 5 - Scenario 2a Results with Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	105.8	0.00	34.4	4,778.38
DH-8	Discharge Header at Pump 8	105.8	0.00	34.4	4,778.41
VL2-I	Flow Meter	105.8	0.00	35.1	4,778.29
VL3-I	Flow Meter	105.8	0.00	35.1	4,778.68
PL-END	Fence line of Plant	107.4	2.32	40.0	4,779.53
HAWC-4	84-inch line at Beltway 8	106.7	0.00	40.0	4,780.50
BFV2-I	Max System Pressure- Pump 2 BFV	135.7	4,484.00	59.9	3,732.28
CK8-O	Min System Pressure – Pump 8 Check Valve	135.4	118.00	6.6(2)	3,174.28

(1) See Exhibit 4, Appendix B for Node location
(2) Minimum system pressure of 6.6 psi occurs at multiple locations.

The maximum system pressure is 135.7 psi, occurring against the closed pump discharge valve on the Pump 2 discharge line, which does not exceed the MASP of 150 psi. The minimum system pressure is 6.6 psi, which occurs at multiple locations along the Pump 7 and 8 discharge lines. The last pump control valve closes at 4,484 seconds, and the surge tanks' pressure reaches equilibrium with the system at 4,778 seconds. The surge tanks do not fully empty in the Scenario, and have a final water volume of 1,662 cu ft (33.2% full). Pumps 2 and 3 (the last pumps running) run beyond their maximum operating point when they are the only pumps running. Pump 2 produces maximum 44 MGD for several minutes, while the pump is only rated for 20 MGD. The model extrapolates the pump curve to meet the system demand, which in theory the system demand would be lower at the time the system comes is taken offline. Beyond the maximum operating point, the pump would potentially cavitate and may not be able to produce the flow.

Table 6 shows the results for Scenario 2b without the surge tanks in the system.

Table 6 - Scenario 2b Results without Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	105.8	0.00	28.7	4,484.01
DH-8	Discharge Header at Pump 8	105.8	0.00	28.7	4,484.02
VL2-I	Flow Meter	105.8	0.00	29.8	4,484.08
VL3-I	Flow Meter	105.8	0.00	29.8	4,484.04
PL-END	Fence line of Plant	107.4	0.00	35.7	4,484.48
HAWC-4	84-inch line at Beltway 8	106.7	0.00	37.4	4,485.42
BFV2-I	Max System Pressure- Pump 2 BFV	135.8	4,484.00	56.3	3,605.01
CK8-O	Min System Pressure – Pump 8 Check Valve	135.4	118.00	6.6(2)	3,174.28

(1) See Exhibit 4, Appendix B for Node location
(2) Minimum system pressure of 6.6 psi occurs at multiple locations.

The maximum system pressure is 135.8 psi, occurring against a closed pump discharge valve on the Pump 2 discharge line, which does not exceed the MASP of 150 psi. The minimum system pressure is 6.6 psi, which occurs at multiple locations along the Pump 7 and 8 discharge lines. The pressure results are similar for Scenarios 2a and 2b, with and without surge tanks in the system. The last pump control valve closes at 4,484 seconds. Pumps 2 and 3 (the last pumps running) run beyond their maximum operating point when they are the only pumps running. Pump 2 produces maximum 44 MGD for several minutes, and is only rated for 20 MGD. In reality the pumps would not produce 44 MGD, because the demand in the system would not be as high when the plant is taken offline.

Graphs for Scenario 2 existing system results can be found in Appendix D.

6.3 Scenario 3 – Normal Pump Start Up

In Scenario 3, the normal start-up of all pumps was assessed. The boundary condition of the plant assumes a system backpressure of 40 psi, from the EWPP, when 0 MGD is being produced from the NEWPP. The NEWPP pumps have induction motors, come online and up to full speed against a closed valve, then the pump control valve begins to open. The next pump comes online, then its pump control valve begins to open 10 seconds after the previous one is finished opening. It is assumed that the pumps start up in reverse order, with Pump 8 first and Pump 2 starting last. The model was run for simulation time of 840 seconds. The surge tanks are assumed to have an initial water volume of 1,662 cu ft (33.2% full) based on the level resulting after pump shut down in Scenario 2a. Table 7 shows the results of Scenario 3a with the surge tanks online.

Table 7 - Scenario 3a Results with Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	103.7	525.54	34.4	0.19
DH-8	Discharge Header at Pump 8	103.7	525.77	34.4	0.18
VL2-I	Flow Meter	104.0	525.74	35.1	0.02
VL3-I	Flow Meter	104.0	525.74	35.1	0.02
PL-END	Fence line of Plant	105.8	532.27	40.0	0.43
HAWC-4	84-inch line at Beltway 8	105.1	534.24	40.0	1.33
CK8-O	Max System Pressure – Pump 8 Check Valve	117.0(2)	9.79	34.4(3)	0.00

(1) See Exhibit 4, Appendix B for Node location
(2) Maximum system pressure of 117.0 psi occurs at multiple locations
(3) Minimum system pressure of 34.4 psi occurs at multiple locations.

The maximum system pressure of 117.0 psi occurs at multiple locations along the pump discharge lines as Pump 8 is coming online against the pump control valve, and does not exceed the MASP of 150 psi. A minimum system pressure of 34.4 psi occurs at multiple locations at the beginning of the simulation time. The surge tanks final water volume is 3,222 cu ft (64.4% full). The pumps run near the end of their maximum operating points in this Scenario, to try to meet the system demand. Pump 8, the first pump to be turned on, produces a maximum flow of 42.3 MGD for approximately 2 minutes. When Pump 7 comes online, both pumps produce flow at 35.1 MGD for approximately 2 minutes. The model extrapolates the pump curve to meet the system demand, which in theory the system demand would be lower at the time the system comes online from a dead system. Beyond the maximum operating point, the pump would potentially cavitate and may not be able to produce the flow.

Table 8 shows the results of Scenario 3b without the surge tanks.

Table 8 - Scenario 3b Results without Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	103.9	536.02	34.4	0.32
DH-8	Discharge Header at Pump 8	103.9	536.02	34.4	0.37
VL2-I	Flow Meter	104.0	536.04	35.1	0.02
VL3-I	Flow Meter	104.0	536.06	35.1	0.03
PL-END	Fence line of Plant	105.8	536.44	35.1	0.03
HAWC-4	84-inch line at Beltway 8	105.1	548.43	40.0	1.33
PUMP-2	Max System Pressure – Pump 2 Discharge	117.0(2)	60.01	34.3(3)	0.00

(1) See Exhibit 4, Appendix B for Node location
(2) Maximum system pressure of 117.0 psi occurs at multiple locations
(3) Minimum system pressure of 34.3 psi occurs at multiple locations.

The maximum system pressure of 117.0 psi occurs at multiple locations along the pump discharge lines, which does not exceed the MASP of 150 psi. A minimum system pressure of 34.3 psi occurs at multiple locations. Pressure results are similar for both Scenarios 3a and 3b, with and without the surge tanks in the system. The pumps run off or at the end of their curves in this Scenario, as they try to meet the system demand as they come online. Pump 8, the first pump to be turned on,

produces a maximum flow of 42.3 MGD for approximately 2 minutes. When Pump 7 comes online, both pumps produce flow at 35.1 MGD for approximately 2 minutes. The pumps have the same maximum flow as the Scenario 3a with surge tanks. In reality the pumps would not produce 42.3 MGD, because the demand in the system would not be as high when the plant is starting up.

Graphs for Scenario 3 existing system results can be found in Appendix D.

6.4 Scenario 4 – Single Pump Failure with Five Other Pumps Running

In Scenario 4, a single pump failure with the other pumps running was assessed. The model was run for 180 seconds with Pump 8 failing after 5 seconds in the simulation, with the other pumps continuing to run. The Scenario was performed both with and without the surge tanks online. Table 9 shows the results for Scenario 4a with the surge tanks online.

Table 9 - Scenario 4a Results with Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	129.8	5.56	89.2	5.62
DH-8	Discharge Header at Pump 8	136.5	5.54	86.4	5.66
VL2-I	Flow Meter	126.7	5.59	91.8	5.67
VL3-I	Flow Meter	129.6	5.60	83.9	5.64
PL-END	Fence line of Plant	116.9	6.00	100.6	8.59
HAWC-4	84-inch line at Beltway 8	111.7	6.90	102.2	22.79
CK8-O	Max and Min System Pressure – Pump 8 Check Valve	254.8	5.53	-14.7	5.58

(1) See Exhibit 4, Appendix B for Node location

The maximum system pressure of 254.8 psi occurs at the check valve on the discharge line of Pump 8, and exceeds the MASP of 150 psi. The check valve on the discharge line of Pump 8 closes at 5.53 seconds in the simulation, causing the pressure spike in the line. A minimum system pressure of -14.7 psi also occurs downstream of the check valve on the discharge line of Pump 8. Backflow occurs through the discharge line and the pump. The check valves begin to close upon backflow, but flow is able to pass through in the time required for the check valve to close.

Table 10 shows the results for Scenario 4b without the surge tanks.

Table 10 - Scenario 4b Results without Surge Tanks

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
DH-2	Discharge Header at Pump 2	119.4	5.57	92.2	5.64
DH-8	Discharge Header at Pump 8	136.5	5.54	87.3	5.65
VL2-I	Flow Meter	126.6	5.59	88.8	5.67
VL3-I	Flow Meter	129.4	5.60	83.9	5.64
PL-END	Fence line of Plant	116.9	6.00	100.6	8.59
HAWC-4	84-inch line at Beltway 8	111.7	6.90	102.2	22.40
CK8-O	Max System Pressure – Pump 8 Check Valve	254.8	5.54	20.1	5.54
CK8-I	Min System Pressure – Pump 8 Check Valve	205.5	5.64	-14.7	5.52

(1) See Exhibit 4, Appendix B for Node location

The maximum system pressure of 254.8 psi occurs on the downstream side of the check valve on the discharge line of Pump 8, and exceeds the MASP of 150 psi. The check valve on the discharge line of Pump 8 closes at 5.54 seconds during the simulation (after the pump fails 5 seconds into the simulation), causing the pressure spike in the line. A minimum system pressure -14.7 psi occurs very briefly on the upstream side of the check valve on the discharge line of Pump 8. Backflow occurs through the discharge line and the pump. The check valves begin to close upon backflow, but flow is able to pass through in the time required for the check valve to close.

Graphs for Scenario 4 existing system results can be found in Appendix D.

6.5 Scenario 5 – Emergency Pump 5 Shut Down with Five Pumps Running

Scenario 5 was used as a confirmation Scenario once the pump control valves were selected. Results and further discussion are provided in Section 7.1.5.

6.6 Scenario 6 – Emergency Pump 5 Start-Up with All Pumps Shut Down

Scenario 6 was used as a confirmation Scenario once the pump control valves were selected. Results and further discussion are in Section 7.1.6.

6.7 Scenario 7 – Macro Model NHCRWA Emergency Valve Closure

The Macro model was used to analyze the large diameter transmission system supplied by the NEWPP. The model includes the NEWPP, the existing 84-inch water transmission line, 66-inch water line along Greens Road, 42-inch water line along Hirsch Road and the NHCRWA 54-inch water line. All demands in the model are represented as single takepoints directly off the transmission line.

In the original demand distribution for 120 MGD, the customer takepoints and demands were based off the 2050 Demands used in the May 2011 Northeast Water Line Feasibility Study (NEWL Feasibility Study) LAN performed with the City. The demands assumed Kingwood would be taking water from the existing 84-inch, along with two Municipal Utility Districts (MUDs).

In Scenario 7, the emergency closure of the NHCRWA flow control valve under worst case closure conditions was evaluated. The NHCRWA flow control valve is an energy dissipating valve by Stealth Valve and Controls Ltd., similar to a sleeve valve by Pratt, and takes 90 seconds to go from

full open to full closed, according to NHCRWA operators. Information for the flow control valve can be found in Appendix C. In this Scenario, the NEWPP is producing 120 MGD, NHCRWA is taking 45 MGD and the valve goes from full open to full closed. The model was run for 270 seconds, with the valve beginning to close after 5 seconds. Table 11 shows the results of Scenario 7a with the NEWPP producing 120 MGD.

Table 11 - Scenario 7a Results NEWPP 120 MGD

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	133.1	133.55	118.8	0.15
46750	Kingwood Take Point	151.9	121.80	110.3	5.50
32375	IAH Take Point 1	159.9	117.05	106.1	4.85
71A4532	IAH Take Point 2	178.7	113.65	101.1	1.70
D717314	Greenspoint Take Point	197.4	103.35	89.6	4.80
D710075	NHCRWA Take Point off City Line	208.5	101.00	88.4	5.45
14625	Aldine and GRP Group A Take Point	133.0	122.30	97.7	0.00
1365	City Main System Take Point	124.1	126.40	94.1	0.00
NH26783	Max System Pressure- NHCRWA 54" Line	236.8	96.30	78.0	161.00
NH032VI	Min System Pressure – NHCRWA Control Valve Inlet	233.3	95.10	67.7	159.70

(1) See Exhibit 5, Appendix B for Node location

The maximum system pressure of 236.8 psi occurs in the NHCRWA 54-inch line, upstream of the flow control valve, and exceeds the MASP of 150 psi. A minimum system pressure of 67.7 psi occurs in the NHCRWA line, directly upstream of the flow control valve. The NHCRWA valve begins closing 5 seconds into the simulation, and fully closes after 95 seconds. The 90-second closure of the NHCRWA valve causes "line packing" to occur. Line packing is a condition that occurs in longer pipelines when flow is stopped at the downstream and the volume in the line increases due to pipe wall expansion. In the last 30-seconds of the valve closure, the pressures in the line rise quickly, and creating a pressure transient that reflects through the system. The pumps at the NEWPP also continue to operate during the valve closure, causing the pump discharge pressure to rise while flow through the pumps is reduced. Pressures above the MASP are seen throughout the NHCRWA water line and the City system.

The valve closure Scenario was also run with the NEWPP producing 80 MGD and the NHCRWA taking 45 MGD, better representing current peak day conditions. Table 12 below shows the results of Scenario 7b, with the NEWPP producing 80 MGD.

Table 12 - Scenario 7b Results NEWPP 80 MGD

Node(1)	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	143.9	132.75	118.4	0.15
46750	Kingwood Take Point	175.5	121.80	111.0	186.50
32375	IAH Take Point 1	180.8	117.25	109.0	181.70
71A4532	IAH Take Point 2	203.8	113.65	89.2	178.35
D717314	Greenspoint Take Point	221.8	103.65	68.2	168.05
D710075	NHCRWA Take Point off City Line	225.4	101.05	60.1	165.65
14625	Aldine and GRP Group A Take Point	160.1	122.25	98.5	186.95
1365	City Main System Take Point	128.8	126.35	92.3	14.25
NH26783	Max System Pressure- NHCRWA 54" Line	246.4	96.30	29.6	161.00
NH032VI	Min System Pressure – NHCRWA Control Valve Inlet	241.1	95.00	16.7	159.85

(1) See Exhibit 5, Appendix B for Node location

The maximum system pressure of 246.4 psi occurs on the NHCRWA 54-inch line, upstream of the flow control valve, and exceeds the MASP of 150 psi. A minimum system pressure of 7.8 psi occurs on the NHCRWA line, downstream of the flow control valve. The NHCRWA valve closes after 95 seconds, resulting in line packing and pressure transients in the system. The pressure in the NHCRWA line builds as the flow control valve closes, increasing quickly over the last 30-seconds of the valve closure. Pressures above the MASP are seen throughout the NHCRWA water line and the City system. Pressures are higher in the 80 MGD scenario than the 120 MGD scenario, because a larger percentage of flow (over half the NEWPP production) is being taken by NHCRWA/CHCRWA in the 80 MGD scenario.

Graphs for Scenario 7 existing system results can be found in Appendix D.

6.8 Lake Houston Cost Share Line

After the existing system Scenarios were modeled, the Lake Houston Cost Share (LHCS) 36-/24-/20-inch water line record drawing information was provided to CDM Smith. The LHCS take point from the Northeast System is off the 84-inch water line within the NEWPP. Both the micro model and macro model were updated to reflect the system with the LHCS line. The worst case Scenarios (Pump Failure) were modeled to determine the changes, if any, to the results caused by the addition of the LHCS line. Table 13 shows how results changed with LHCS in the Simultaneous All Pump Failure Scenario.

Table 13 - Scenario 1 Simultaneous All Pump Failure

	Without LHCS		With LHCS	
	Max Pressure	Min Pressure	Max Pressure	Min Pressure
Discharge Header at Pump 2	244.6	5.7	243.4	5.9
Discharge Header at Pump 8	234.8	15.2	234.7	12.3
Flow Meter	189.4	11.0	188.0	21.1
Flow Meter	216.0	0.6	221.0	22.1
Plant End	178.5	38.2	173.0	38.0

Table 14 below shows how results changed with LHCS in Scenario 4 Single Pump Failure with All Other Pumps Running.

Table 14 - Scenario 4 Single Pump Failure

	Without LHCS		With LHCS	
	Max Pressure	Min Pressure	Max Pressure	Min Pressure
Discharge Header at Pump 2	129.8	89.2	129.8	89.0
Discharge Header at Pump 8	136.5	86.4	136.2	81.7
Flow Meter	126.7	91.8	126.5	89.4
Flow Meter	129.3	83.9	129.3	83.8
Plant End	116.9	100.6	116.0	100.5

Table 15 below shows how results changed with LHCS in Scenario 7 NHCRWA Emergency Valve Closure.

Table 15 - Scenario 7 NHCRWA Emergency Valve Closure

	Without LHCS		With LHCS	
	Max Pressure	Min Pressure	Max Pressure	Min Pressure
NEWPP	133.1	118.3	135.1	120.1
IAH Take Point	159.9	106.1	162.3	117.1
Greenspoint Take Point	197.4	89.6	196.1	94.5
City Main Take Point	124.1	94.1	133.7	100.3
NHCRWA Take Point (Off City Line)	208.5	88.4	206.6	92.4

Results varied within 1 to 3 psi with the addition of the LHCS line. The exceptions were the minimum pressure at the NEWPP flow meters under Scenario 1 Simultaneous All Pump Failure, and the pressures at City's Main system take point (Hirsch and Little York) under Scenario 7 NHCRWA's valve closure, which varied 21.5 psi and 9.6 psi respectively. The City's main system takepoint varied more because less flow is being delivered to the City's Main system with the addition of the LHCS line. The addition of the LHCS line did not change the model results enough to lose confidence in the results without the LHCS line.

6.9 Summary of Existing System Results

Based on the analyses described above, the following overall results were noted.

- The existing check valves slammed and caused high pressure spikes and vapor cavities in the pump discharge lines and header during single pump failure and all pump failure scenarios. The results were worse with the surge tanks in the system, due to the check valve slamming with the additional outflow from the surge tanks.
- When the existing check valves closed on the pump discharge lines, the air valves became isolated from the system and no longer protected the discharge header or flow meters.
- Backflow was able to pass through the pump discharge line and through the pumps in the time it takes the check valves to close. It is recommended, however, that the design engineer review whether the quantity or rate of backflow would be an issue. The pumps have ratchet devices, preventing the pumps from back spin.
- In the case of simultaneous all pump failure, the surge tanks in the system did not empty when there is 40 psi backpressure in the system from the EWPP. Instead, the pressures in the surge tanks reached equilibrium with the system pressure at 35.5 psi, and settled at 33.2% full of water.
- In a case where the EWPP is also inoperable or the Hirsch Rd flow control valve is closed, the surge tanks did empty. The system can operate both with and without the surge tanks; however with the surge tanks, additional surge protection devices or measures would be needed.
- Excessive high pressures were an issue in the NHCRWA Emergency Valve Closure Scenario due to line packing. The high pressures occurred both in the NHCRWA 54-inch line and in the City system during the valve closure, and assuming the NEWPP continues to produce at its normal rate.

7.0 Phase II - Mitigation Scenarios and Results

Three main transient issues were identified from the existing system scenario runs:

- Existing Check Valves
- Surge Tanks and EWPP Backpressure
- NHCRWA Emergency Valve Closure

Several solution alternatives were modeled to mitigate these issues.

7.1 Proposed Pump Control Valves

One solution evaluated to mitigate the transient issues occurring with the existing check valves is to replace the check valves with different pump control valves. Three different types of pump control valves, selected by the design engineer, were modeled with the existing pump control valves remaining in service, but set in the open position. The proposed pump control valves would replace the existing check valves while the existing pump control valves (butterfly valves) would have a manual actuator installed and be set in the open position. Drawings provided by the design engineer for the pump control valve installation can be found in Appendix E.

The proposed type and size of pump control valves selected to be evaluated include:

- 30-inch Adams Triple Offset Disc Valve
- 24-inch Golden Anderson Resilient Seated Ball Valve
- 30-inch Golden Anderson Resilient Seated Ball Valve

- 30-inch Golden Anderson Checktronic Wye Valve
- 24-inch Adams Triple Offset Disc Valve

The Adams Disc Valve has three independent timing settings, one for normal opening, one for normal closure, and one for emergency closure. A 60-second and 180-second normal opening and closure stroke were evaluated, as well as 5, 30 and 60 second emergency closure. The 24-inch valve has a CV value of 19,000, and the 30-inch valve has a CV value of 33,000.

The Golden Anderson Ball Valve also has three independent timing settings, one for normal opening, one for normal closure, and one for emergency closure. A 60 and 180 second normal opening and closure were evaluated, as well as 5-, 30- and 60-second emergency closure. The 24-inch valve has a CV value of 82,480 and the 30-inch valve has a CV value of 131,779.

The Golden Anderson Wye Valve has one time setting for both normal opening and normal closure, and has a hydraulically controlled emergency closure. The Wye Valve can act like a check valve upon emergency closure, depending on the flow through the valve. In the Pump Failure scenarios, the flow through the discharge lines change direction in a matter of tenths of a second, which would cause the valve to slam. A 60 and 180 second closure normal opening and closure were evaluated, as well as 0.5, 1, 3 and 5 second emergency closure. The 30-inch valve has a CV value of 16,755.

Valve data provided by the manufacturers can be found in Appendix E.

7.1.1 Scenario 1 – Simultaneous All Pump Failure

In Simultaneous All Pump Failure for the existing system, high pressure spikes and vapor cavities occurred in the pump discharge lines, as seen in Table 2. Simultaneous All Pump Failure was modeled with the different proposed pump control valve alternatives, with the surge tanks and with the backpressure from the EWPP. Table 16 highlights the maximum and minimum pressures for the 30-inch Adams Disc Valve for different closure times.

Table 16 - 30-inch Adams Disc Valve Simultaneous All Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
5 Second Emergency Closure	131.3	8.50	Directly Downstream of Pump 6 Control Valve (CK6-O)	-5.9	8.50	Directly Upstream of Pump 7 Control Valve (CK7-I)
30 Second Emergency Closure	115.8	1.34	Yard Piping to North Surge Tank (ST-1)	5.7	26.00	Directly Upstream of Pump 2 Control Valve (CK2-I)
60 Second Emergency Closure	115.8	1.39	Yard Piping to North Surge Tank (ST-1)	6.3	47.00	Directly Upstream of Pump 2 Control Valve (CK2-I)

All pressures for the 30-inch Adams Disc Valve are within the acceptable range, with a maximum pressure of 131.3 psi and a minimum pressure of -5.9 psi. The 5-second closure has the highest and lowest pressures out of all the Scenarios. The surge tanks do not empty in any of the Scenarios.

Table 17 highlights the maximum and minimum pressures for the 24-inch Golden Anderson Ball Valve for different closure times.

Table 17 - 24-inch GA Ball Valve Simultaneous All Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	2.3	2.25	Directly Upstream of Pump 2 Control Valve (CK2-I)
30 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	6.2	35.00	Directly Upstream of Pump 2 Control Valve (CK2-I)
60 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	6.6	65.00	Directly Upstream of Pump 2 Control Valve (CK2-I)

All pressures for the 24-inch Golden Anderson Ball Valve are within the acceptable range, with a maximum pressure of 115.9 psi and a minimum pressure of 2.3 psi between the Scenarios. The pressure results do not vary much between the above closure times. The surge tanks empty in the 60-second valve closure Scenario.

Table 18 highlights the maximum and minimum pressures for the 30-inch Golden Anderson Ball Valve for different closure times.

Table 18 - 30-inch GA Ball Valve Simultaneous All Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	-1.2	10.00	Directly Upstream of Pump 2 Control Valve (CK2-I)
30 Second Emergency Closure	115.9	1.39	Yard Piping to North Surge Tank (ST-1)	6.1	35.00	Directly Upstream of Pump 2 Control Valve (CK2-I)
60 Second Emergency Closure	115.9	1.37	Yard Piping to North Surge Tank (ST-1)	6.5	65.00	Directly Upstream of Pump 2 Control Valve (CK2-I)

All pressures for the 24-inch Golden Anderson Ball Valve are within the acceptable range, with a maximum pressure of 115.9 psi and a minimum pressure of -1.2 psi between the Scenarios. The pressure results do not vary much between the above closure times. The results also do not vary much between the 24-inch Ball Valve Scenario and the 30-inch Ball Valve Scenario. The surge tanks empty with the 60-second valve closure time.

Table 19 highlights the maximum and minimum pressures for the 30-inch Golden Anderson Checktronic Wye Valve for different closure times.

Table 19 - 30-inch GA Checktronic Wye Valve Simultaneous All Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
0.5 Second Emergency Closure	178.4	5.55	Directly Downstream of Pump 4 Control Valve (CK4-O)	6.6	179.8	Directly Upstream of Pump 2 Control Valve (CK2-I)
1 Second Emergency Closure	183.9	6.00	Directly Downstream of Pump 7 Control Valve (CK7-O)	-12.9	6.50	Directly Upstream of Pump 3 Control Valve (CK3-I)
3 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	2.5	8.00	Directly Upstream of Pump 2 Control Valve (CK2-I)
5 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	4.6	10.00	Directly Upstream of Pump 2 Control Valve (CK2-I)

Pressure spikes over 150 psi occur with the 0.5-second and 1-second valve closure, while the 3-second and 5-second valve closure have pressure results within the acceptable range. The Checktronic Wye valve has a hydraulically controlled emergency closure, so it is likely the valve could close in 1-second or faster.

Both the Adams Disc Valve and the Golden Anderson Ball Valve mitigate transient issues seen with the existing check valves. The Golden Anderson Checktronic Wye valve has unacceptably high pressure spikes with the faster emergency closure times. Graphs for these Scenarios can be seen in Appendix F.

The Simultaneous All Pump Failure Scenario (worst case scenario) was also modeled without surge tanks for the 24-inch Adams Disc Valve as a confirmation scenario. Since results were similar between the Golden Anderson Ball Valve and the Adams Disc Valve, for both the 24-inch and 30-inch valves, the 24-inch Adams Disc Valve was used for confirmation scenarios. Table 20 highlights the maximum and minimum pressures for Simultaneous All Pump Failure with the 24-inch Adams Disc Valve without the surge tanks in the system.

Table 20 - 24-inch Adams Disc Valve Simultaneous All Pump Failure without Surge Tanks

With EWPP Backpressure						
	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
5 Second Emergency Closure	115.6	0.00	Yard Piping to North Surge Tank (ST-1)	-14.7	8.55	Directly Downstream of Pump 8 Control Valve (CK8-O)
30 Second Emergency Closure	109.5	0.00	84-inch Water Line (HAWC-1)	5.81	7.71	Downstream of Pump 8 Control Valve (BFV8-O)
60 Second Emergency Closure	109.4	0.00	84-inch Water Line (HAWC-1)	5.8	7.72	Discharge Header at Pump 8 (DH-8)
Without EWPP Backpressure						
30 Second Emergency Closure	115.6	0.02	Yard Piping to North Surge Tank (ST-1)	5.7	18.58	Discharge Header at Pump 8 (DH-8)
60 Second Emergency Closure	115.6	0.02	Yard Piping to North Surge Tank (ST-1)	5.7	35.04	Discharge Header at Pump 5 (DH-5)

More detailed results can be seen in Appendix F, Exhibits 2 and 3.

From the results above, the system can operate without the surge tanks. The proposed pump control valves protect the system with or without the EWPP backpressure, when the tanks are operated with the correct initial water level, as discussed in Section 7.2. The emergency valve closure should be set at 30 seconds for the Golden Anderson Ball Valve and the Adams Disc Valve.

7.1.2. Scenario 2 – Normal Shut Down

In the Normal Shut down Scenario with existing system conditions, transients were not an issue, as seen in Table 4 under Section 6.1. The Scenario was modeled with the different proposed pump control valves, with surge tanks, and with 60-second and 180-second normal closure times. Transients were not an issue with the proposed pump control valves installed. The maximum system pressures range from 135.4 psi to 136.0 psi for the different valves, and the minimum system pressure was 6.6 psi for all valves. More detailed results can be seen in Appendix F, Exhibit 5. Pumps running beyond maximum operating point was still an issue with the proposed pump control valves, with Pump 2 (the last pump online) producing about 43 MGD in the model in all Scenarios.

7.1.3. Scenario 3 – Normal Start-Up

In the Normal Start-Up Scenario with existing system conditions, transients were not an issue, as seen in Table 7 in Section 6.2. The Scenario was modeled with the different proposed pump control valve alternatives, with surge tanks, and with 60-second and 180-second normal opening times. Transients were not an issue with the proposed pump control valves installed. The maximum system pressures range from 115.8 psi to 117.0 psi for the different valves, and the minimum system pressure was 18.3 psi for all valves. Pumps running beyond maximum operating

point was still an issue, with Pump 8 producing about 43 MGD in the model in all Scenarios. More detailed results can be seen in Appendix F, Exhibit 7.

7.1.4. Scenario 4 – Single Pump Failure with Five Pumps Running

In the Single Pump Failure with Five Remaining Pumps Running with existing system conditions, vapor cavities and pressure spikes occurred in the Pump 8 (the pump that failed) discharge line, as seen in Table 8. The Scenario was modeled with the proposed pump control valve alternatives, with surge tanks, with the EWPP backpressure, and with different emergency closure times. Table 21highlights the maximum and minimum pressures for the 30-inch Adams Disc Valve for different closure times.

Table 21 - 30-inch Adams Disc Valve Single Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
5 Second Emergency Closure	118.2	8.50	Directly Downstream of Pump 8 Control Valve (CK8-O)	-5.3	8.50	Directly Upstream of Pump 8 Control Valve (CK8-I)
30 Second Emergency Closure	115.8	0.16	Yard Piping to North Surge Tank (ST-1)	4.8	26.00	Directly Upstream of Pump 8 Control Valve (CK8-I)
60 Second Emergency Closure	115.8	0.16	Yard Piping to North Surge Tank (ST-1)	5.7	47.00	Directly Upstream of Pump 8 Control Valve (CK8-I)

All pressures for the 30-inch Adams Disc Valve Scenarios are within the acceptable pressure range, with a maximum pressure of 118.2 psi and minimum pressure of -5.3 psi in all Scenarios. Results do not vary much between the different emergency valve closure times.

Table 22 highlights the maximum and minimum pressures for the 24-inch Golden Anderson Ball Valve for different closure times.

Table 22 - 24-inch GA Ball Valve Single Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	1.6	10.00	Directly Upstream of Pump 8 Control Valve (CK8-I)
30 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	5.8	35.00	Directly Upstream of Pump 8 Control Valve (CK8-I)
60 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	6.2	65.00	Directly Upstream of Pump 8 Control Valve (CK8-I)

All pressures for the 24-inch Golden Anderson Ball Valve Scenarios are within the acceptable pressure range, with a maximum pressure of 115.9 psi and minimum pressure of 1.6 psi in all Scenarios. Results do not vary much between the different emergency valve closure times.

Table 23 highlights the maximum and minimum pressures for the 30-inch Golden Anderson Ball Valve for different closure times.

Table 23 - 30-inch GA Ball Valve Single Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	-1.6	10.00	Directly Upstream of Pump 8 Control Valve (CK8-I)
30 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	5.3	35.00	Directly Upstream of Pump 8 Control Valve (CK8-I)
60 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	5.6	65.00	Directly Upstream of Pump 8 Control Valve (CK8-I)

All pressures for the 30-inch Golden Anderson Ball Valve Scenarios are within the acceptable pressure range, with a maximum pressure of 115.9 psi and minimum pressure of -1.6 psi in all Scenarios. Results do not vary much between the different emergency valve closure times. Results also do not vary much between the 24-inch and 30-inch valve Scenarios.

Table 24 highlights the maximum and minimum pressures for the 30-inch Golden Anderson Checktronic Wye Valve for different closure times.

Table 24 - 30-inch GA Checktronic Wye Valve Single Pump Failure

	Max Pressure	Max Pressure Time	Description (Node)	Min Pressure	Min Pressure Time	Description (Node)
0.5 Second Emergency Closure	144.8	5.50	Yard Piping to North Surge Tank (ST-1)	6.6	6.58	Directly Upstream of Pump 8 Control Valve (CK8-I)
1 Second Emergency Closure	126.4	6.00	Yard Piping to North Surge Tank (ST-1)	-7.6	5.99	Directly Upstream of Pump 8 Control Valve (CK8-I)
3 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	2.4	8.00	Directly Upstream of Pump 8 Control Valve (CK8-I)
5 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	4.2	10.00	Directly Upstream of Pump 8 Control Valve (CK8-I)

All pressures for the 30-inch Golden Anderson Checktronic Wye valve are within the acceptable pressure range, though the 0.5- and 1-second closure times have high pressures close to the allowable limits.

The proposed pump control valve alternatives in all Scenarios mitigate the high pressure spikes and vapor cavities that occurred with existing system conditions. Detailed results can be seen in Appendix F, Exhibit 9. Graphs from these Scenarios are provided in Appendix F.

LHCS Line Addition

After the proposed pump control valve scenarios were modeled, the LHCS 36-/24-/20-inch water line record drawings were provided to the design engineer. Scenarios 1-4 were modeled again to determine the effects of adding the line, with the 24-inch Adams Disc Valve and 24-inch Golden Anderson Ball Valve, with surge tanks, the EWPP backpressure, and the addition of the LHCS line. Results with the addition of the LHCS line were very similar to the existing system results in all Scenarios. More detailed results can be seen in Appendix F.

7.1.5. Scenario 5 – Emergency Pump Shut Down with Other Pumps Running

Since results were similar between the Adams Disc Valve and the Golden Anderson Ball Valve for both the 24-inch and 30-inch sizes, the 24-inch Adams Disc Valve was selected to model confirmation scenarios. In the Emergency Pump Shut down Scenario, the emergency pump (Pump 5) is shut down while the other 6 pumps are running, with the surge tanks and backpressure from the EWPP. The pump control valve fully closes over its time before the pump is taken offline. The Disc Valve was modeled with a 60-second and 180-second closure. Transients were not an issue in this Scenario, with a maximum pressure of 135.6 psi and a minimum pressure of 6.6 psi for between both Scenarios. Results can be seen in Appendix F, Exhibit 11.

7.1.6. Scenario 6 – Emergency Pump Start-Up with all Pumps Shut Down

Using the 24-inch Adams Disc Valve, the Emergency Pump Start-Up with No Other Pumps Running was modeled. In the Scenario, the emergency pump (Pump 5) comes online from a dead system, with the surge tanks and the backpressure from the EWPP. The Disc Valve was modeled with a 60-second and 180-second opening. The pump comes online against the closed pump control valve, and the valve opens continuously over the time until fully open. Transients were not an issue in the Scenario, with a maximum pressure of 136.1 psi and minimum pressure of 18.3 psi between both opening times. The emergency pump, though, runs beyond its maximum point of operation to meet the system demand, producing a maximum 44 MGD between both Scenarios. Results can be seen in Appendix F, Exhibit 12.

In Emergency Pump Start-Up, it is assumed that the station is without power. An actuator that relies solely on electric power should not be installed. Instead, the actuator should have a standby battery backup or the valve should be fitted with oil dashpots for normal opening and closing of the valve.

7.1.7. Proposed Pump Control Valve Summary

In the existing system conditions, transient issues were identified with the existing check valves on the pump distribution lines slamming and creating high pressure spikes and vapor cavities.

Replacing the check valves with either the Adams Disc Valve or Golden Anderson Ball Valve, either 24-inch or 30-inch sizes, mitigate transients in all conditions modeled without the need for additional air valves or surge devices. The results for the Adams Disc Valve and the Golden Anderson Ball Valve are very similar. Results also do not change much between the 24-inch and the 30-inch valves. The Golden Anderson Checktronic Wye Valve creates high pressure spikes and vapor cavities in the All Pump Failure Scenario, because the valve's emergency closure is hydraulically controlled and can potentially slam. This valve is not recommended for this project.

7.2 Surge Tanks and Backpressure From the EWPP

According to information provided by the City Drinking Water Operations staff, when the NEWPP pump station is offline, the EWPP is able to maintain a system backpressure of approximately 40 psi. The two systems are connected by the 42-inch water line along Hirsch Rd. In high demand periods for the NEWPP system, there are times the flow control valve at Hirsch Rd and Little York is closed to maintain pressures at the NEWPP. In the Simultaneous All Pump Failure Scenario with the NEWPP producing 120 MGD, it was observed that the surge tanks empty when the 40 psi backpressure from the EWPP was not available. Vapor pressures also occurred in the piping to the surge tanks when the tanks emptied, although it is believed that this may be due primarily to a limitation of the modeling software. While the surge tanks each have a 6-inch vacuum relief valve mounted on the top that should protect the tanks from collapsing under extreme low pressure, it is not good engineering practice to allow the tanks to empty. The surge tanks are each connected to an air compressor, which help regulate the air pressure and water level in the tanks. However, the compressors provide no benefit during a transient event. The water level in the surge tanks is also dependent upon the pressure and flow rate of the water being produced from the pumps.

Simultaneous All Pump Failure (worst case) was modeled with different surge tank sizes and water volumes to ensure the tanks do not empty. The existing surge tanks are 12 feet in diameter and 5000 cu ft in volume, each. The surge tanks were observed during a field visit to operate with a water level of 6.5 ft (65% full) when the plant was producing less than 80 MGD.

The analysis was performed several times increasing the size of the surge tanks, up to 10,000 cu ft total volume each, with the tanks 65% full of water. Without the EWPP backpressure and with the water volume at only 65% of the total tank volume, the tanks emptied in every instance, regardless of tank size.

When the water level was increased to the O&M manual's recommended level of 8.1 ft (approximately 80% full), the surge tanks did not empty in Simultaneous All Pump Failure with the plant producing 120 MGD. Instead, the pressure within the tank balanced with the system at about 12 psi, and the tanks had a final water volume of about 2,000 cu ft each. It is recommended that the plant always operate with the O&M Manual recommended volume of 80% full.

With the 24-inch Adams Disc Valve installed, the system was modeled <u>without</u> the surge tanks both with and without the EWPP backpressure, as seen in Table 20 under Section 7.1.1. For the 30-second and 60-second valve closures, transients were not an issue, regardless the EWPP backpressure. During the 5-second closure, vapor cavities occurred in the pump discharge lines.

In summary, under current conditions it is necessary to operate the surge tanks at the O&M manual recommended 80% full when the Hirsch Rd flow control valve is closed, to ensure the surge tanks do not empty. Once the proposed pump control valves have been installed, and assuming a 30 to

60-second valve closure time, the system can operate without the surge tanks, regardless of the EWPP backpressure. The City staff has stated there are problems with maintenance with the existing surge tanks, which would be alleviated with removing the surge tanks. One of the surge tanks does not have an isolation valve and therefore cannot be isolated from the system for maintenance and inspection. Graphs showing the air volume and air pressure within the surge tanks during these Scenarios can be seen in Appendix G.

7.3 NHCRWA Emergency Valve Closure

7.3.1 Surge Relief Devices

In the NHCRWA Emergency Valve Closure Scenario, high pressures occurred in the NHCRWA 54-inch line and in the City system due to line packing caused by the 90-second valve closure time, as seen in Table 12 in Section 6.7. A 90-second time for the flow control valve to go from full open to full close, without the NEWPP pumps backing off, caused the increase in pressures along with the NEWPP pumps running higher on their curves. This analysis was performed for both the current 80 MGD and future 120 MGD NEWPP flow rates with NHCRWA/CHCRWA taking 45 MGD and 44 MGD in the scenarios, respectively. The 80 MGD Scenario proved to be the most critical Scenario, due to NHCRWA taking over half the NEWPP's production. Customer take points and Customer's demands can be seen in Appendix B, Exhibit 2. Surge relief valves were evaluated as a potential solution, located at the NHCRWA Spears Rd Pump Station directly upstream of the flow control valve. Based on conversations with a surge relief valve manufacturer, 29 MGD of flow to be relieved can be accommodated with either two (2) 12-inch surge relief valves or three (3) 10-inch surge relief valves. Table 25 shows the NHCRWA 90-second valve closure with four (4) 12-inch Golden Anderson Surge Relief valves installed, set to open at 120 psi, and the NEWPP producing 80 MGD. Information on the Golden Anderson Surge Relief Valve can be found in Appendix C.

Table 25 - NHCRWA Valve Closure at 80 MGD with Surge Relief Valves

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	134.5	293.6	118.4	0.15
46750	Kingwood Take Point	131.9	283.05	113.1	11.20
32375	IAH Take Point 1	130.5	283.65	109.9	10.35
71A4532	IAH Take Point 2	130.0	103.25	106.4	1.75
D717314	Greenspoint Take Point	133.1	104.50	98.0	3.10
D710075	NHCRWA Take Point off City Line	133.5	102.15	96.8	5.45
14625	Aldine and GRP Group A Take Point	117.6	282.40	101.0	10.25
1365	City Main System Take Point	105.7	292.70	92.3	14.25
71C570	Max System Pressure- Hardy Tollway Crossing	142.5	104.95	107.7	2.65
NH032VO	Min System Pressure – NHCRWA Control Valve Outlet	76.0	0.20	8.0	95.00

With the four surge relief valves installed, the high pressure in the system dropped from 246.4 psi to 142.5 psi. The Scenario results for both 80 MGD and 120 MGD plant production can be seen in Appendix H.

After the surge relief valve Scenario was modeled, the Customer demands used in the model were asked to be reevaluated. The Customer demands were revisited and reallocated, using City Planning and Developmental Services (Planning) updated Peak Day planning numbers. The 80 MGD demand set closely represents current day Peak Day demands, if all customers are peaking simultaneously. The 120 MGD demand set represents Planning's 2021 Peak Day demands, if all customers peak simultaneously. In both demand sets, NHCRWA/CHCRWA is taking 44 MGD, the purchased capacity of the existing 66-inch Greens Rd water line. An exhibit showing the revised take point locations and customer demands can be seen in Appendix B, Exhibit 3. Table 26 shows how the revised demand set changed results.

Table 26 - Original Demand Set vs Revised Demand Set (80 MGD)

Node	Location Description	Original Demands		Revised Demands	
		Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	133.1	118.3	138.7	117.1
32375	IAH Take Point	159.9	106.1	167.4	109.0
D717314	Greenspoint Take Point	197.4	89.6	202.6	93.7
D710075	NHCRWA Take Point off City Line	208.5	88.4	212.2	92.6
14625	Aldine and GRP Group A Take Point	160.1	98.5	167.9	108.6
1365	City Main System Take Point	124.1	94.1	179.1	93.6
71C570	Hardy Tollway Crossing	231.2	79.1	212.1	93.7

Pressure results vary some throughout the system between the demand sets, mostly because the NEWPP is not sending water to the main system in the Revised Demand Scenario and a smaller percentage of water is being taken at the extremities of the system.

At the request of NHCRWA, and as an alternative to the installation of surge relief valves, revised flow control valve closure times were evaluated for the Spears Rd pump station. This analysis revised demand set was used for both 80 MGD and 120 MGD NEWPP flow rates to determine the minimum time for NHCRWA to close their flow control valve without causing high pressures throughout the system. Table 27 shows the results for a 30-minute continuous valve closure when the NEWPP produces 80 MGD (worst case Scenario).

Table 27 – NHCRWA 30-Minute Valve Closure (80 MGD)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	133.0	1840.95	117.1	15.70
32375	IAH Take Point	130.4	1826.95	109.0	5.50
D717314	Greenspoint Take Point	131.1	1813.35	93.7	19.05
D710075	NHCRWA Take Point off City Line	132.1	1811.00	92.6	21.80
14625	Aldine and GRP Group A Take Point	129.1	1832.25	108.6	0.60
1365	City Main System Take Point	128.6	1836.25	107.8	22.60
71C570	Max System Pressure - Hardy Tollway Crossing	140.5	1813.80	103.6	18.55

With a 30-minute closure of the flow control valve, the maximum system pressure dropped from 246.4 psi to 140.5 psi. With the 120 MGD demand set, a 6-minute valve closure time brought the maximum pressure under 150 psi. As this is a current practice, it is therefore recommended that the NHCRWA immediately change their emergency valve closure time from 90 seconds to 30 minutes, and that they notify the NEWPP operations staff anytime this valve is operated so that pump station discharge can be reduced accordingly.More detailed results and graphs can be seen in Appendix H.

7.3.2 Simultaneous All Pump Failure at the NEWPP

To insure the transmission lines are properly protected in the Northeast System, a Pump Failure Scenario at the NEWPP was modeled using the updated macro model developed previously for the transmission system design. It was assumed that all combination air/vacuum valves on the City's and NHCRWA's transmission lines are in working order, and the 24-inch Adams Disc Valve had been installed at the plant. Due to the timestep limitations of the macro model, neither the combination air/vacuum valves on the pump discharge lines, nor both the combination air/vacuum valves in series directly upstream of the flow meters were included. Table 28 highlights some of the results from the Simultaneous All Pump Failure Scenario in the macro model with the NEWPP producing 120 MGD.

Table 28 – Simultaneous All Pump Failure Macro Model

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	116.8	0.00	0.4	115.55
32375	IAH Take Point	108.7	13.10	2.9	125.75
D717314	Greenspoint Take Point	93.5	26.85	7.6	144.90
D710075	NHCRWA Take Point off City Line	92.4	29.15	7.9	147.75
14625	Aldine and GRP Group A Take Point	108.5	8.00	6.6	141.85
1365	City Main System Take Point	107.7	3.80	-0.24	138.95
MUD0250	Max System Pressure – LHCS Line	122.0	0.85	3.34	116.85

The maximum system pressure in the event of Simultaneous All Pump Failure is 122.0 psi, occurring in the LHCS line. In conclusion, in the event of NEWPP power failure, the transmission lines are protected with the existing combination air/vacuum valves. Graphs of the results can be seen in Appendix H.

8.0 Conclusions and Recommendations

- Pressure spikes and vapor cavities occur in the pump discharge lines due to the existing check valves slamming in Pump Failure. The existing check valves on the pump distribution lines should be replaced with one of the proposed pump control valves. From a transient perspective, the 24-inch and 30-inch Adams Disc Valves or the Golden Anderson Ball Valves are recommended. A 30-second emergency valve closure setting is recommended, as well as a 60-second normal valve opening and closure setting. These valves and timings mitigate transients both with and without the surge tanks, and do not require additional air/vacuum valves or surge devices.

- Backflow through the pump discharge lines and through the pumps was noted during the time it takes the control valves to close. Although the pumps are equipped with ratchet devices, preventing the pumps from backspin, it is recommended that the design engineer, CDM Smith, evaluate whether the quantity or rate of backflow would be an issue for the pumps, motors or existing pipe.

- The surge tanks empty in Simultaneous All Pump Failure Scenarios when the initial water level is at the level observed during site visits (65% full), and without the backpressure from the EWPP. When the surge tanks are reset to operate at 80% full (O&M manual recommended level), the tanks do not empty with or without backpressure. It is recommended that the surge tanks operate at 80% full until the proposed pump control valves can be installed. Once the proposed pump control valves are installed, the surge tanks are no longer necessary to protect the pump station and can be removed.

- When the NHCRWA flow control valve closes at the current defined emergency closure time of 90 seconds, line packing and pressure transients occur causing extended pressure increases throughout the transmission system in excess of 200 psi, while the NEWPP continues pumping the same rate. Four 12-inch Golden Anderson Surge Relief valves, with a 120 psi setting to open, are recommended at the NHCRWA Spears Rd Pump Station. Until the surge relief valves can be installed, or as an alternative to the installation of these valves, NHCRWA should adjust their flow control valve closure of 90 seconds no faster than 30 minutes. NHCRWA should also notify the NEWPP before they begin closing their valve, so the NEWPP operators can adjust their pumping operations.

- For this study, it has been assumed that all existing combination air vacuum valves at the NEWPP pump station and in the transmission system are operational. It is recommended that proper operation of all existing air/vacuum valves on the NEWPP and NHCRWA transmission mains be confirmed, and that these facilities be maintained in proper working conditions.

Appendix A

NEWPP Existing System Information

Index

NEWPP HSPS System Description

NEWPP Existing HSPS Startup and Shutdown and Valve Timing Evaluation (Pump Witness Testing completed September 18th, 2013)

Pump Research History

NEWPP HSPS Pump Information from Floway

NEWPP Surge Tank Shop Drawings

14.2 COMPONENT DESCRIPTION

14.2.1 PRIMARY HIGH SERVICE PUMPS

The High Service Pumps are constant speed, vertical turbine, two-stage pumps. The pump drives are electric motors. The description of the primary high service pumps is presented in Table 14-1. The seven primary pumps are identical.

Table 14-1: Primary High Service Pump Criteria

Item	Pump Tag No.						
	08-P-01	**08-P-02**	**08-P-03**	**08-P-04**	**08-P-06**	**08-P-07**	**08-P-08**
Type	Vertical Turbine						
Stages	2						
Manufacturer	Floway Pumps						
Capacity/Head	13,888 GPM @ 191-Feet TDH						
Impeller	Enclosed						
Strainer	No						
Bowl Diameter	54-inch						
Suction Diameter	42-inch						
Discharge Diameter	30-inch						
Motor	800 HP, 4160V,3 phase, 60 Hz TEFC						
Drive	Constant Speed						
Suction Bearings	Permanently Grease Packed						
Dry Weights (lbs):							
Motor	8,800						
Discharge Head	5,275						
Barrel	10,450						
Column	4,440						
Bowl	4,000						
Total	**32,965**						

The pumps (08-P-01 through 08-P-04 and 08-P-06 through 08-P-08) receive electrical power from the medium voltage motor-control-center (MCC) MCC-MV-1. The medium voltage MCC is located in a prefabricated enclosure near the northeast corner of the High Service Pump Station.

14.2.2 EMERGENCY HIGH SERVICE PUMP

The Emergency High Service Pump is a two-stage, vertical turbine pump. The pump driver is a diesel engine and right angle drive. The description of the Emergency High Service Pump is presented in Table 14-2.

Table 14-2: High Service Emergency Pump

Item	Pump Tag No.
	08-P-05
Type	Vertical Turbine
Stages	2
Manufacturer	Floway Pumps
Capacity/Head	13,888 GPM @ 191-feet TDH
Impeller	Enclosed
Strainer	No
Bowl Diameter	54-inch
Suction Diameter	42-inch
Discharge Diameter	30-inch
Motor/Drive	Cummins Diesel – Right Angle Johnson Drive 950 HP 2,100 rpm
Suction Bearings	Permanently Grease Packed
Dry Weights (lbs):	
Engine	24,350
Right Angle Drive	3,240
Discharge Head	5,275
Drive Shaft	709
Column	4,440
Bowl	5,875
Total	**43,889**

14.2.3 CHECK VALVES, BUTTERFLY VALVES AND FLOW METERS

A manually operated isolation butterfly valve is located on the suction line of each pump. The discharge lines are equipped with a check valve for backflow prevention and a butterfly valve for pump isolation. The discharge butterfly valves are motor controlled. The check valves and butterfly valves are described in the following table.

Table 14-3: Check and Butterfly Valves

Item	Pump Tag Number							
	08-P-01	**08-P-02**	**08-P-03**	**08-P-04**	**08-P-05**	**08-P-06**	**0-P-07**	**08-P-08**
Check Valves								
Tag Number	08-V-01	08-V-02	08-V-03	08-V-04	08-V-32	08-V-236	08-V-232	08-V-228
Size	30-inch							
Manufacturer	Val-Matic							
Intake Butterfly Valves								
Tag Number	08-V-17	08-V-18	08-V-19	08-V-20	08-V-34	08-V-21	08-V-21	08-V-35
Size	42-inch							
Manufacturer	SPX-DeZurik							
Type	Buried with 2-inch operating nut							
Note: Suction lines for future pumps have butterfly valves similar to above (08-V-22 & 08-V-36)								
Discharge Butterfly Valves								
Tag Number	08-V-05	08-V-06	08-V-07	08-V-08	08-V-33	08-V-245	08-V-242	08-V-241
Size	30-inch							
Valve Manufacturer	SPX-DeZurik							
Control	Automatic Fully Open-Fully Closed							
Operator Manufacturer Model No.	Rotork IQ12/IW52				Rotork IQ12/IW4	Rotork IQ12/IW52		

The discharge piping system outside of the station makes provisions for treated water metering, bypass to the GST and a potable supply to the plant. Two flow meters are located on dual sections of 42-inch diameter pipe on the discharge side of the pump station. The meter produces a DC pulsed signal directly proportional to and linear with the liquid flow rate. The meters transmit flow data to PLC-3 and the HMI located in the High Service Pump Station building. The potable plant water supply is also metered and monitored by the HMI. The valves and flow meters for these facilities are shown in the following table.

14-4: Discharge Piping Valves and Flow Meters

Item	Description
Bypass Line to Ground Storage Tank	
Isolation Butterfly Valve	08-V-37
Size	20-inch
Manufacturer	SPX-DeZurik
Operator	Manual Handwheel
Control Sleeve Valve	08-V-38
Size	20-inch
Manufacturer	Val-Matic
Operator	Electric Operator
Treated Water Metering System	
Flow Meters	08-FE-1000 and 08-FE-1001
Type	Magnetic
Manufacturer	Endress+Hauser
Flow Range	0-120 mgd
Isolation Butterfly Valves	08-V-28; 08-V-29; 08-V-30; 08-V-31
Size	42-inch
Manufacturer	SPX-DeZurik
Operator	Manual - Handwheel
Plant Potable Water	
Flow Meter	08-FE-1002
Type	Magnetic
Manufacturer	Endress+Hauser
Flow Range	0-3000 gpm
Isolation Butterfly Valves	08-V-23 & 08-V-24
Size	8-inch
Manufacturer	SPX-DeZurik
Operator	Manual - Handwheel

14.2.4 AIR RELEASE VALVES

An air release valve is located prior to the check valve on each high service pump discharge. These valves exhaust air that may accumulate in the pipes. An air release valve is located on each of the external meter lines and on the bypass line. These valves are described in the following table.

Table 14-5: Air Release Valves

Item	Description							
Pump Discharge Lines								
Pump Tag No.	08-P-01	08-P-02	08-P-03	08-P-04	08-P-05	08-P-06	08-P-07	08-P-08
Air Release Valve	08-V-09	08-V-10	08-V-11	08-V-12	08-V-13	08-V-234	08-V-230	08-V-226
Size	6-inch	6-inch	6-inch	6-inch	6-inch	6-inch	6-inch	6-inch
Manufacturer	-	-	-	-	-	-	-	-
Metering Lines								
Air Release Valves	Tag Nos. 08-V-43 and 08-V-45							
Size	6-inch							
Manufacturer /Model	Val-Matic Combo Air Valve with Air Release No. 156/38							
Bypass Line								
Air Release Valve	No Tag No.							
Size	2-inch							
Manufacturer	Val-Matic							

14.2.5 VENTILATION EQUIPMENT

Supply louver, exhaust fan and thermostat.

14.2.6 BRIDGE CRANE

Bridge crane.

14.2.6 ANALYZERS

Chlorine residual, ammonia and pH analyzers.

14.3 INSTRUMENTATION AND CONTROL

14.3.1 GENERAL

The HMI and PLC-3 provide remote monitoring and control for the high service pumps, discharge butterfly valves and the standby transfer pump. The status of the bypass control valve and the discharge pressure is also monitored from PLC-3. Flow data from the two treated water flow meters and one potable plant water meter are monitored from PLC-3 and the HMI. In addition, data from the treated water magnetic flow meters are transmitted to the City.

The PLC cabinet and equipment power panel are located in the High Service Pump Station. Power for the motor operated valves and the bridge crane is provided from panel 08-STBY-PP01.

14.3.2 HIGH SERVICE PUMPS

Each of the high service pumps are driven by constant speed electric motors. Thus the output of each is fixed depending on the TDH at any given moment in time. Pump output can be varied through manipulation of the head and taking pumps on or off-line. The high service pumps are controlled from PLC-3 and the HMI. The pumps have a local H-O-R switch for manual Start/Stop control.

The head on the pumps will depend on the operating pressure created by the City of Houston's water distribution system and the friction losses in the transmission lines. Maximum flow to the City occurs when all pumps are operating, the butterfly valves are fully open, bypass valve is fully closed, and the demand in the City of Houston distribution system is high (resulting in low distribution pressure).

The flow delivery rate can be controlled by the number of pumps on-line. For short-term periods the delivery rate of the High Service Pump Station to the finished water transmission main can be decreased without decreasing the flow through the treatment process by opening the control sleeve valve (08-V-38) on the bypass line recycling water back to the GST. During the periods when water is recycled, the level in the GST might rise.

The operator can set desired transfer rate to the City system at the HMI. This flow setting should be maintained by automatically adjusting the positioning of the bypass flow control line, (i.e., more or less flow to recycle vs. more or less flow to the transmission main).

14.3.3 LOW PRESSURE SWITCH

There is a low pressure switch, 08-PSL-1000, on the suction manifold to the High Service Pumps. In the REMOTE mode, the low pressure switch will stop all of the high service

pumps on low inlet pressure to prevent the pumps from operating with no water and being damaged. The low level pressure switch initiates a LOW INLET PRESSURE alarm when the inlet pressure falls below a pre-set limit.

14.3.4 FLOW METERS

Flow meters 08-FIT-1000 and 08-FIT-1001 monitor flow from the High Service Pumps to the Finished Water Transmission main. Signals from the flow meters are used to control the By-pass Control Valve in the REMOTE mode. They will also generate LOW and HIGH FLOW alarms if the flow is different from the operation input setpoint.

Flow meter 08-FIT-1002 monitors the flow to the plant water system.

14.3.5 ANALYZERS

There are three analyzers in the High Service Pump Station to monitor the finished water quality: 1) pH/temp, 2) chlorine residual and 3) ammonia. The finished water is monitored by PLC-3 and HMI for pH/temp and chlorine residual prior to entering the Finished Water Transmission Main.

14.3.6 BRIDGE CRANE

The bridge crane is controlled through a local control panel and control station (pendant).

14.3.6 VENTILATION EQUIPMENT

The supply louvers and exhaust fans are controlled by thermostat located on the inside walls of the pump station.

14.4 OPERATING PROCEDURES

14.4.1 NORMAL OPERATING PROCEDURES

NEWPS staff should refer to Volume II of this Manual for Standard Operating Procedures applicable to this facility.

14.4.1.1 General Monitoring

The HMI monitors for all high service pumps the following; H-O-R status, RUN status, discharge valve OPEN/CLOSE status, motor bearing and winding TEMPERATURES, and HIGH PRESSURE shutdown.

The HMI also monitors the following distribution parameters; individual high service meter FLOW rates, combined high service FLOW rate, service water FLOW rate, discharge line PRESSURE, surge tank air compressor TROUBLE alarm, and end of the line (Little York and Hirsch) PRESSURE and CL_2 RESIDUAL. The flow control valve REMOTE status and OPEN/CLOSE status are monitored by the HMI.

For all three high service meters LOW and HIGH FLOW alarms are activated when flow meters are nearing their measuring range limits. The operator manually re-aligns the flow meters to work within their limits.

A control valve (08-V-38) is installed on the discharge header to provide flow control to the distribution system.

At the valve there is a LOCAL-REMOTE (L/R) switch for the actuator. In the LOCAL position the valve is controlled locally. In the REMOTE position the valve is controlled by HMI system.

14.4.1.2 Local Manual Control Mode

The pumps may be operated from their respective MCC. The MCC's have H-O-R switches and a START/STOP pushbutton. When the H-O-R switch is in the HAND mode, the pump is controlled by the START/STOP pushbuttons. In the OFF position, the pump is off. In the HAND position, the HIGH TEMPERATURE and HIGH PRESSURE interlocks are not removed. In the AUTO position, the pump is controlled by the HMI.

The flow control valve can be operated at its respective valve actuator. When the L/R is in the LOCAL position, the valve is controlled by the OPEN and CLOSE pushbuttons on the valve actuator. Local OPEN and CLOSE status is indicated at the actuator.

14.4.1.3 HMI Manual Control Mode

A START/STOP switch is provided for each pump in the HMI. When the local H-O-R switch is in the AUTO position, the HMI operator is able to operate the High Service Pumps using the START/STOP switch. The HMI prevents the operator from starting more than one pump at a time. The HMI allows thirty seconds for the pump to start and come up to speed.

The HMI generates a PUMP FAILURE alarm when a pump is called to RUN, power is on, the field H-O-R switch is in the AUTO position, and RUN status is not received for three seconds.

When the local L/R switch is in the REMOTE position a MANUAL/AUTO mode can be selected for that pump. In MANUAL mode the operator is able to operate the valve using a POSITION SET POINT command at the HMI.

14.4.1.4 HMI Automatic Control

In AUTO mode the operator is able to control the discharge flow rate by setting a discharge FLOW RATE set point. The flow control valve automatically adjusts the position to match the discharge flow to the set point. If the valve fails to maintain the flow rate of the set point a LOW or HIGH FLOW alarm is activated.

14.4.2 EMERGENCY SHUTDOWN PROCEDURES

If it is necessary to discontinue flow to the City, all primary high service pumps should be shutdown one at a time and the emergency pump should be activated to maintain positive pressure throughout the transmission main. The flow from the emergency pump should be set at the minimum necessary to maintain positive pressure in the transmission main while minimizing drawdown from the GST. The bypass line valve should be fully closed.

There are at least two conditions under which the high service water pumps would be operated under emergency conditions: 1) failure of the SCADA system and 2) failure of the High Service Pump Station PLC (PLC-3).

Should the SCADA system fail, the pumps can be started and stopped at PLC-3 in the manual mode. The speed of pumps 08-P-01 through 08-P-04, as well as pumps 08-P-06 through 08-P-08, can be controlled manually through PLC-3.

Should all primary pumps fail, or a general power outage is encountered, the emergency diesel motor driven pump should be activated. Start up for this unit is accomplished locally at the diesel drive panel 08-LCP-05. This pump can deliver flow for 12-hours or more at a rate of approximately 20 MGD to the City; while, maintaining a positive pressure throughout the transmission main. The standby pump will be operated until the

primary pumps are back on-line or until the tanks are empty in the event of plant-wide power loss. The valve on the 20-inch diameter bypass line should be fully closed during operation of the standby pump.

14.5 MAINTENANCE

14.5.1 STANDARD MAINTENANCE PROCEDURES

NEWPS personnel should refer to Volume III of this Manual for Standard Maintenance Procedures applicable to this facility. For specific equipment related maintenance procedures refer to the equipment manufacturers manuals included in Volume IV of this O&M Manual.

14.5.2 ROUTINE MAINTENANCE

The high service pumps are provided by Floway Pumps. The preventative maintenance procedures for the pumps and lubrication schedules for the pumps and motors are presented in Section 3 of the Operation and Maintenance Manual provided by Floway.

The pump manufacturer, Floway, recommends a monthly inspection for all pumps. During this inspection the pump and driver should be checked for performance and change in noise or vibration level, loose bolts or piping, dirt or corrosion. Clean and repaint all areas that are rusted or corroded. Observations or checks that should be done routinely by operations:

- observe pump and motor for proper operation daily,
- check for adequate water flow at the packing box, excessive noise, and excessive heat near the packing gland, and
- check lubricant levels in High Service Pump motors once per shift

The standby diesel motor is manufactured by Cummins. The preventative maintenance procedures and lubrication scheduled recommended by the manufacturers are presented in the Operation and Maintenance Manual provided by Cummins.

The motor has an integral fuel tank which should be monitored for volume. Depending on the fuel use rate, a preservative may need to be added. The battery should be maintained in fully charged condition at all times.

Full load should be applied through the pump to assure the unit will carry the load. Prior to and during operation of the diesel engine pump the following observations and checks should be performed:

- fuel level,
- oil level,
- coolant level,
- coolant temperature,
- engine speed,
- packing gland leakage rate,
- listen for excessive noise and/or vibration,
- fuel level in tank, and
- output of the pump.

If necessary for maintenance or inspection, a bridge crane is provided for lifting and removing the pumps from the building. The crane should be operated at least once per month to verify operating condition. Refer to the manufacturers Operation and Maintenance Manual for preventative maintenance schedules.

14.5.3 HOUSEKEEPING

The pump station should be kept free of any trash or debris. No equipment or materials should be stored in or around the pump station. Oil spills on the floor must be cleaned up with absorbent material. The oil soaked absorbent must be place in a container designated for such material. The absorbent material must be disposed of in a proper manner. Excess water on the floor should be squeegeed out to allow for quicker drying and eliminate slip areas.

The pump station should be closed and locked at all times to prevent trash or debris from entering and interfering with operations. The control enclosures should be closed and locked at all times.

14.6 SAFETY

14.6.1 HIGH SERVICE PUMP STATION SAFETY

14.6.1.1 Pumps

Caution must be observed at all times when work or inspections are required in the vicinity of the high service pumps. These pumps start and stop automatically. Specific safety considerations for the pumps and motors are presented in the Operation and Maintenance Manual provided by Floway.

The diesel drive motor for the emergency pump is located on the outside of the west wall of the building on a 16.5-feet by 25-feet platform about 7 feet above grade. When performing maintenance on this equipment caution should be observed and fall protection tie-offs used when required.

14.6.1.2 Bridge Crane

An overhead traveling bridge crane is provided for the removal of the pumps and motors. The operator should become familiar with crane operation and safety issues as described in the manufacturers Operation and Maintenance Manual. The removal of equipment with the crane is a hazardous activity and proper safety precautions should be observed at all times.

The crane should be operated on a monthly basis to verify that the equipment is in good working condition and to allow the operators to become knowledgeable in the operation and safety requirements of the equipment.

The following general safety practices regarding crane operation should be observed.

- bridge crane equipment should be inspected on a regular basis,
- equipment should not be operated if components are worn or in disrepair,
- slings should be replaced immediately if excessively worn,
- loads should not be suspended over personnel,
- load movements should be made smoothly and deliberately,
- under no circumstances should personnel ride the hook or load,
- rated capacity of the crane, hoist, sling or other component must never be exceeded,
- slings should be securely seated in hook before moving the load,
- remove the slack from sling before lifting,
- never leave bridge crane controls unattended,
- perform periodic inspections and maintenance as recommended by manufacturer, and
- when repairs are required, disconnect power and tag out control panel.

ATTACHMENT A

PROCESS AND INSTRUMENTATION DRAWINGS

HIGH SERVICE PUMP STATION

15.1 PROCESS DESCRIPTION

15.1.1 SURGE TANK

The purpose of the Surge Tanks are to dampen any potential water hammer or surge pressures that may develop in the Finished Water Transmission Main between the High Service Pump Station and the City of Houston water distribution system. The air volume in the Surge Tank is compressed by any water hammer or pressure surges that may occur in the transmission main. The Surge Tanks also protect the pumps and valves in the High Service Pump Station from water hammer and other potential surge pressures. The Surge Tanks are located adjacent to the discharge header at the High Service Pump Station.

The Surge Tanks are connected to the 84-inch diameter High Service Pump Station discharge header by a 42-inch diameter pipe. An isolation butterfly valve is located on the pipe at the tank inlet, to allow the Surge Tank to be taken off-line for maintenance or inspection. The required air cushion in the tank is maintained by an air compressor located in the High Service Pump Station. A sight glass is provided to visually see the water level in the Surge Tank. A 6-inch vacuum relief valve and a 4-inch valved drain line are also provided on the Surge Tank.

During the initial startup of the High Service Pump Station, the Surge Tanks are filled with water to the midpoint of the tank at normal operating discharge pressure. The air in the upper half of the tank is compressed to the system operating pressure.

The Surge Tanks installation includes the following major components:

- Surge Tank
- Butterfly Valve
- Air Compressor Unit

15.2 COMPONENT DESCRIPTION

15.2.1 SURGE TANKS

The description of the Surge Tanks is presented in Table 15.1.

Table 15-1: Surge Tank Criteria

Item	Description
Internal Diameter	144-inch
Material	Steel
Tank Capacity	5,000 cf (37,400 gal)
Working Pressure	96 psig
Surge Pressure	140 psig
Shutoff Pressure	181 psig
Design Internal Temperature	35 to 75° F
Design External Temperature	35 to 140° F
Weight	
Head	5,360 lbs
Shell	45.731 lbs
Head	5,266 lbs
Attachments	3,884 lbs
Total	**60,241 lbs**

15.2.2 BUTTERFLY VALVE

A butterfly valve is located on the 42-inch diameter pipe that connects the Surge Tank to the High Service Pump Station discharge header. This valve is used to isolate the tank if maintenance or inspection of the tank is necessary. The valve is described in the following table.

Table 15-2: Butterfly Valve Criteria

Item	Description	
Tag Number	08-V-26	08-V-226
Size	42-inch	42-inch
Manufacturer		
Operator	Manual - Handwheel	Manual - Handwheel

15.2.3 COMPRESSOR SYSTEM

Compressed air is required in the Surge Tanks to provide cushioning for any pressure surges in the Finished Water Transmission Main. An air compressor located in the High Service Pump Station Building provides air. The description of the compressor system is

presented in Table 15-3. The compressor is a horizontal tank-mounted positive displacement unit, air-cooled 2-stage, V-belt driven, oil-free type with alternator.

Table 15-3: Air Compressor Unit

Item	Description
Tag Number	08-ME-01
Manufacturer	Ingersoll-Rand
Service	Air for Surge Tank
Elevation above sea	63 ft.
Piston displacement, minimum	59 acfm
Discharge pressure	125 psig
Motor size, minimum – 2 units	15 hp
Motor speed, maximum	1,750 rpm
Compressor speed, maximum	750 rpm
Size of receiver tank	750 gal
Pressure rating of receiver	150 psig

The Surge Tanks are each equipped with a pressure relief valve, ball check valve, shutoff valve, high-pressure switches, air filters, and pressure gauge and valve.

15.3 INSTRUMENTATION AND CONTROL

15.3.1 GENERAL

The HMI and PLC-3 provide remote monitoring and control for the Surge Tank and air compressor. The LCP (08-LCP-01 and 08-LCP-203) transmits data to the HMI and PLC – 3. This includes indication of water level in the Surge Tanks and failure of the system. High level or low level shutoff switches on each tank show status. High and low level conditions together with system failure are transmitted to the HMI and PLC – 3. The air compressor is powered at panel 08-STBY-PP01.

The following functions are provided by the LCP:

1. AUTO/MANUAL control mode selection.

2. Level Control:

   a. Air addition sequence proceeds as follows:

      1) Actuation of the HIGH level setpoint activates the air addition time delay.
      2) After the prescribed time delay, the air addition valve is opened.
      3) Air is added until the MIDDLE level setpoint de-actuates and closes the air addition valve.

   b. Air venting sequence proceeds as follows:

      1) Actuation of the LOW level setpoint activates the air venting time delay.
      2) After the prescribed time delay, the air vent valve is opened.
      3) MIDDLE level setpoint actuates and closes the air addition valve.

4. Level Alarms: The level control system includes level probes to detect and indicate LOW-LOW and HIGH-HIGH levels and provides a SPDT alarm contact for each condition for connection to the Local Control Panel. A 0-to 20-minute adjustable time delay is provided in activating the HIGH-HIGH or LOW-LOW level alarm contacts.

15.3.2 SURGE TANK

The Surge Tank is charged with air so that the liquid level is at its normal location at the mid point of the tank, 8.1 feet. The high set point is 8.6 feet and the low level set point is 7.6 feet. A high level alarm is set at 9.0 feet with a low level alarm at 7.2 feet. The compressor will automatically maintain the air volume in the tank within the normal operating range.

The air compressor unit maintains the air charge in the Surge Tank to maintain the water level within prescribed limits. This is accomplished by level switches connected to the compressor control panel. The control panel has a running light indicator, warning lights for low oil and run high temperature. System failure is transmitted to the HMI and PLC – 3. High pressure switches are provided to shut down the unit if pressures rise too high.

The compressor unit maintains the operating water level in the Surge Tank within the prescribed limits. Once on-line, the compressor unit operates intermittently to maintain the proper levels. The compressor unit is operated and monitored at the LCP. Indication of compressor failure is sent to the HMI and PLC – 3.

15.4 OPERATING PROCEDURES

15.4.1 STANDARD OPERATING PROCEDURES

NEWPS staff should refer to Volume III of this Manual for Standard Operating Procedures applicable to this facility.

15.4.1.1 General Monitoring

The HMI monitors distribution parameters; discharge line PRESSURE, surge tank air compressor TROUBLE alarm, and end of the line (Little York and Hirsch) PRESSURE.

15.4.1.2 Manual Operation

The MANUAL mode allows manual OPEN and CLOSE control of the air addition and air venting solenoid valves from the LCP.

15.4.1.3 Automatic Operation

When in AUTO mode, Surge Tank water levels are controlled to remain in a predetermined level range. Control is accomplished by sensing water levels and adding air to, or venting air from the tanks until the setpoint level of the range is reached. The tank has a level element and transmitter. The panel includes a level controller, and has adjustable setpoints, referred to as HIGH, MIDDLE, and LOW setpoints. A 0-to 30-minute adjustable time delay is provided to suppress air addition or venting during surge conditions, or level changes initiated by opening and closing valves.

15.4.2 EMERGENCY AND SHUTDOWN PROCEDURES

The charged Surge Tank(s) should remain in service whenever the primary High Service Pumps are operating to prevent surge pressure damage to valves and pumps. Loss of air from the tank will be limited, and if necessary, the compressor unit can be taken off-line for repair or maintenance for a limited time. The compressor unit has two motors and compressors so one unit could be taken off-line for repair with the other unit maintaining operation.

The Surge Tank(s) would only be shutdown or taken off-line when the Finished Water Transmission Main was taken out of service. The Surge Tanks have drain valves and lines should draining be necessary for maintenance or inspection.

It is expected that the Surge Tank system will reliable and functional as long as the air cushion inside the tanks is maintained. The compressor unit has dual motor/compressors which will further minimize any potential loss of air. Should both blowers fail, the air/water interface level in the tank should be monitored closely. If the level rises to the

15.5 MAINTENANCE

15.5.1 STANDARD MAINTENANCE PROCEDURES

NEWPS staff should refer to Volume III of this Manual for Standard Maintenance Procedures applicable to this facility. For specific equipment related maintenance procedures refer to the equipment manufacturers manuals listed in Attachment C and included in Volume III of this manual.

15.5.2 ROUTINE MAINTENANCE

The air compressor unit is provided by Ingersoll-Rand. The preventative maintenance procedures for the compressor and receiver are presented in the Operation and Maintenance Manual provided by the manufacturer.

Maintenance of the Surge Tanks will include exterior painting as experience may dictate. A certain amount of interior corrosion of the tank is to be anticipated. An entry hatch is provided for each tank to allow a person to enter for inspection, cleaning and recoating. This can only be done when the pumped flow would be minimal to avoid surge pressures during the downtime.

15.5.3 HOUSEKEEPING

The air compressor and accessories are located in the High Service Pump Station. The pump station should be kept free of any trash or debris and no equipment or materials should be stored in or around the pump station. The pump station should be closed and locked at all times to prevent trash or debris from entering and interfering with operations. The control enclosure for the air compressor should be closed and locked at all times.

The sight glass on the level gauge on the Surge Tanks should be kept clean to allow viewing of the Surge Tank water level.

15.6 SAFETY

15.6.1 SURGE TANK SAFETY

Caution must be observed at all times when work or inspections are required in the vicinity air compressor and accessories. The compressor starts and stops automatically. The air compressor is provided by Ingersoll-Rand. Specific safety considerations are presented in the Operations and Maintenance Manual provided by the manufacturer.

A hatch is provided on each Surge Tank for access. This hatch should be locked at all times except when tank inspection or maintenance is required. The Surge Tanks are a confined space and entry is subject to NEWPS confined space procedures.

During painting of a tank, proper precautions should be taken to safeguard personnel from any fumes given off by the paint or other coatings. Entry into a tank for inspection or maintenance must be considered entry to a confined space with the proper precautions taken. Coating the inside of the tanks will require special breathing equipment.

City of Houston, Texas
Northeast Water Purification Plant - Improvements
WBS No.: S-000066-0012-3
Existing HSPS Pump Startup and Shutdown and Valve Timing Evaluation

SWTP PRODUCTION (MGD):
HSPS PRODUCTION (MGD): 67 MGD at 66 psi (9:41 AM)

	Pump Start-Up / Pump Shut-Down Scenario	SURGE TANK LEVEL Prior to… (feet)	Header Pressure (psig)	Pump Discharge Pressure Prior to…. (psig)	GST Level Prior to …..(psig)	Position of EMO BFV Prior to Shutdown	EMO Moved to 100% Open (YES OR NO)	Time at Start of Shutdown or Start-up	EMO BFV Close Time at Valve Position @ 75% open (seconds)	EMO BFV Close Time at Valve Position @ 50% Open (seconds)	EMO BFV Close Time at Valve Position @ 25% Open (seconds)	EMO BFV Close Time at Valve Position @ 0% Open (seconds)	EMO BFV Valve Position When Pump Motor Disabled	Time for Pump To Spin Down to 0% Speed (seconds)	SURGE TANK LEVEL After… (feet)	Header Pressure (psig)	Mechanical Check Valve Closure @ BFV Position	Water Hammer Observed? (YES OR NO)
1	PUMP 6 SHUTDOWN	7'-1" E 6'-11.5" W	SCADA 78 psi Field 84 psi	80 psi	26.38'	Fully Open	Yes	10:39 AM	29.12 Note: 3 second delay between operator starting sequence and control valve begin closing (not included in time)	57.01	84.96	112.91	27°	1.5	6'-7" E 6'-8" W	69 psi	22°	
2	PUMP XXXX SHUTDOWN																	
3	PUMP XXXX SHUTDOWN																	
4	PUMP XXXX SHUTDOWN																	

City of Houston, Texas
Northeast Water Purification Plant - Improvements
WBS No.: S-000066-0012-3
Existing HSPS Pump Startup and Shutdown and Valve Timing Evaluation

SWTP PRODUCTION (MGD):
HSPS PRODUCTION (MGD): 67 MGD at 66 psi (9:41 AM)

	Pump Start-Up / Pump Shut-Down Scenario	SURGE TANK LEVEL Prior to… (feet)	Header Pressure (psig)	Pump Discharge Pressure Prior to…. (psig)	GST Level Prior to …..(psig)	Adjacent Pump Discharge Pressure Prior to…. (psig)	EMO BFV 100% Closed? (YES OR NO)	Time at Start of Shutdown or Start-up	EMO BFV Open Time at Valve Position @ 100% open (seconds)	EMO BFV Open Time at Valve Position @ 75% open (seconds)	EMO BFV Open Time at Valve Position @ 50% Open (seconds)	EMO BFV Open Time at Valve Position @ 25% Open (seconds)	EMO BFV Open Time at Valve Position @ 0% Open (seconds)	Time for Pump To Spin Up to 100% Speed (seconds)	SURGE TANK LEVEL After… (feet)	Header Pressure (psig)	Mechanical Check Valve Open @ BFV Position	Water Hammer Observed? (YES OR NO)
5	PUMP 6 STARTUP	6'-8" E 6'-7" W	SCADA 65.5 psi Field 78 psi	0 psi	26.52'	Pump 7 Before - 96 psi Pump 7 After - 100 psi	Yes	10:30 AM	120.39	92.65	64.30	36.35	10.00 Note: 10 second delay between operator starting sequence and control valve begin opening	1.5	7'-1" E 6'-11.5" W	SCADA 77 psi Field 84 psi		
6	PUMP 3 STARTUP								38.84	29.13	19.42	9.71	Note: Control Valve for Pump 3 was opened with Pump 3 offline					
7	PUMP XXXX STARTUP																	
8	PUMP XXXX STARTUP																	

History of NEWPP HSPS Pump Research

The following information was provided by CDM-Smith to LAN July 1, 2013 via the eRoom:

- Curves for Pumps 1 – 4 dated December 2002 showing rated flow 20 MGD and TDH of 144-ft.
- Floway pump shop drawing certified 10/18/02 showing rated flow 27 MGD (19,000 gpm) and TDH of 117-ft
- 14.2 Component Description showing rated flow 20 MGD (13,888 gpm) and TDH of 191-ft

LAN conducted a site visit of the HSPS on July 12, 2013. During our visit, we noticed the Pumps' 1 – 4 nameplates indicated rating of 27 MGD at 117-ft TDH. In an effort to reconcile the pump curves, we contacted the Steve Gavlick with Floway Pumps. (Steve was assigned to us as the Floway rep through Weir Minerals when we first obtained the pump WR^2 values.)

We gave Steve all the pump information we had received, including pictures of the existing pump nameplates. Steve then provided:

- Certified shop drawing for Pumps 1 - 4 dated 1/15/05 with rated flow 20 MGD (13,888 gpm) at TDH 191-ft. (see pump submittal and pump curve)

Based on LAN's conversations with Steve Gavlick, all 8 pumps at the NEWPP HSPS are 20 MGD pumps with a TDH of 191-ft. Steve confirmed, when Pumps 6 - 8 were installed in 2005, Pumps 1 – 5 were rebowled and given new column assemblies. However, the heads were reused and it is believed that the nameplates were not replaced.

THIS DRAWING IS CERTIFIED

☐ FOR APPROVAL
NO PRODUCTION WILL START UNTIL APPROVED IN WRITING.

☒ FOR CONSTRUCTION
PRODUCTION HAS STARTED. ANY CHANGES MAY AFFECT PRICE AND DELIVERY.

OUR ORDER No.: 55589-6

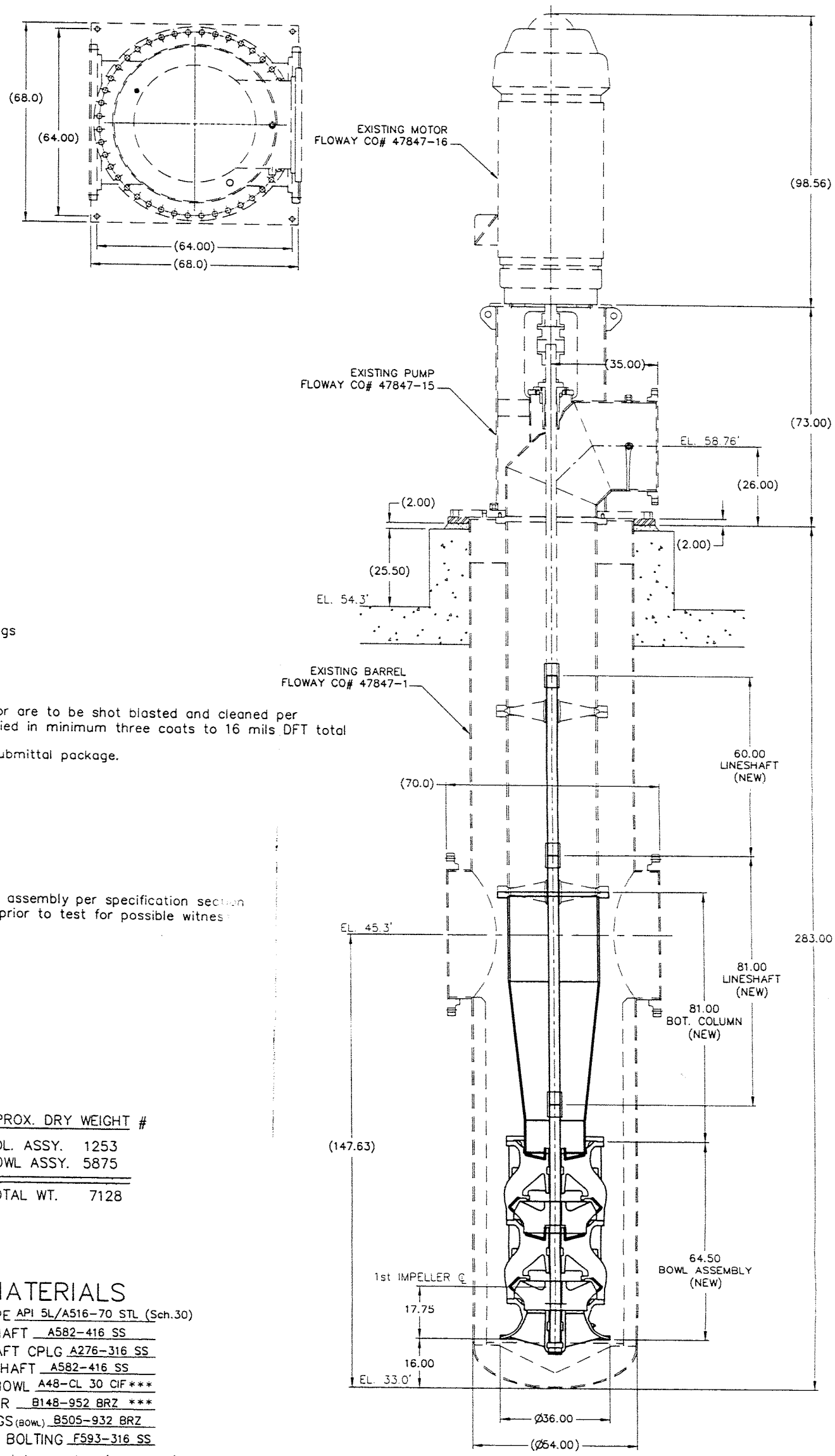
CUST. ORDER No.: P7010432-007

BY: SCW DATE: 1/15/05

FLOWAY PUMPS
FRESNO, CALIFORNIA

VERTICAL TURBINE PUMP

TYPE "VFR"



SPECIAL FEATURES:

1. Stainless steel bowl nameplates.
2. Double keyed & dynamic balanced impellers.
3. Pemanately grease packed suction bearing.
4. Maximum 10'-0" column and shaft lengths.
5. Spare Parts (one set only)
   - 1 set of all pump bearings
   - 1 set of impellers
   - 2 sets of all gaskets and orings
   - 1 set of bronze impeller and bowl wear rings (not provided on original equipment)

COATING:

Column pipe ID and OD and bowl assembly exterior are to be shot blasted and cleaned per SSPC-SP-5. Carboline Carbgard 891 will be applied in minimum three coats to 16 mils DFT total thickness.
Please refer to the coating data sheets in this submittal package.

TESTING:

Hydrostatic testing:
None required.

Performance testing:
A performance test will be performed on the bowl assembly per specification section 11100-2.5. The customer will be notified 14 days prior to test for possible witness

PUMPAGE

FLUID: TREATED WATER
SPEC. GRAVITY: 1.0
VISCOSITY: 1.12 cP
TEMPERATURE: 37° - 77° F
PH: 6-9

APPROX. DRY WEIGHT #

COL. ASSY.	1253
BOWL ASSY.	5875
TOTAL WT.	7128

COLUMN PIPE

3.438" LINE SHAFT 30" COL

BOWL ASSEMBLY

PROD.LUBE YES OIL LUBE -
TYPE 34 DKL STAGES 2
13888 GPM 191' BOWL HD △1
IMPELLER ENCLOSED
STRAINER NO
THRUST @ SHUT-OFF 31534 LBS.
△2 THRUST @ DESIGN 21559 LBS.

MATERIALS

COL PIPE API 5L/A516-70 STL (Sch.30)
LINE SHAFT A582-416 SS
LINESHAFT CPLG A276-316 SS
BOWL SHAFT A582-416 SS
PUMP BOWL A48-CL 30 CIF***
IMPELLER B148-952 BRZ ***
BEARINGS (BOWL) B505-932 BRZ
WETTED BOLTING F593-316 SS

***Fusion bonded epoxy lined (10-12 mils)

LOCATION: Northeast Water Purification System - Phase 2
Houston, TX

CUSTOMER: MWH Constructors, Inc.
Montgomery Watson Harza
12121 N. Sam Houston Parkway
Humble, TX 77396

FLOWAY CO: 55589-6
SERIAL #: ~~55589-6-1/4~~
PUMP ID: Treated Water Pumps 08-P-01/02/03/04
SPECIFICATION: ~~11103~~

NOTES:
1. ALL DIMENSIONS IN INCHES
2. DRAWING SCALE = 1:40
3. DO NOT SCALE UNKNOWN DIMENSIONS
4. NOT TO BE USED FOR CONSTRUCTION UNLESS CERTIFIED

REV	BY	DATE	DESCRIPTION
1	SCW	9/24/04	Change bowl TDH to 191' from 187' per submittal review comments dated 6/23/04.
2	SCW	10/22/04	Add down thrust values at shut-off and at rated design condition.

OUTLINE DRAWING

DRAWN BY: SCW

DATE: 6/16/04

DRAWING NUMBER
5558906COD

7

TYPICAL REED CRITICAL FREQUENCY DATA

USEM MODEL NO: NA
USEM CATALOG NO: NA

Frame: 6810P Type: HVE4

REED CRITICAL FREQUENCY:	25	HZ
CENTER OF GRAVITY:	41	IN
DEFLECTION @ CENTER OF GRAVITY:	0.016	IN
UNIT WEIGHT:	8800	LBS.
BASE DIAMETER:	30.5	IN.
MAXIMUM MOTOR DIAMETER:	42.5	IN.
DATE:	3/2/2005	

Home Email

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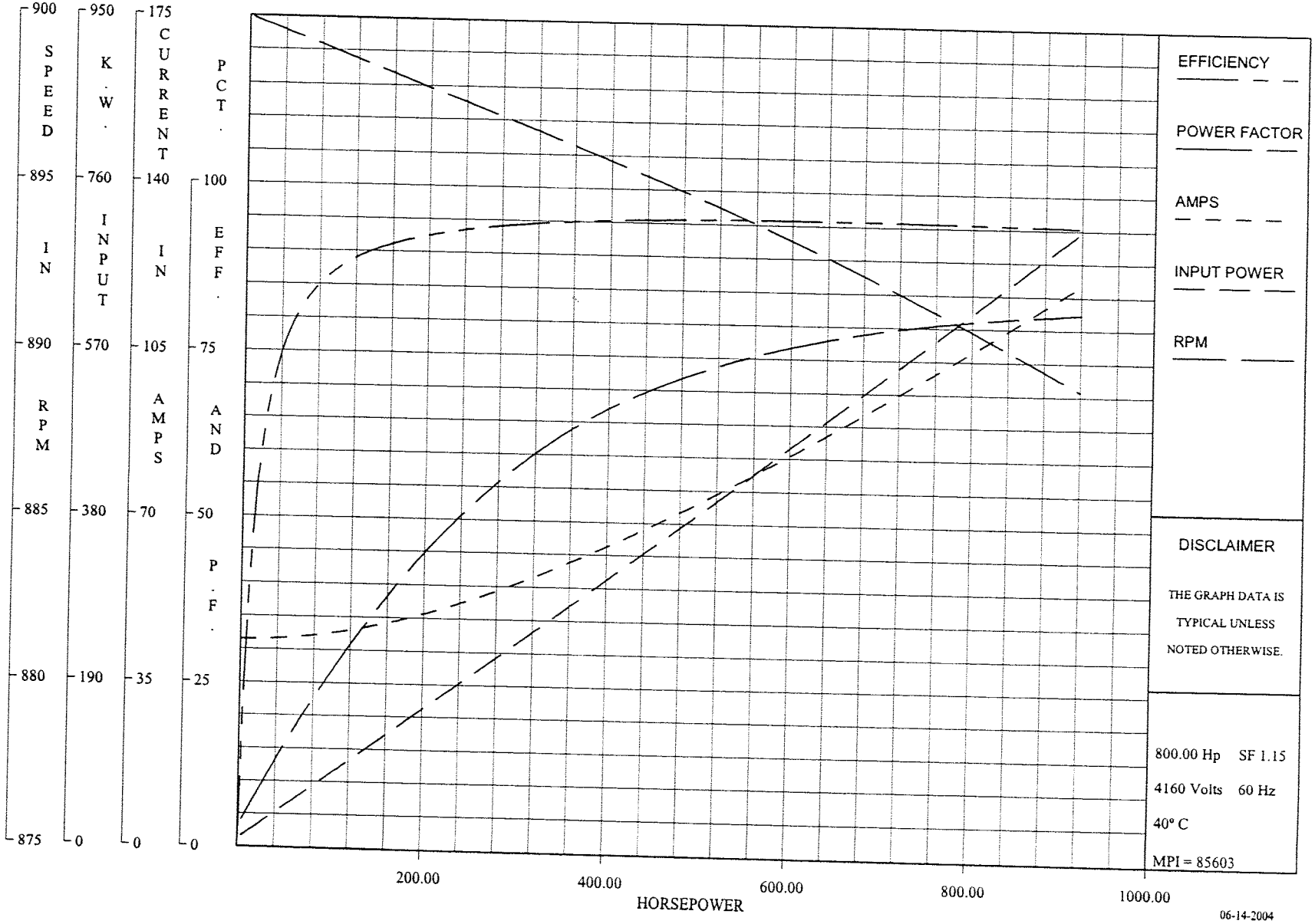
U.S. ELECTRICAL MOTORS



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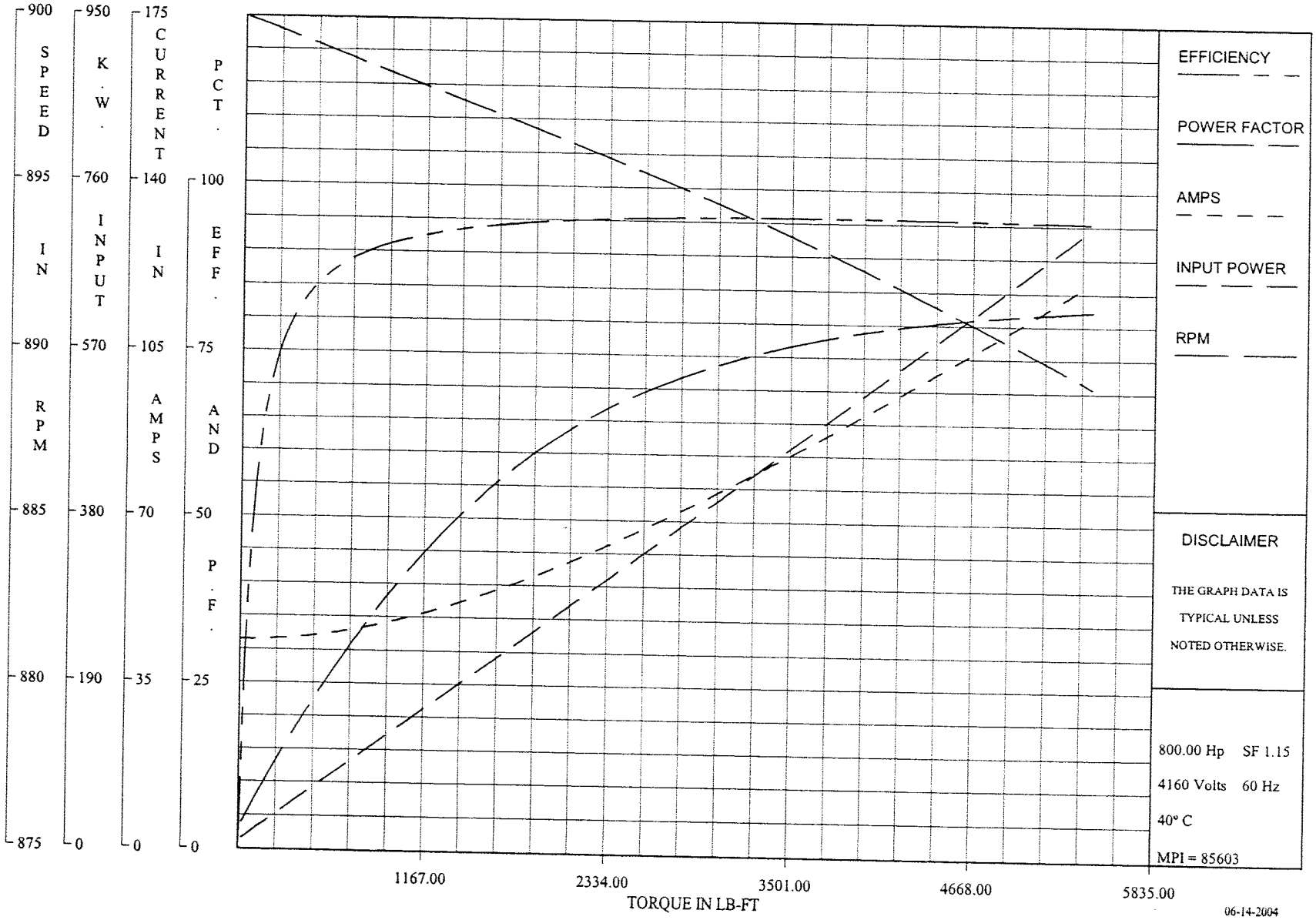
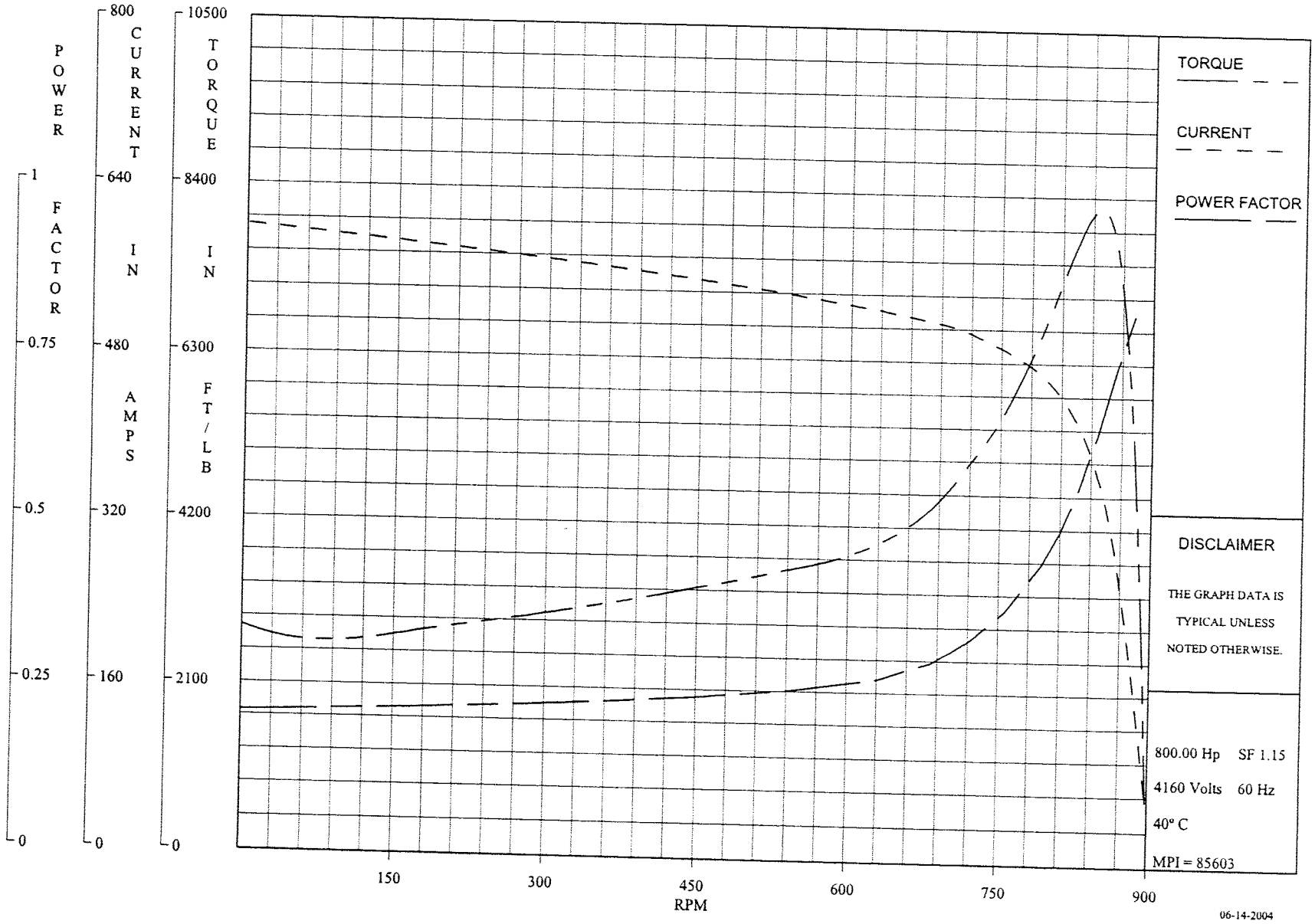
U.S. ELECTRICAL MOTORS



U.S. ELECTRICAL MOTORS



EMERSON.
Motor Technologies

EMERSON MOTOR COMPANY
8100 WEST FLORISSANT AVE.
P.O. BOX 3946 * BLDG. K * ST. LOUIS, MO 63136
FAX (314) 553-1101

DATE: 12/20/2004

P.O. NO.: 178989
USEM Order/Line NO.: 03058158 SO 100

TO: Floway Pumps
2494 Railroad Avenue
PO Box 164
Fresno, CA, 93706
ATTN: DICK FORNEY

Model Number: NA
Catalog Number: NA
Submittals
CONF,LLC,SUBMITTALS

REVISIONS:
(NONE)

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY US ELECTRICAL MOTORS.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Features:

```
Horsepower ............... 00800.00~00000.00 ~ KW: 596.8
Enclosure ................ WPI
Poles .................... 08~00 ~ RPM: 900~0
Frame Size ............... 6810~P
Phase/Frequency/Voltage.. 3~060~4160 ~ Form Wound
Service Factor .......... 1.15
Insulation Class ........ Class "F" ~ Insulife 5000
Altitude In Feet (Max) .. 3300 Ft.(1000 M)
Ambient In Degree C (Max) +40 C
Efficiency Class ........ Premium Efficiency
Application ............. Centrifugal Pump
Customer Part Number .... 55589-8
Base Diameter (Inches) ....... 30.5
Non-Reverse Ratchet
Pricebook Thrust Value (lbs).. 15300
Customer Down Thrust (lbs) ... 22055
Customer Shutoff Thrust (lbs).
Up Thrust (lbs) ..............
"AK" Dimension (Inches).. NA
Shaft Dimensions:~U=3.875 ~ AH/V=7.500
KEYWAY=1.000 ~ ES=5.500
Temperature Rise (Sine Wave): "B" Rise @ 1.0 SF (Resist)
Starting Method ......... Direct-On-Line Start
Duty Cycle .............. Continuous Duty
Load Inertia (lb-ft2): NEMA ~ NEMA Inertia: 15826.00 ~ 1.00
Number Of Starts Per Hour: NEMA
Motor Type Code ............ HVE4
Rotor Inertia (LB-FT²)       867. LB-FT²
Qty. of Bearings PE (Shaft)  1
Qty. of Bearings SE (OPP)    1
Bearing Number PE (Shaft)    6226-J
Bearing Number SE (OPP)      29438 EJ
```

EMERSON
Motor Technologies

EMERSON MOTOR COMPANY
8100 WEST FLORISSANT AVE.
P.O. BOX 3946 * BLDG. K * ST. LOUIS, MO 63136
FAX (314) 553-1101

DATE: 12/20/2004

P.O. NO.: 178989
USEM Order/Line NO.: 03058158 SO 100

TO: Floway Pumps
2494 Railroad Avenue
PO Box 164
Fresno, CA, 93706
ATTN: DICK FORNEY

Model Number: NA
Catalog Number: NA
Submittals
CONF,LLC,SUBMITTALS

REVISIONS:
(NONE)

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THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Accessories:
100,000 Hours L-10 Brg. Life
Counter CW Rotation FODE
500% Extra High Thrust
Ground Lug In Conduit Box
Insul. Bearing - Upper Bracket
115 Volt Space Heaters
Synthetic Lubrication
Bearing RTD-100 Ohm,3 Lead
Both Bearings
Winding RTD's-100 Ohm,3 Lead
Q-1 Accessory Outlet Box ~ Same Side As Main O/B
1" NPT Conduit Opening
One Box with Terminal Board
Shipping Tag Information:
HI SERVICE
08-P-06, 07, 08
Test Requirements:
Short Commer. Test - Unwit

USE THE DATA PROVIDED BELOW TO SELECT THE APPROPRIATE DIMENSION PRINT

Horsepower	800
Pole(s)	08
Voltage(s)	4160
Frame Size	6810P
Shaft U Diameter	3.875
Outlet Box AF	10.94
Outlet Box AA	3.50
Accessory Outlet Box DM	1

Emerson Motor Company is a division of Emerson Electric Co.
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EMERSON.
Motor Technologies

Report Of Short Commercial Test (TITAN)

12/20/2004

Purchaser Floway Pumps
Serial No. H12 03058158-100 R1
TR # 03058158 R1

Purchaser's Order No. 178989
U.S.E.M. Order No. 03058158-SO-100
Date Of Test 12/20/04

Nameplate Rating

Rated HP	Frame	Type	Design Letter	Ambient Temp.	Phase	Insulation Class
800	6810P	HVE4	#	40 C	3	F

Hertz	Service Factor	Volts	Amperes	Code Letter	Rated Speed RPM	Time Rating
60	1.15	4160	107.0	G	890	CONT

Test Report Of This Motor

No Load

Volts	Amperes	Watts	Hertz	Speed RPM
4295	46	16800	60	900

Locked Rotor

Volts	Amperes	Hertz
2300	319	60

Bearing Inspection	Vibration Test	Winding Resistance @25°	Dielectric Test		
PASSED	PASSED	0.411 OHMS	PASSED	16000 VDC	60 SEC.

Tested At: Mena AR

Data from test on actual motor

omments:

Approved By: K BUNTIN
Date: 12/20/04
Tested By: KEB

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EMERSON
Motor Technologies

Report Of Short Commercial Test (TITAN)

12/20/2004

Purchaser Floway Pumps
Serial No. H12 03058158-100 R2
TR # 03058158 R2

Purchaser's Order No. 178989
U.S.E.M. Order No. 03058158-SO-100
Date Of Test 12/17/04

Nameplate Rating

Rated HP	Frame	Type	Design Letter	Ambient Temp.	Phase	Insulation Class
800	6810P	HVE4	#	40 C	3	F

Hertz	Service Factor	Volts	Amperes	Code Letter	Rated Speed RPM	Time Rating
60	1.15	4160	107.0	G	890	CONT

Test Report Of This Motor

No Load

Volts	Amperes	Watts	Hertz	Speed RPM
4397	48	15900	60	900

Locked Rotor

Volts	Amperes	Hertz
2356	325	60

Bearing Inspection	Vibration Test	Winding Resistance @25°	Dielectric Test		
PASSED	PASSED	0.410 OHMS	PASSED	16000 VDC	60 SEC.

Tested At: Mena AR

Data from test on actual motor

Comments:

Approved By: K BUNTIN
Date: 12/20/04
Tested By: WH

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EMERSON
Motor Technologies

Report Of Short Commercial Test (TITAN)

12/20/2004

Purchaser Floway Pumps
Serial No. H12 03058158-100 R3
TR # 03058158 R3

Purchaser's Order No. 178989
U.S.E.M. Order No. 03058158-SO-100
Date Of Test 12/20/2004

Nameplate Rating

Rated HP	Frame	Type	Design Letter	Ambient Temp.	Phase	Insulation Class
800	6810P	HVE4	#	40 C	3	F

Hertz	Service Factor	Volts	Amperes	Code Letter	Rated Speed RPM	Time Rating
60	1.15	4160	107.0	G	890	CONT

Test Report Of This Motor

No Load

Volts	Amperes	Watts	Hertz	Speed RPM
4329	47	16900	60	900

Locked Rotor

Volts	Amperes	Hertz
2320	323	60

Bearing Inspection	Vibration Test	Winding Resistance @25°	Dielectric Test		
PASSED	PASSED	0.410 OHMS	PASSED	16000 VDC	60 SEC.

Tested At: Mena AR

Data from test on actual motor

Comments:

Approved By: K BUNTIN
Date: 12/20/04
Tested By: KEB

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Emerson Motor Company is a division of Emerson Electric Co.

NORTHWEST WATER PURIFICATION
SYSTEM PHASE 2
HOUSTON TX
TREATED WATER PUMP 08-P-06
PUMP TEST: PC # 30646

CERTIFIED CORRECT

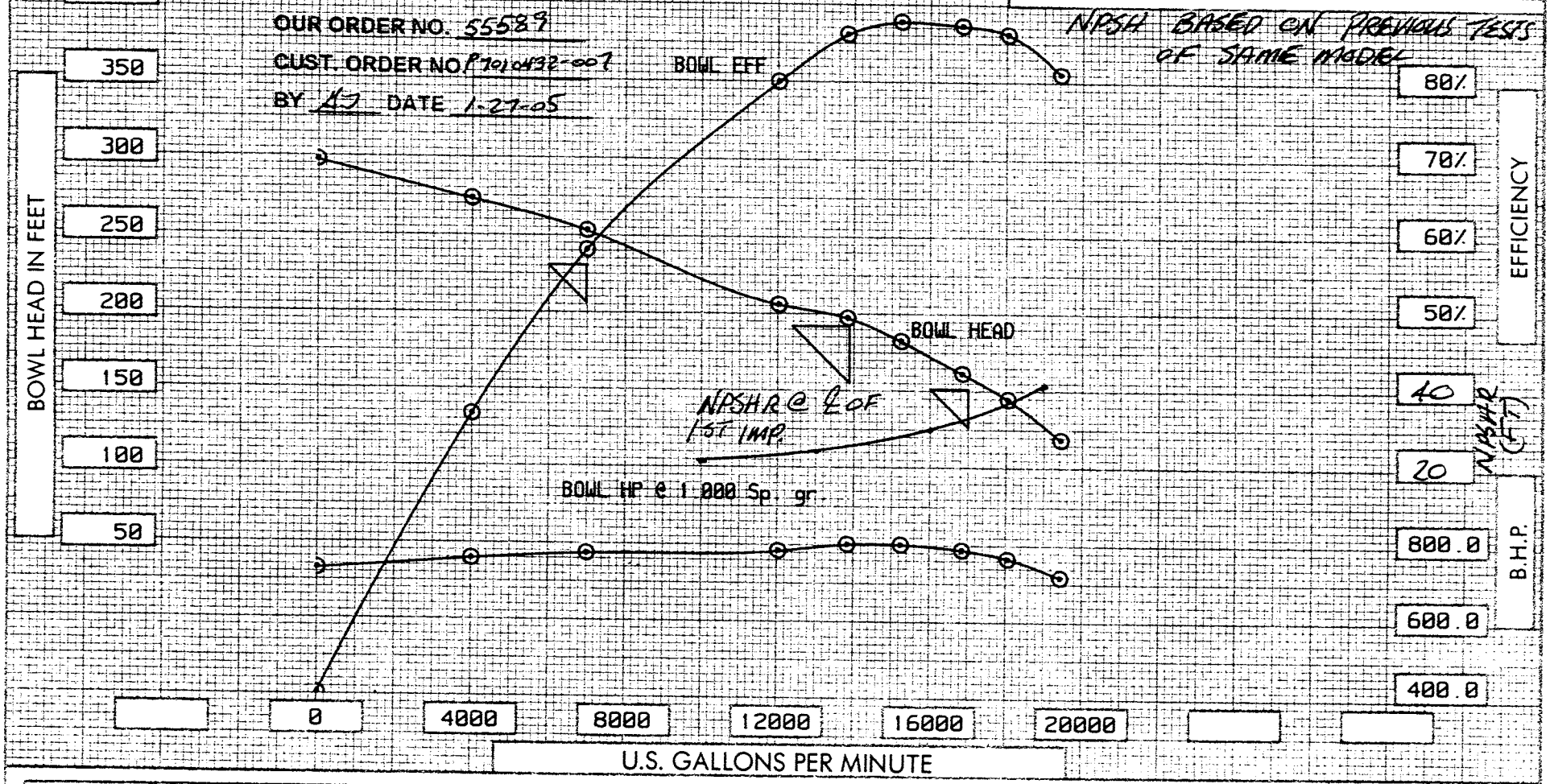
FOR

OUR ORDER NO. 55589

CUST. ORDER NO P7010432-001

BY AJ DATE 1-27-05

NPSH BASED ON PREVIOUS TESTS OF SAME MODEL



MWH CONSTRUCTORS
MONTGOMERY WATSON HARZA
12121 N SAM HOUSTON PKWY
HUMBLE TX 77390

DWG. NO. 55589-7-1-T1

FLOWAY PUMPS
FRESNO, CALIFORNIA

A WEIR COMPANY

TYPE 34 DKL
NO. OF STAGES 2
R.P.M. 890
PUMP SERIAL NO. 55589-7-1

DWN. BY GRT DATE 01/27/2005

PF-614

TEST NUMBER PC#: 30646 S.O. # : 55589-7-1 DATE: 01/27/2005
CONDITION POINT: GPM= 13888 TDH= 191 RPM = 890
CALCULATED BY: GRT DRAWING No. = 55589-7-1-T1
PUMP TYPE (Bb$): 34 DKL
MANOMETER CONSTANT (Mc) = 1.0070 IMPELLER TRIM DIA. = 21.750 inch
GAGE HEIGHT (Ght) = 5.130 IMPELLER FINAL DIA. = 21.750 inch
NUMBER OF STAGES(Stages) = 2 NUMBER OF STAGES TESTED (Ds) = 2
SPECIFIC GRAVITY (SPG) = 1.0000
WATER TEMPERATURE = 80 DEGREES (F) SPECIFIC WEIGHT = 62.324 Lbs/Cu Ft.
COLUMN SIZE = 24
MOTOR NUMBER (Mno) = 21

RUN	RPM	GPM	PRESS	GA COR	S LOSS	C-LOS	DH-LOS	VEL HD	HP RDG.	B LOS
1	895	0.0	127.80	0.00	0.00	0.00	0.00	0.00	775.00	0.00
2	895	4000.0	117.00	-0.10	0.00	0.00	0.00	0.14	805.00	0.00
3	895	7000.0	108.10	-0.20	0.00	0.00	0.00	0.44	821.00	0.00
4	894	12000.0	86.30	0.23	0.00	0.00	0.00	1.30	828.00	0.00
5	894	13800.0	82.40	0.20	0.00	0.00	0.00	1.72	847.00	0.00
6	894	15200.0	75.80	0.12	0.00	0.00	0.00	2.08	846.00	0.00
7	894	16800.0	66.50	0.00	0.00	0.00	0.00	2.54	831.00	0.00
8	894	18000.0	59.00	0.00	0.00	0.00	0.00	2.92	807.00	0.00
9	895	19400.0	47.50	0.00	0.00	0.00	0.00	3.39	758.00	0.00

I	RPM	GPM	TDH	TDH/STAGE	BHP	BHP/STAGE	EFF	MTR EFF
1	890	0.0	297.07	148.53	726.55	363.27	0.00	0.9534
2	890	4005.5	272.30	136.15	754.86	377.43	36.49	0.9536
3	890	7009.6	252.04	126.02	769.97	384.99	57.94	0.9537
4	890	12029.9	204.51	102.26	779.19	389.60	79.73	0.9538
5	890	13834.4	195.93	97.96	797.06	398.53	85.88	0.9538
6	890	15237.9	180.99	90.50	796.12	398.06	87.48	0.9538
7	890	16841.9	159.88	79.94	782.01	391.01	86.95	0.9538
8	890	18044.9	143.08	71.54	759.29	379.65	85.87	0.9536
9	890	19426.7	116.95	58.48	710.51	355.25	80.75	0.9532

FLOWAY PUMPS
FRESNO, CALIFORNIA

INPUT LAB TEST REPORT

COMMENTS

REF. NO:

TIME: START 12:15 FINISH 12:40

DATE 1-27-05 TEST NO PC-3046 CUSTOMER MWH CONSTRUCTORS INC S/N # 55589-7-1
PUMP DESCRIPTION 34DKL NO. OF STAGES 2 COL. SIZE & LENGTH 24"x15'6" SHAFT SIZE 2 11/16
HEAD SIZE & TYPE 24" F BOWL(C.I.) (P.C.I.) EVSECOAT IMPELLER (OPEN) (CLOSED) (SEMI) (P.C.I.) IMPELLER DIA 22.375 / 22.125 U F 5 3/4 x 2 1/4
MOTOR DATA MAKE LAB SERIAL NO. #21 H.P. 1000 POLES 8 PHASE 3 CYCLE 60 VOLTS 2300 TYPE VHS
MOTOR EFF. (PUBLISHED)(GUARANTEED) — x FULL LOAD AMPS N/A METER CONSTANT Kh = 138.93 (50HP-230V) 80.43 (25HP-460V) ☐ 1158.18 (100HP-460V)
METER SIZE & TYPE 24x14½ GAGE DESCRIPTION 100#/300# Kh= ☐ 2779.6246 (400H-460V) ☒ 6949.0616 (1000HP-2300V)
☐ 12160.875 (2500HP-4160V)
MANIFOLD ADAPTER SIZE 24X24 OFFSET ☐ STRAIGHT ☒ AXIAL ADJUSTMENT @ 2½ Turns/Inches 8 TPI

	TEST RPM	MANOMETER READING IN GPM	TOTAL GPM READING x 1.027	GPM @ 890 RPM K=	PRESSURE GAGE	DISCHARGE GAGE READING IN P.S.I.	DISCHARGE GAGE CORRECTION	TOTAL P.S.I.	GAGE HEAD IN FEET Ⓐ	SYSTEM LOSSES IN FEET Ⓑ	GAGE ELEV. IN FEET Ⓒ	VELOCITY HEAD IN FEET Ⓓ	TOTAL HEAD IN FEET Ⓐ+Ⓑ+Ⓒ+Ⓓ	HEAD IN FEET @ 890 RPM K2 =	HEAD PER STAGE @ RPM		SECONDS PER 4 REVOLUTIONS	AVERAGE VOLTS	AVERAGE AMPS	POWER METER INPUT ☐ KW ☒ HP	FIELD HP	F HP @ 890 RPM K3 =	F HP @ 1000 SPEC GRAVITY		OVERALL EFF	PUMP EFF
1	895	0			300#	127.8	.00				5.13															
2	895	4000			↓	117.0	-.10				↓									775						
3	895	7000			↓	108.1	-.20				↓									805						
4	894	12000			100#	86.3	.23				↓									821						
5	894	13800			↓	82.4	.20				↓									828						
6	894	15200			↓	75.8	.12				↓									847						
7	894	16800			↓	66.5	.00				↓									846						
8	894	18000			↓	59.0	.00				↓									831						
9	895	19400			↓	47.5	.00				↓									807						
10																				758						
11																										
12																										
13																										
14																										

FORMULAE: GAGE HEAD P.S.I. x 2.3105 INPUT H.P. = $\frac{\text{NO. OF REV} \times \text{Kh}}{\text{TIME}} = \frac{\text{AMPS} \times \text{VOLTS} \times \text{P.F.}}{431}$ FIELD HP = INPUT HP X MTR. EFF OVERALL EFF = $\frac{\text{TOTAL HEAD}}{\text{INPUT H.P.}} \times \frac{\text{GPM}}{3960}$ PUMP EFF = $\frac{\text{OVERALL EFF}}{\text{MOTOR EFF}}$ K = $\frac{\text{JOB RPM}}{\text{TEST RPM}}$

CONDITION POINT: 13888 GPM @ 191 T.D.H. @ 890 RPM

NOTES: BAROMETRIC PRESSURE = 30.09 AMBIENT TEMP = 49 WATER TEMP = 80

TESTED BY: DATE:

WITNESSED BY: DATE: 1/27/05 PAGE 1 OF 1

TEST EQUIPMENT

DESCRIP	EQUIP NO	CALIB	DUE DATE
100#	TL/1200	1-20-05	2-20-05
300#	TL/1515	1-20-05	2-20-05
POWERMETER	TL/3000	5-29-04	5-29-05
AIR PRP	TL/2002	SELF CAL	SELF CAL

TL-002HO

U.S. ELECTRICAL MOTORS
DIVISION OF EMERSON ELECTRIC CO.
8100 WEST FLORISSANT AVE.
P.O. BOX 3946 * BLDG. K * ST. LOUIS, MO 63136
FAX (314) 553-1101

DATE: 8/15/02

P.O. NO.: 163079
USEM Order/Line NO.: 1052284 SO 100

TO: Floway Pumps
2494 Railroad Avenue
PO Box 164
Fresno, CA, 93706
ATTN: DICK FORNEY

Model Number: NA
Catalog Number: NA
Titan VSS-HT Weather Protected
CONF,MOTOR,TITAN VSS-HT

REVISIONS:
ADD WDG/BRG RTD
8/13/02

MARKS: PO 163079,CO 47847-16 , HIGH SERVICE 08-P-01,02,03,04

ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY US ELECTRICAL MOTORS.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Features:

```
Horsepower ............... 00800.00~00000.00 ~ KW: 596.8
Enclosure ................ WPI
Poles .................... 08~00 ~ RPM: 900~0
Frame Size ............... 6810~P
Phase/Frequency/Voltage.. 3~060~4160 ~ Form Wound
Service Factor ........... 1.15
Insulation Class ........ Class "F" ~ Insulife 5000
Altitude In Feet (Max) .. 3300 Ft.(1000 M)
Ambient In Degree C (Max) +40 C
Efficiency Class ........ Premium Efficiency
Application ............. Centrifugal Pump
Customer Part Number .... 47847-16
Base Diameter (Inches) ....... 30.5
Non-Reverse Ratchet
Pricebook Thrust Value (lbs).. 15300
Customer Down Thrust (lbs) ... 16508
Customer Shutoff Thrust (lbs).
Up Thrust (lbs) ..............
"AK" Dimension (Inches).. NA
Shaft Dimensions:~U=3.875 ~ AH/V=7.500
KEYWAY=1.000 ~ ES=5.500
Temperature Rise (Sine Wave): "B" Rise @ 1.0 SF (Resist)
Starting Method ......... Direct-On-Line Start
Duty Cycle .............. Continuous Duty
Load Inertia (lb-ft2): NEMA ~ NEMA Inertia: 15826.00 ~ 1.00
Number Of Starts Per Hour: NEMA
Motor Type Code ........... HVE4
Rotor Inertia (LB-FT²)       867. LB-FT²
Quantity of Bearings PE      1
Quantity of Bearings SE      1
Bearing Number PE            29338 EJ
Bearing Number SE            6226-J
```

U.S. ELECTRICAL MOTORS
DIVISION OF EMERSON ELECTRIC CO.
8100 WEST FLORISSANT AVE.
P.O. BOX 3946 * BLDG. K * ST. LOUIS, MO 63136
FAX (314) 553-1101

EMERSON

DATE: 8/15/02

P.O. NO.: 163079
USEM Order/Line NO.: 1052284 SO 100

TO: Floway Pumps
2494 Railroad Avenue
PO Box 164
Fresno, CA, 93706
ATTN: DICK FORNEY

Model Number: NA
Catalog Number: NA
Titan VSS-HT Weather Protected
CONF,MOTOR,TITAN VSS-HT

REVISIONS:
ADD WDG/BRG RTD
8/13/02

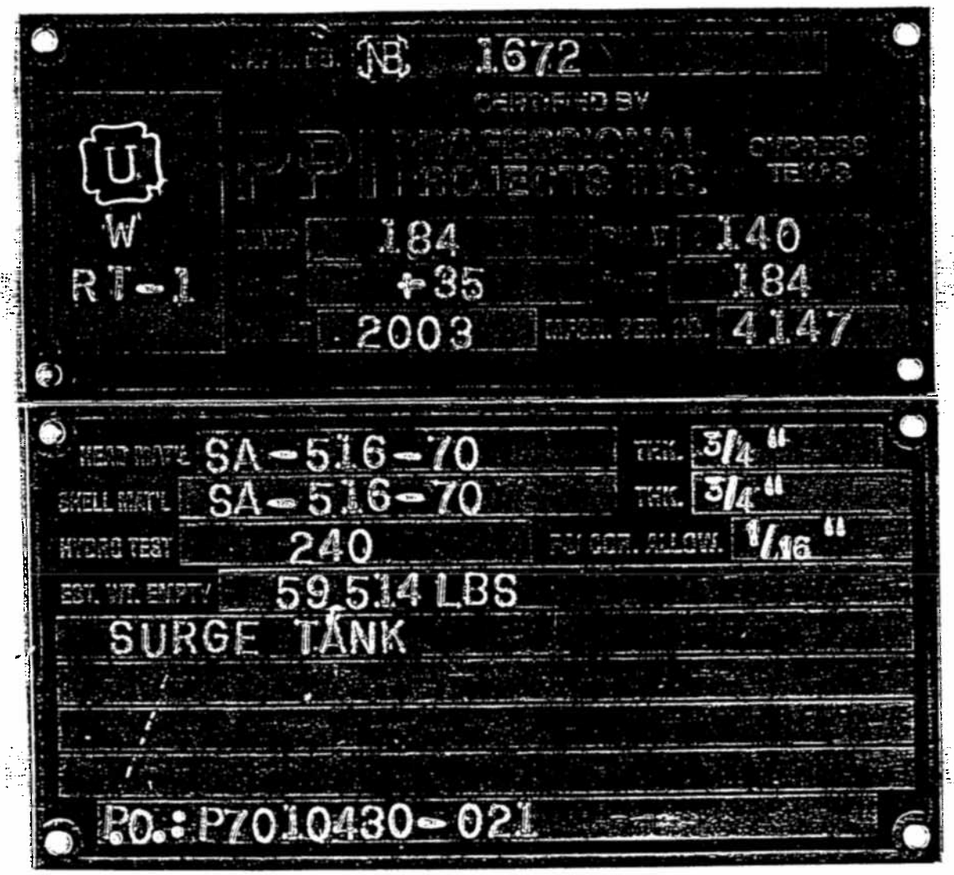
MARKS: PO 163079,CO 47847-16 , HIGH SERVICE 08-P-01,02,03,04

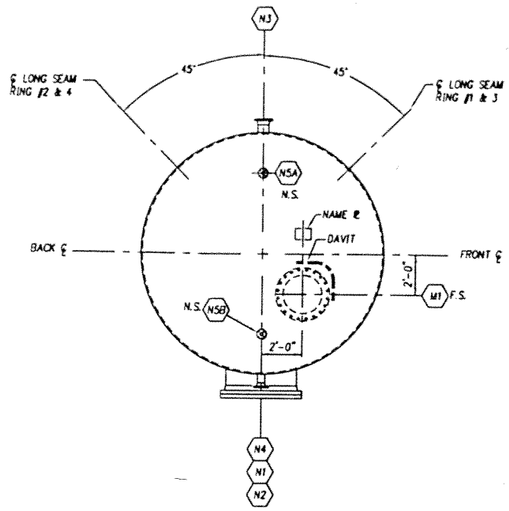
ALL DOCUMENTS HEREIN ARE CONSIDERED CERTIFIED BY US ELECTRICAL MOTORS.
THANK YOU FOR YOUR ORDER AND THE OPPORTUNITY TO SERVE YOU.

Accessories:
100,000 Hours B-10 Brg. Life
Counter CW Rotation FODE
300% Extra High Thrust
Ground Lug In Conduit Box
Insul. Bearing - Upper Bracket
115 Volt Space Heaters
Bearing RTD-100 Ohm,3 Lead
Both Bearings
Winding RTD's-100 Ohm,3 Lead
Q-1 Accessory Outlet Box ~ Same Side As Main O/B
1" NPT Conduit Opening
One Box with Terminal Board
Shipping Tag Information:
HI-SERVICE
08-P-01,02,03,04
Test Requirements:
Short Commer. Test - Unwit
Polarization Index - Unwit

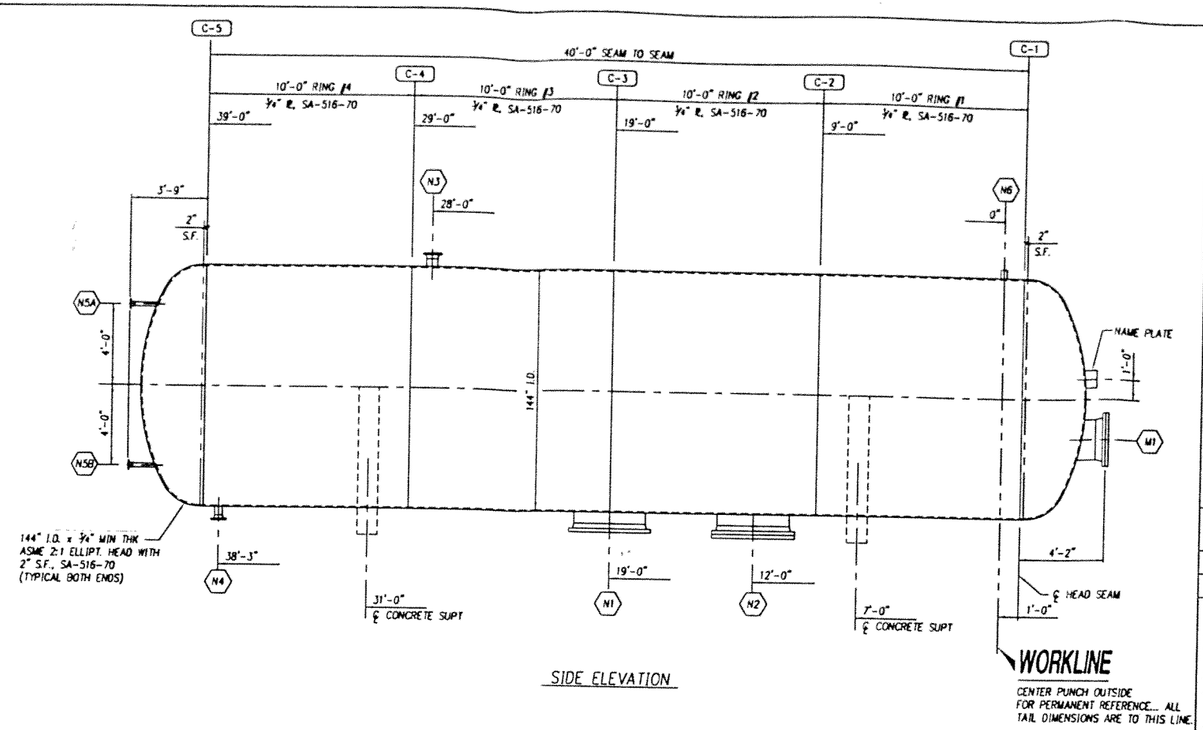
USE THE DATA PROVIDED BELOW TO SELECT THE APPROPRIATE DIMENSION PRINT

Horsepower	800
Pole(s)	08
Voltage(s)	4160
Frame Size	6810P
Shaft U Diameter	3.875
Outlet Box AF	10.94
Outlet Box AA	3.50
Accessory Outlet Box DM	1


NB 1672
CERTIFIED BY
PROFESSIONAL PRODUCTS INC.
CYPRESS TEXAS
U
W
RT-1
184
140
+35
184
2003
4147
HEAD MAT'L SA-516-70
THK. 3/4"
SHELL MAT'L SA-516-70
THK. 3/4"
HYDRO TEST 240
FU CORR. ALLOW. 1/16"
EST. WT. EMPTY 59 514 LBS
SURGE TANK
P.O.: P7010430-021



END ELEVATION



SIDE ELEVATION

DESIGN DATA

CONST. IN ACCORDANCE WITH 2001 EDITION OF ASME CODE SECT. VIII

DIV. 1 INCLUDING A02 ADDENDA MFG. SER NO. 4147

CODE STAMP U5 REQUIRED NAT'L BOARD 1672

DESIGN PRESS. (INT.) 181 P.S.I.G. TEMP. 140 °F

DESIGN PRESS. (EXT.) --- P.S.I.G. TEMP. --- °F

M.A.W.P. (DESIGN) 184 P.S.I.G AT 140 °F, LIMITED BY SHELL

MIN. DESIGN METAL TEMP. +33 °F @ 184 P.S.I.G.

SHOP HYDROSTATIC TEST @ 240 PSIG, HOLD (1) HOUR w/ PRESSURE CHART RECORDING

CORROSION ALLOW. SHELL 0.0625" HEADS 0.0625" NOZZ. 0.0625"

RADIOGRAPHY: SHELL LONG & GIRTH SEAMS - FULL UW-11(a)

HEAD/SHELL SEAMS-FULL UW-11(a)

P.W.H.T. NOT REQ'D

AUTHORIZED INSPECTION BY: ONE BEACON AMERICA INSURANCE CO

WEIGHT EMPTY 59,514 LBS FULL OF WATER 366,156 LBS

INSULATION THICK N/A

MATERIAL SPECIFICATIONS

SHELL	SA-516-70	FLANGES	SA-105 125-250 AARH
HEADS	SA-516-70	SUPPORTS	N/A
CPLGS.	SA-105	INTERNALS	N/A
STUDS	SA-193-B7	REINF. PADS	SA-516-70
NUTS	SA-194-2H	NOZZLE NECKS	SA-106B/SA-516-70

GASKETS SPIRAL WOUND GRAPHITE FILLER 316SS WINDINGS, C.S. OUTER RING

WELDING PROCEDURES

WPS No.	PQR NO.	PROCESS	JOINT	COMMENTS
148	148-1	GMAW FCAW	NOZZLES & ATTACH	
150	150-1	GMAW, FCAW SAW	ROUND & LONG SMS	

COATING REQUIREMENTS (EXTERNAL)

SYSTEM 2
SURFACE PREPARATION: PER SSPC-SP6
1) PRIMER: AMERON DIMETCOTE 21-5 OR 21-9 TO 3 MILS D.F.T.
2) MID COAT: AMERON 385 TO 4 MILS D.F.T.
3) FINISH: AMERON AMERSHIELD TO 3 MILS D.F.T.

COATING REQUIREMENTS (INTERNAL)

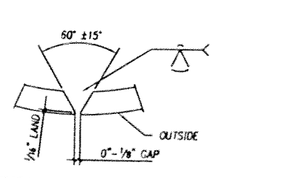
SYSTEM 100
SURFACE PREPARATION: PER SSPC-SP6
1) PRIMER: AMERON 39 AMINE-CURED EPOXY TO 16 MILS D.F.T.

SHIPPING PREPARATION

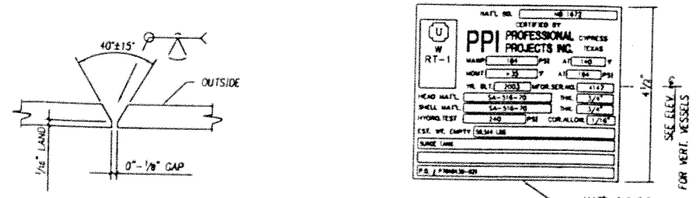
A) ALL FLANGE FACES SHALL BE CLEANED AND COVERED FOR SHIPMENT WITH 1/2" PLYWOOD, HELD IN PLACE BY A MINIMUM OF (4) BOLTS.

B) APPLY A SUITABLE RUST PREVENTATIVE TO GASKET SURFACES.

C) ALL WEEP HOLES SHALL BE PLUGGED WITH STIFF GREASE.



TYPICAL LG. SEAM DETAIL



NAME PLATE FACSIMILE & BRACKET DETAILS

ONE (1) REQUIRED

SHELL ROUND SEAM DETAIL

MK. NO.	QUANT.	SIZE	RTG.	TYPE	SERVICE
M1	ONE	24"	150#	R.F.	MANWAY W/DAVIT
N6	ONE	1"	6000#	CPLG	AIR LINE
N5A/B	TWO	2"	150#	F.F.	LEVEL GAUGE
N4	ONE	4"	150#	R.F.	DRAIN
N3	ONE	6"	150#	R.F.	VACUUM VALVE
N2	ONE	42"	150#	R.F.	OUTLET WITH BLIND
N1	ONE	42"	150#	R.F.	INLET

2	REVISED AS BUILT	MAK	5/7/03
1	ISSUED FOR CONSTRUCTION	MAK	1/17/03
0	ISSUED FOR CUSTOMER APPROVAL	MAK	12/16/02

CERTIFIED FOR CONSTRUCTION
BY _____ DATE _____

FILE NAME: 4147-1
PLOT DATE: 5/7/03
PLOT TIME: 3:00
BY: MAK

PPI Professional Projects, Inc.
P.O. BOX 618 (18115 TELGE RD.) CYPRESS, TEXAS 77429

TITLE
144" I.D. x 40'-0" SM/SM
ITEM: SURGE TANK
ELEVATIONS & GENERAL NOTES

CUSTOMER: MWH CONSTRUCTORS

CUSTOMER P.O. NO.: P70104.30-021

PPI NO.: 2883

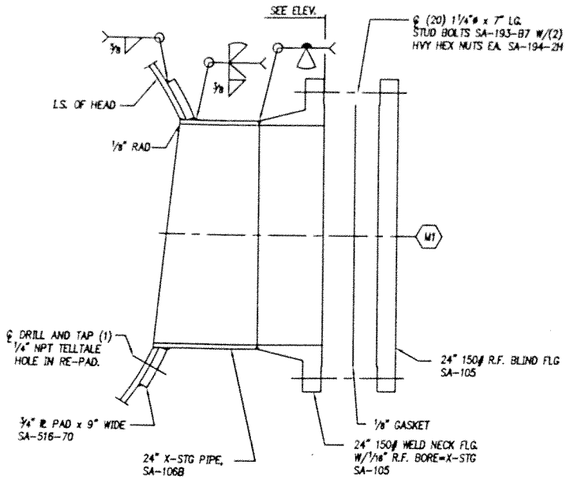
DRAWN: M. KING DATE: 12/16/02

CHECKED: DATE:

DRAWING NO.: S/O 4147

SHEET NUMBER: 1

REVISION NO.: 2



DETAIL OF 24" 150# MANWAY MK "M1"

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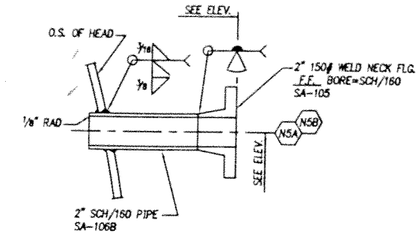

DETAIL OF 2" 150# NOZZLES MK "N5A & N5B"

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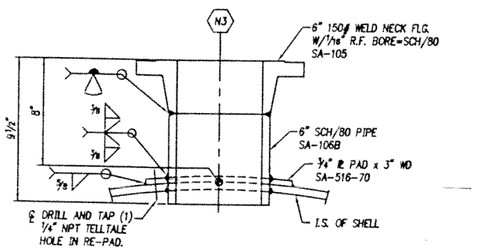

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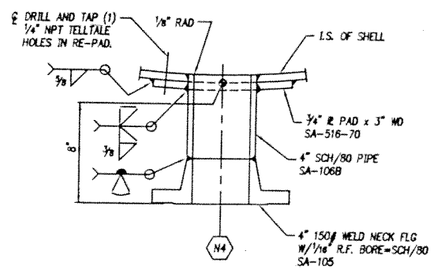

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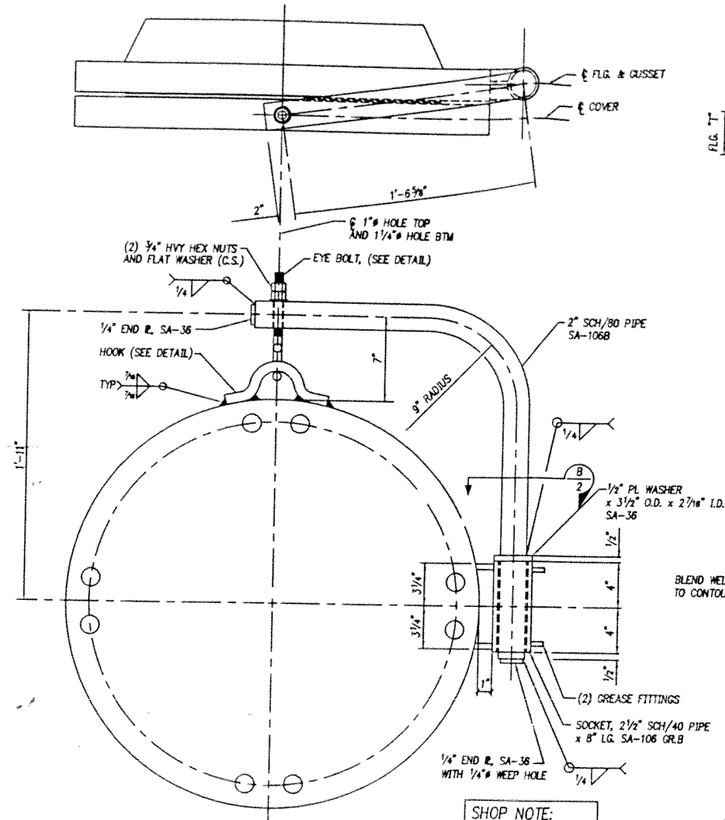
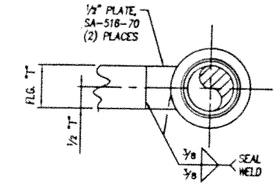


DETAIL OF 24" 150# MANHOLE DAVIT

ONE (1) REQ'D FOR MK "M1"

SHOP NOTE:
SEE SHEET #1 FOR TRUE DAVIT ORIENTATIONS.



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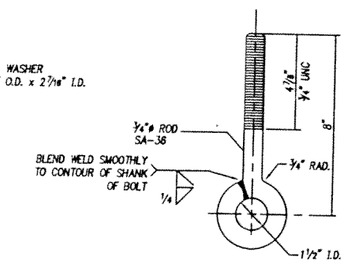

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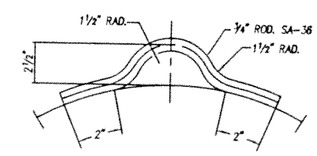

HOOK DETAIL

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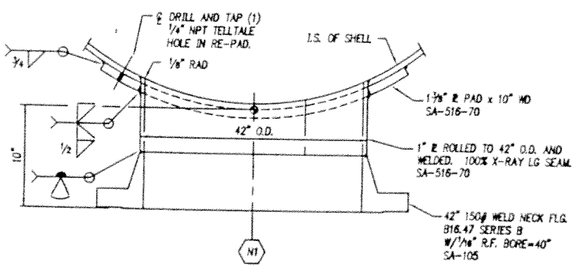

DETAIL OF 42" 150# NOZZLE MK "N1"

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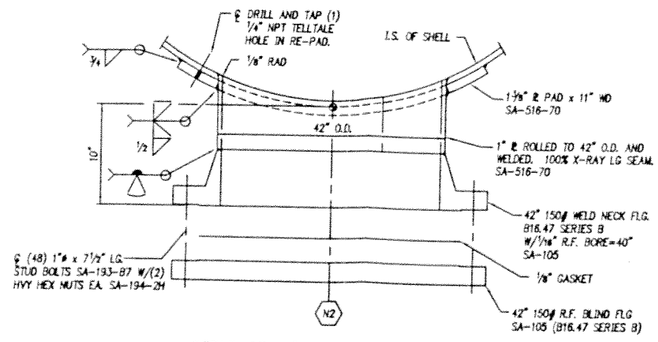

DETAIL OF 42" 150# NOZZLE MK "N2"

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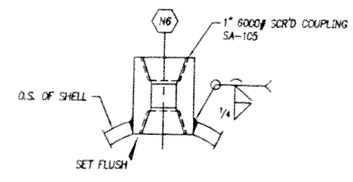

DETAIL OF COUPLING MK "N6"

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1	REVISED PER CUSTOMER APPROVAL	MAK	1/17/03
0	ISSUED FOR CUSTOMER APPROVAL	MAK	12/16/02

CERTIFIED FOR CONSTRUCTION
BY _____ DATE _____

FILE NAME: 4147-2
PLOT DATE: 5/7/03
PLOT TIME: 3:00
BY: MAK

PPI Professional Projects, Inc.
P.O. BOX 618 (18115 TELGE RD.) CYPRESS, TEXAS 77429

TITLE: 144" I.D. x 40'-0" SM/SM
ITEM: SURGE TANK
DETAILS

CUSTOMER: MWH CONSTRUCTORS

CUSTOMER P.O. NO.: P7010430-021
PPI NO.: 2883

DRAWN: M. KING DATE: 12/16/02
CHECKED: DATE:

DRAWING NO.: S/O 4147
SHEET NUMBER: 2
REVISION NO.: 2

Appendix B

Model Exhibits and Schematics

Index

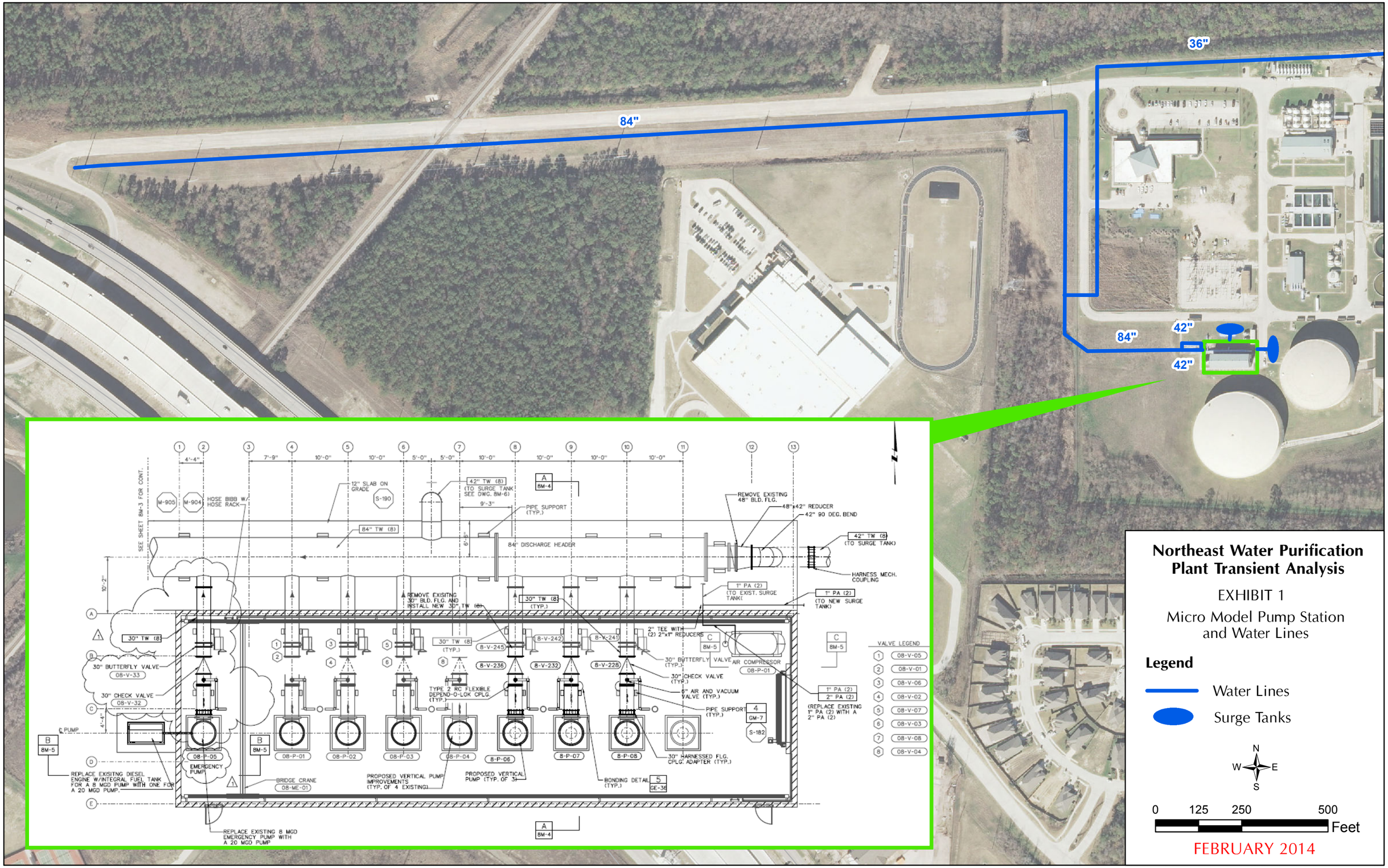
Exhibit 1 Micro Model Pump Station and Water Lines

Exhibit 2 Original Demand Set – Macro Model Water Lines and Theoretical Demands

Exhibit 3 Macro Model Water Lines and Revised Theoretical Demands

Exhibit 4 NEWPP Micro Model Schematic

Exhibit 5 NEWPP Macro Model Schematic



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Date: 2/20/2014

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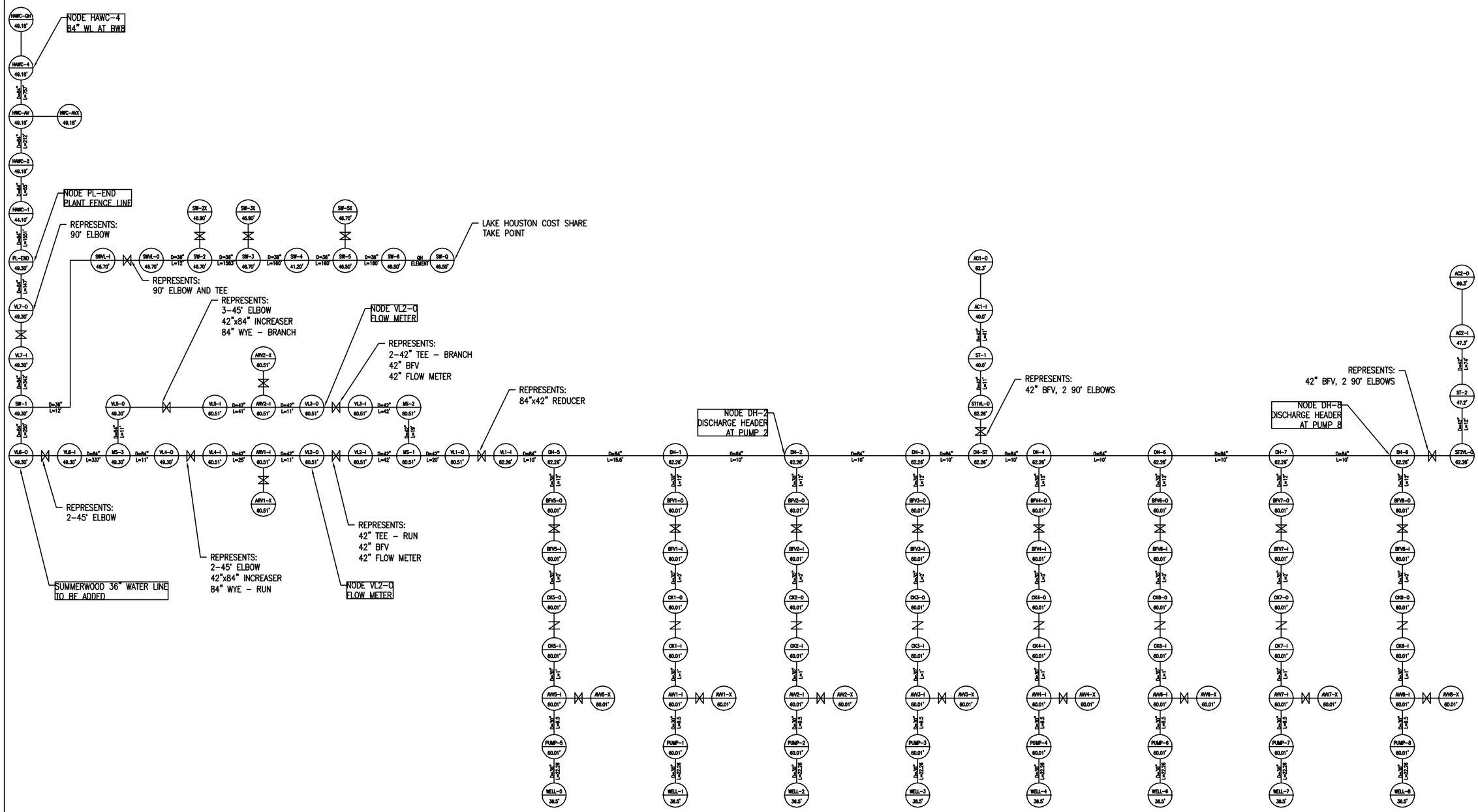
Date: 2/20/2014

Document Path: L:\130-10531-000\9-0-LIQT\GIS\MXD\Revised Demand Set Exhibit.mxd
Date: 2/20/2014

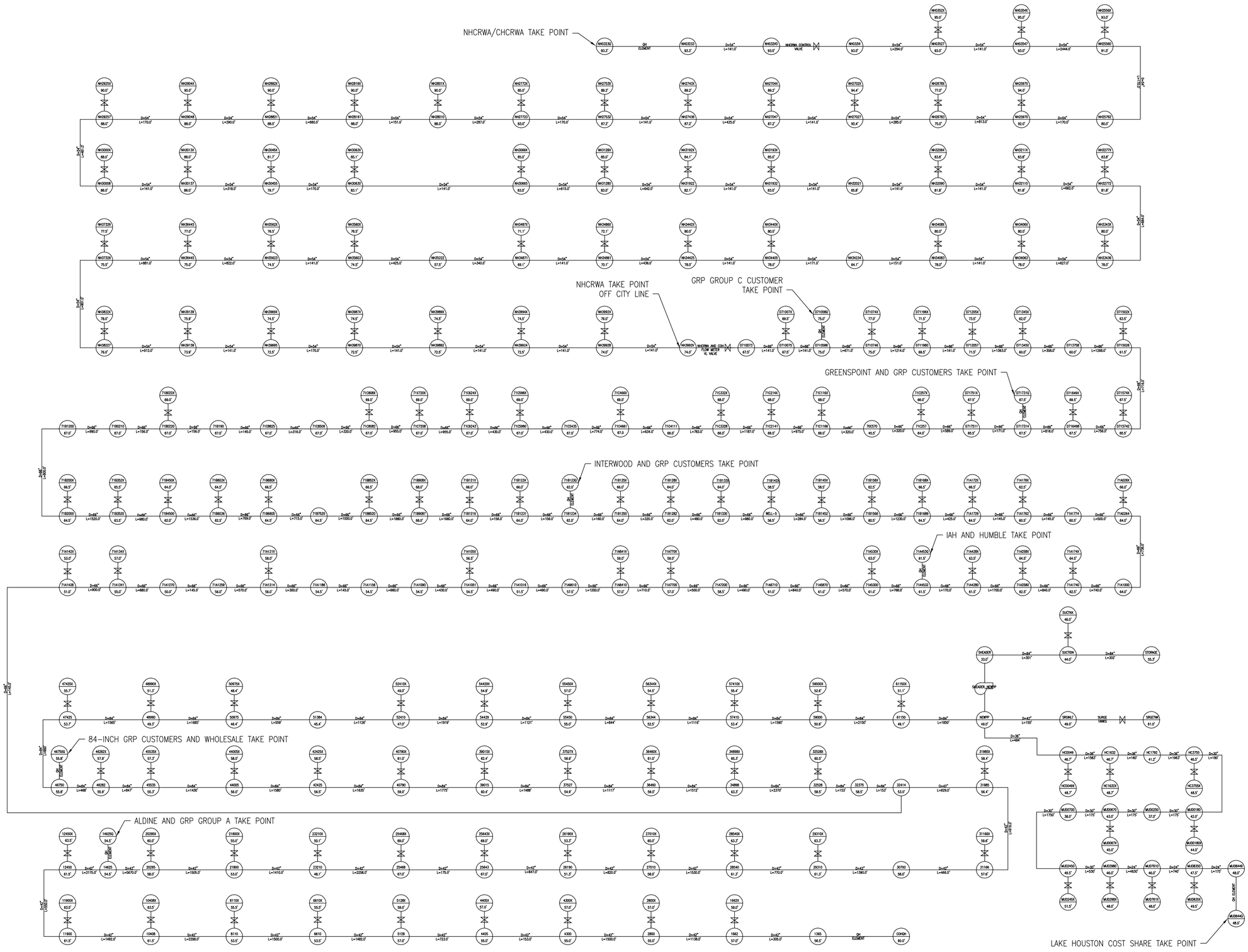
JANUARY 2014



NORTHEAST WATER PURIFICATION PLANT IMPROVEMENTS TRANSIENT ANALYSIS
WBS NO. S-000066-0012-3

EXHIBIT 4
NEWPP MICRO MODEL SCHEMATIC

JANUARY 2014



NORTHEAST WATER PURIFICATION PLANT IMPROVEMENTS TRANSIENT ANALYSIS
WBS NO. S-000066-0012-3

EXHIBIT 5
NEWPP MACRO MODEL SCHEMATIC

Appendix C

NHCRWA Valve Information

Index

Stealth Energy Dissipating Valve Information

Pratt Sleeve Valve Information

Summary of Surge Relief Valve Conversations with Fred Peirce, Senior Engineer GA Industries, LLC

Golden Anderson Surge Relief Valve Information

EST. 1991

STEALTH

INTERNATIONAL INC

"THE APPLICATION SOLUTION COMPANY"

The BLUE CRUDE VALVE® for H_2O

ENERGY DISSIPATING VALVES

100MM (4 INCH) – 3000MM (120 INCH)

Stealth International Inc.

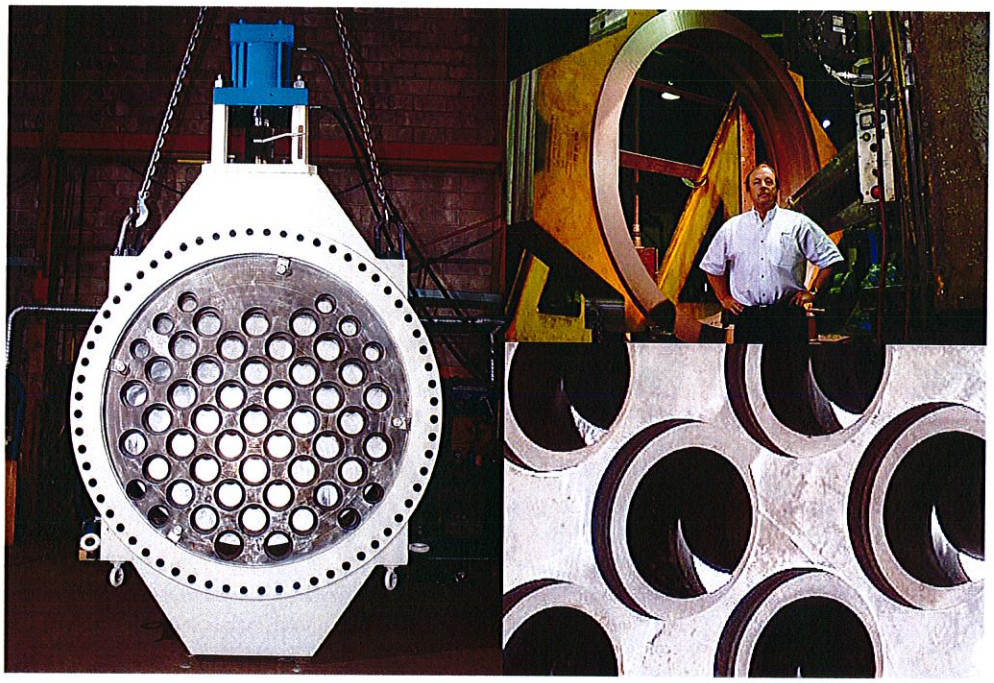
Stealth IBC Energy Dissipating Valve

Stealth Valve & Controls Ltd.

Engineered by Stealth Valve & Controls Ltd. and **Manufactured in Canada**

Patents Incorporated

- Stealth Packing Device – **6561517**
- Stealth Bi-Directional Adjustable Energy Dissipating Head Loss Valve – **6886595**



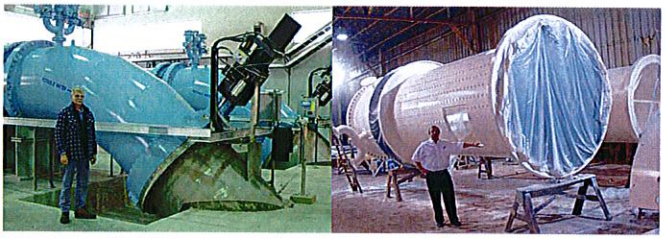
FEATURES

STEALTH – First to Develop and Incorporate

- **TAPER RINGS** – suitable for bi-directional flow capabilities
- **LOWER STEMS** – for horizontal mounting and linear stability
- **DI-ELECTRIC LINKS** – anti-corrosion feature for disassembly advantages
- **PACKING** – blow out proof self adjusting packing system
- **BEARING & SEALS** – stainless steel housed bearing and seal journals

Also Available

Piping Systems and Diffusers



Fixed ED Heads

sales@stealthvalve.com • **STEALTH INTERNATIONAL INC** • www.stealthvalve.com

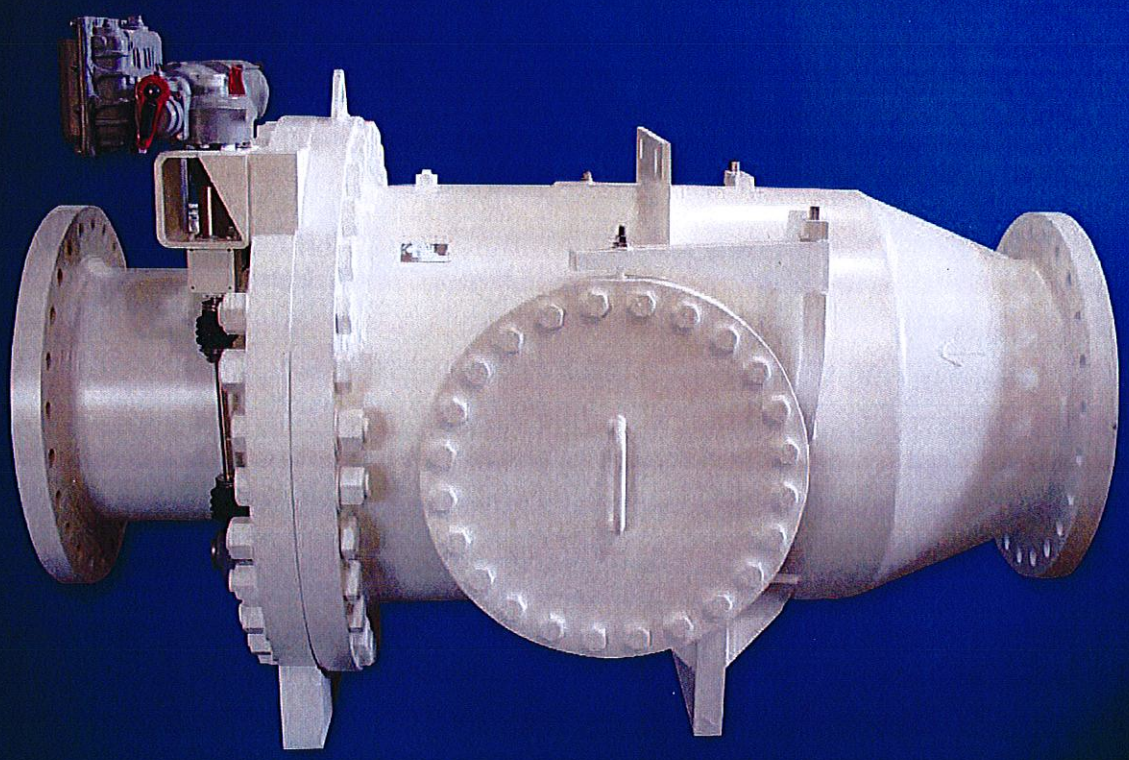
ONTARIO – 1273 North Service Road East, Unit F7, Oakville ON L6H 1A7 – TEL 905 845 4500 • FAX 905 845 4505
BRITISH COLUMBIA – TEL 604 922 1855 • FAX 604 922 1355

PRATT

Henry Pratt Company

Sleeve Valves

Energy Dissipaters



Valves for the 21st Century

Since 1901

PRATT

A Tradition of Excellence

With the development of the first rubber seated butterfly valve more than 70 years ago, the Henry Pratt Company became a trusted name in the flow control industry, setting the standard for product quality and customer service. Today Pratt provides the following range of superior products to the water, wastewater and power generation industries.

Butterfly Valves: from 3" to 162"

Rectangular Valves: 1' x 1' to 14' x 16'

Ball Valves —
Rubber Seated: from 4" to 60"
Metal Seated: from 6" to 48"

Plug Valves: from 1/2" to 36", 3 ways

Hydraulic Control Systems

Valve Controls

Energy Dissipating Valves and Fixed Energy Dissipaters

Cone Valves

Check Valves

A Commitment to Meeting The Customers' Needs

Henry Pratt valves represent a long-term commitment to both the customer and to a tradition of product excellence. This commitment is evident in the number of innovations we have brought to the industries we serve. In fact, the Henry Pratt Company was the first to introduce many of the flow control products in use today, including the first rubber seated butterfly valve, one of the first nuclear N-Stamp valves, and the bonded seat butterfly valve.

Innovative Products For Unique Applications

Though many of the standard valves we produce are used in water filtration and distribution applications, Pratt has built a reputation on the ability to develop specialized products that help customers to meet their individual operational challenges.

Creative Engineering for Fluid Systems

Pratt's ability to provide practical solutions to complex issues is demonstrated by the following case histories.

Earthquake Proof Valves

Pratt designed and manufactured hydraulically actuated valves for a water storage application so that the valves would automatically operate in the event of earthquakes. This lead to the development of a valve that will withstand forces of up to 6g's.

Custom Actuation/ Isolation Valves

Pratt designed and manufactured valves that would isolate a working chamber in the event of a nuclear emergency during the decommissioning of armed nuclear warheads. The valves were able to close in a millisecond using specially designed Pratt electro-pneumatic actuators.

Valves Designed for Harsh Environments

Pratt designed and manufactured a 144" diameter butterfly valve for the emergency cooling system at a jet engine test facility. The valve was designed to supply water to help dissipate the tremendous heat generated by the engines during testing.

PRATT
Henry Pratt Company

Through experience, commitment and creative engineering, Pratt is uniquely suited to provide superior products for our customers' special needs. For more information, contact our corporate headquarters in Aurora, Illinois.

PRATT
Henry Pratt Company

401 South Highland Avenue
Aurora, Illinois 60506-5563
www.henrypratt.com
phone: 630.844.4000
fax: 630.844.4160
toll free: 877.436.7977

SLEEVE VALVES

TABLE OF CONTENTS

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PRECISION FLOW CONTROL 2
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SLEEVE VALVE APPLICATIONS 3
ENERGY DISSIPATER DEVICE MODEL 211 4
MODEL 711 VALVE SPECIFICATIONS 4
SLEEVE VALVE SIZING CHART 5
SLEEVE VALVE ED DETERMINATION CHART 6
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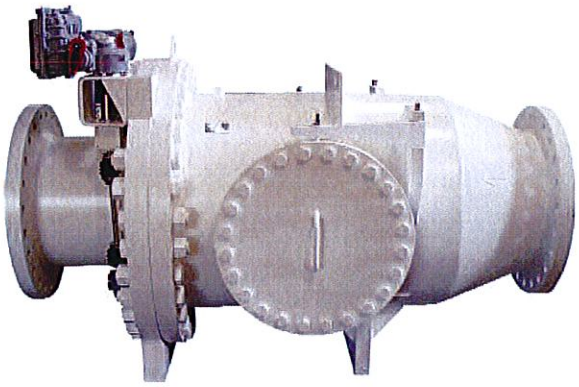
Introduction to Energy Dissipating Valves



Over the years, Pratt has maintained a commitment to product innovation by designing water control valves that improve our clients' processes and reduce their operation and maintenance costs. Our products are developed to meet and surpass even the most difficult specifications.

By adding sleeve valves, fixed cone valves, and energy dissipaters to our product line, Pratt continues to expand our offering to those customers who require specialty valves for applications where there is zero or low back pressure, cavitation or high flow rates.

Scope of the Line: Model 711 Axial Flow Multijet Sleeve Valve

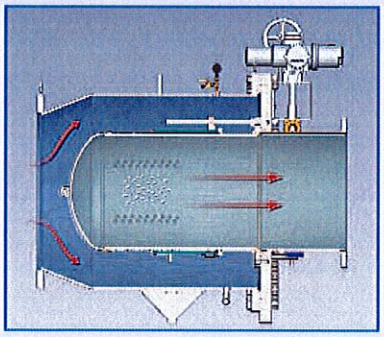
Water jets striking each other instead of the valve walls

- Available in sizes 12 inches and larger
- Fabricated steel construction
- 304 or 316 stainless steel sleeve
- Tapered radial nozzles
- Stainless steel drive screws
- Stainless steel gate with Nitronic 60 inserts

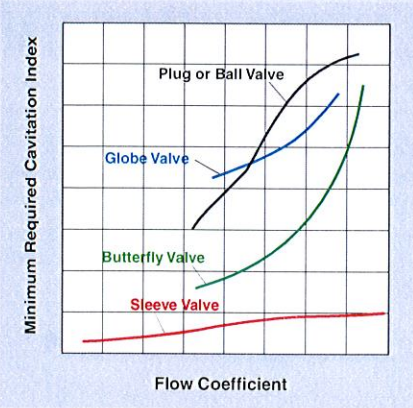
Nozzle pattern on the valve sleeve

Cavitation Control Advantage

The Model 711 Sleeve Valve is used to reduce and regulate pressure and control flow. Designed specifically to dissipate energy, the Model 711 controls the point of cavitation, but does not eliminate cavitation completely. The stainless steel sleeve and innovative nozzle pattern balance the fluid forces in the valve. The water jets strike each other instead of the valve walls preventing damage.



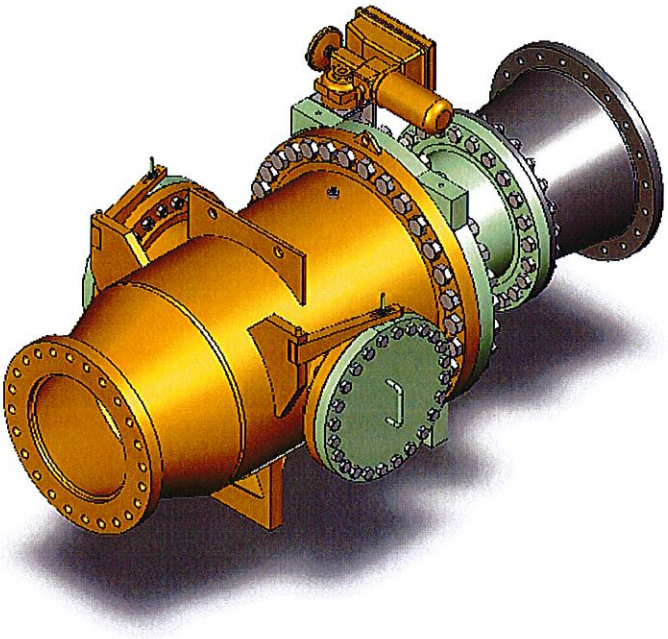
Model 711 Cross Section

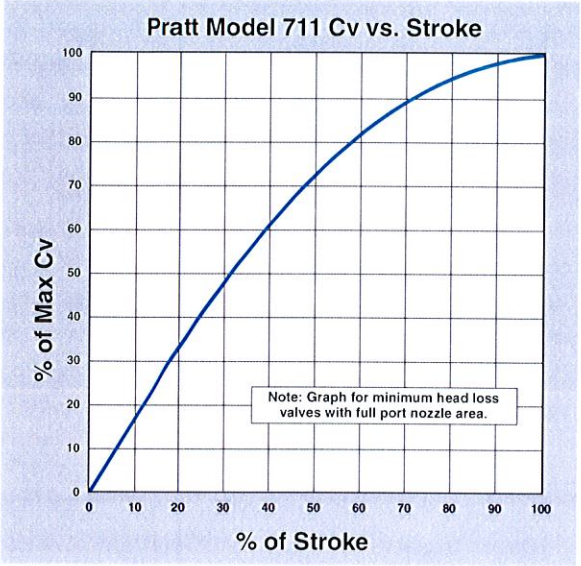


Cavitation Index Curve

Precision Flow Control

The Model 711 sleeve valve provides a flow coefficient with a nearly constant rate of change, allowing precise flow control over the entire stroke of the valve. The chart below illustrates the near linear flow characteristic of the Pratt sleeve valve.





Pratt Model 711 Cv vs. Stroke

Features and Benefits: Model 711 Sleeve Valve

Feature	Benefit
External seat on sleeve	• Provides drip tight shut off
Opposing tapered nozzle pattern	• Balances the fluid forces and minimizes vibration • Water flows through the nozzles and dissipates energy
Linear flow pattern	• Allows precise flow control over the stroke of the valve
Large access ports	• Maintenance can be performed while the valve is in line

Sleeve Valve Applications

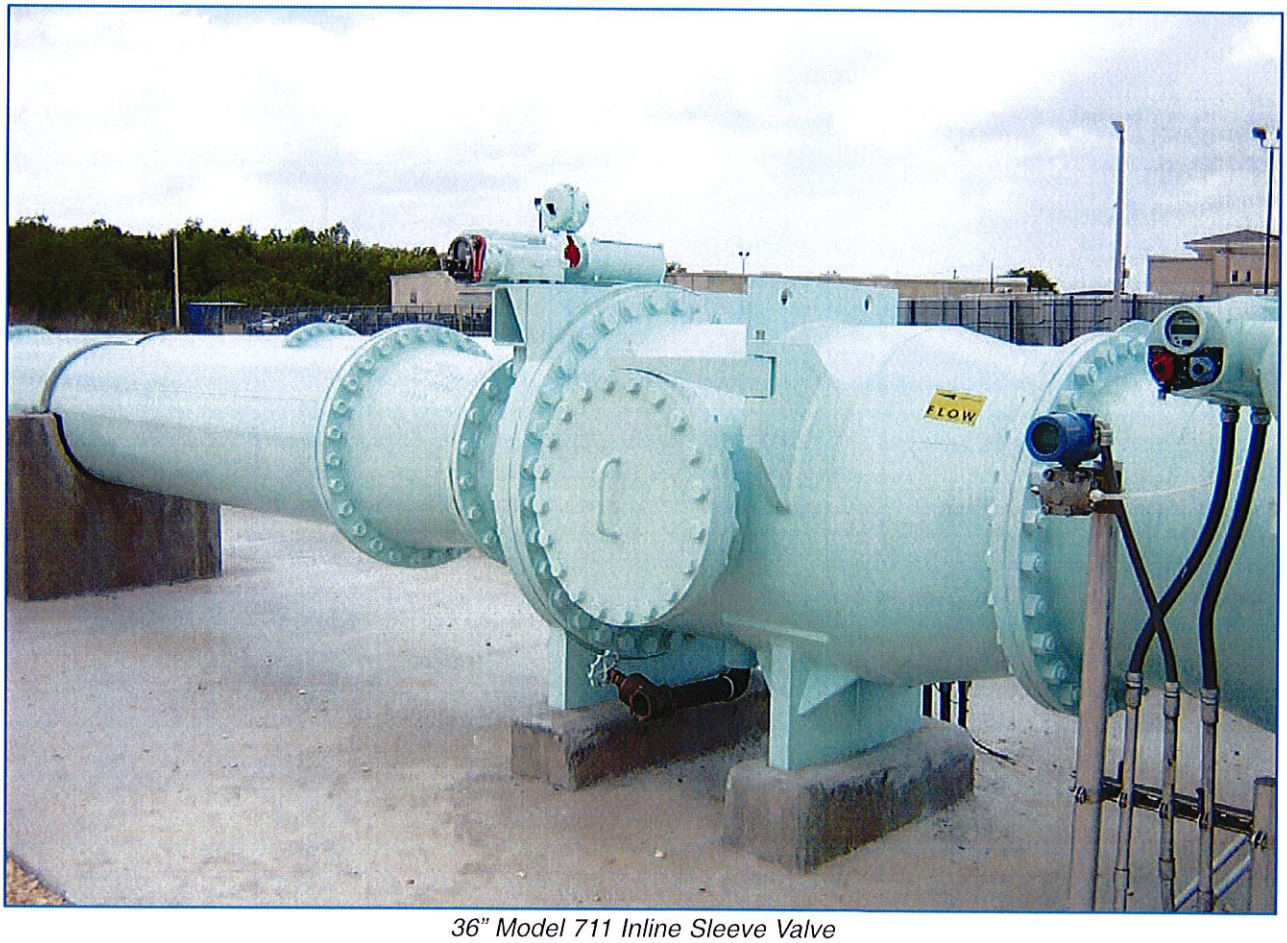
Reservoir Discharge
Pratt sleeve valves are used to control flow and dissipate excess energy from a reservoir outlet. Commonly used in areas with a high pressure drop, the sleeve valve can discharge to the atmosphere, or to a submerged outlet in a downstream creek.

Pump Control
Sleeve valves can be designed to have lower pressure drops than other types of control valves. Because the valve has a near linear flow characteristic, it will cycle less often thus minimizing energy loss and reducing operational costs over the life of the valve.

Pressure Regulation
A sleeve valve can be used to reduce pressure from a high pressure supply to a lower pressure distribution zone. Typically a SCADA system controls the valve position.

Turbine Bypass
When a valve is needed to bypass an energy recovery turbine, a sleeve valve can minimize upstream and downstream pressure surges by slowly opening and closing in proportion with the turbine.

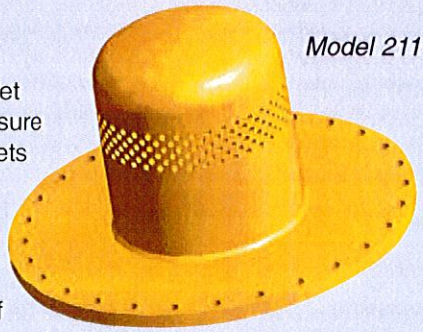
Tank Level Control
Sleeve valves are ideal to control the water level in a distribution system storage tank in potable water applications.



36" Model 711 Inline Sleeve Valve

Energy Dissipater Device

The energy dissipater device uses the same technology as the Multi-Jet Sleeve Valve. The energy dissipating mechanism forces the high pressure water through specially tapered nozzles that cause the water to form jets which impact each other in the center of the sleeve, providing energy dissipation with smooth operation.



Model 211

Model 211 Inline Fixed Sleeve Energy Dissipater

The Model 211 is used in transmission lines to restrict the discharge of fluid in a line break. They are also used to prevent excess velocities due to high line pressure.

Consult the factory for more information.

Suggested Specification for Model 711 Sleeve Valve

General

The valve shall be of the Axial Flow (Inline) Multi-Jet type Sleeve Valve as manufactured by the Henry Pratt Company or approved equal.

Design

The valve shall be designed to operate throughout its flow range without damaging cavitation for the conditions specified. The design shall incorporate multiple tapered nozzles on the sleeve for controlling flow and reducing pressure. These nozzles shall be arranged in a pattern which effectively directs the water streams to collide at the center of the downstream discharge pipe. The valve shall be capable of regulating flow by the linear movement of the sleeve gate which exposes the required amount of nozzles to achieve the correct flow rate. Valves shall be capable of dissipating energy thus enabling them to be opened against high differential head without damaging the seals.

Valve Body

The valve body shall be flanged on both the upstream and downstream ends conforming to applicable standards for bolting into the system conduit. The body section and flanges shall be carbon steel or other specified materials. The body shall have an integral clean out port, sized as required and situated in line with the sleeve for debris removal. Lifting eyes should also be attached to the body for ease of installation.

Sleeve

The sleeve shall be constructed of 304 or 316 stainless steel which shall contain the tapered nozzles. The size and quantity of the nozzles shall be determined by the flow and pressure requirements to meet the application for which it is intended.

Sleeve Gate

The sleeve gate shall be manufactured of stainless steel 304 with Nitronic 60 inserts, providing long life, non-galling operation.

Actuators

The sleeve valve shall be capable of being operated by pneumatic or hydraulic cylinders, electric motor actuators or manual gear actuators.

Testing

The valve shall be hydrostatically tested in the open position at a pressure equal to two times the working pressure for a period of not less than 30 minutes. A seat leak test shall be performed at the working pressure with the valve in the closed position, for a minimum of 15 minutes. The valve shall be cycled from closed to open three times for operational testing.

Options

Isolation valves are recommended for all sleeve valves so that debris removal can be achieved. Considerations should be given to placement of isolation valves if not full port. Consult factory for recommendations.

SLEEVE VALVE SIZING

THE STEPS:

See examples last page of brochure.

1. Based on the site specific conditions for the application being considered determine: 1) the required maximum flow rate (Qmax), 2) the minimum dynamic inlet pressure (P1), at this flow rate, and 3) the outlet pressure (P2) required.
2. Using Table 1, pick the smallest sleeve size with an available flow rate that exceeds the (Qmax) flow rate required.
3. Next calculate the application Cv from (Qmax) and the application pressure differential (P1 – P2) determined in Step 1. (i.e. Cv = Qmax in gpm /√(P1-P2) in psi). For convenience use flow and pressure units that match those listed in Table 2. Finally, include a flow safety factor, thus the calculated application Cv x 1.2 provides the Cv required or Cv(reqd).
4. Using Table 2, check if the sleeve size chosen in Step 2 has an available Cv equal to or greater than Cv(reqd) calculated in Step 3. If so, your sleeve valve size has been determined. If not, choose a larger sleeve size that exceeds the Cv(reqd) value.
5. Check Table 3 to see if a second stage Energy Dissipater should be considered. For valves utilizing an additional Energy Dissipater, a Model 712 is provided. For less severe applications, a Model 711 is recommended.
6. Use Table 4 for Model 711 valves, and Tables 4 and 5 for Model 712 valve applications, to find the approximate laying length of the valve. Factors affecting the final laying length depend on the sleeve size vs. mating pipe size. A variety of body styles are shown in Table 4 to accommodate various valve installations.
7. Contact Henry Pratt Sales to optimize and verify your initial selection.

TABLE 1

Nominal Sleeve Diameter		Maximum Available Flow Rates				
in	mm	cfs	gpm	mgd	m3/s	l/s
12	300	25.1	11,310	16.2	0.71	711.8
14	350	34.2	15,394	22.1	0.97	968.8
16	400	44.7	20,106	28.9	1.27	1,265.4
18	450	56.5	25,447	36.5	1.60	1,601.5
20	500	69.8	31,416	45.1	1.98	1,977.1
24	600	100.5	45,239	65.0	2.85	2,847.0
30	750	157.1	70,686	101.5	4.45	4,448.5
36	900	226.2	101,788	146.2	6.41	6,405.8
42	1100	308.7	138,529	199.5	8.74	8,739.8
48	1200	402.1	180,956	259.9	11.39	11,388.2
54	1400	508.9	229,023	328.9	14.41	14,413.2
60	1500	628.3	282,744	406.1	17.79	17,794.0

TABLE 2

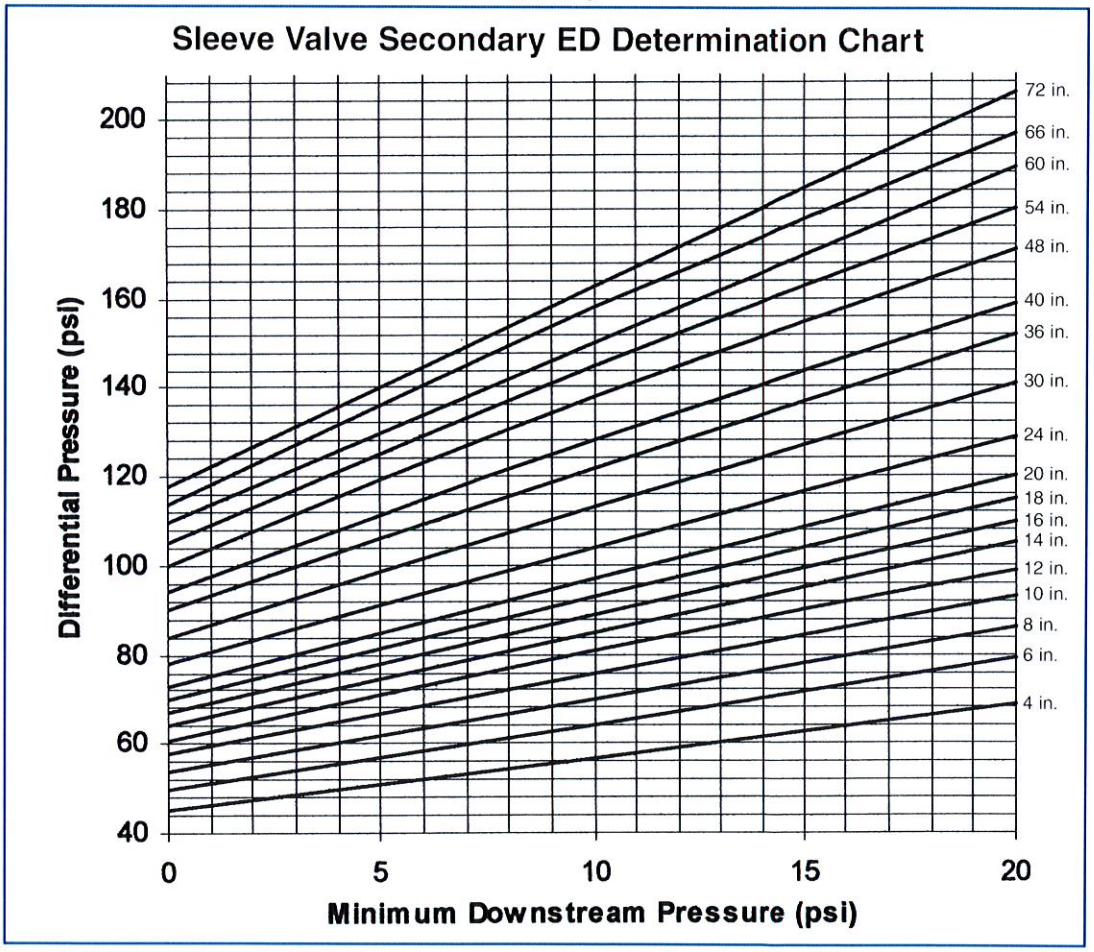
Nominal Sleeve Diameter		Maximum Available Flow Coefficients				
		cfs/√ft	Cv=gpm/√Δpsi	mgd/√Δpsi	$(m^3/s)/\sqrt{m}$	(l/s)/√m
12	300	3.97	2,717	3.91	0.20	204
14	350	5.41	3,698	5.33	0.28	277
16	400	7.06	4,830	6.96	0.36	362
18	450	8.94	6,113	8.80	0.46	458
20	500	11.03	7,547	10.87	0.57	566
24	600	15.89	10,868	15.65	0.82	815
30	750	24.83	16,981	24.45	1.27	1,274
36	900	35.75	24,453	35.21	1.83	1,834
42	1100	48.81	33,268	47.90	2.50	2,503
48	1200	63.56	43,472	62.60	3.26	3,260
54	1400	80.44	55,019	79.23	4.13	4,126
60	1500	99.31	67,925	97.81	5.09	5,094

Procedure for Secondary ED Determination

For some applications, a two stage valve will be needed. The Model 712 with the Energy Dissipater (ED) is the extreme application solution.

1. Choose a sleeve size (see sleeve valve sizing steps).
2. Using Table 3, find the intersection of the maximum differential pressure across valve at maximum flow rate and the minimum available downstream/back pressure for your application. If this point lies below the line for the sleeve size chosen, then no ED is required. If the point is above the line for the sleeve size chosen, then an ED may be required.
3. If the point is above the line for the sleeve chosen but the downstream pressure is above 20 psi an ED may not be required.
4. Contact the factory for a detailed analysis.

Table 3

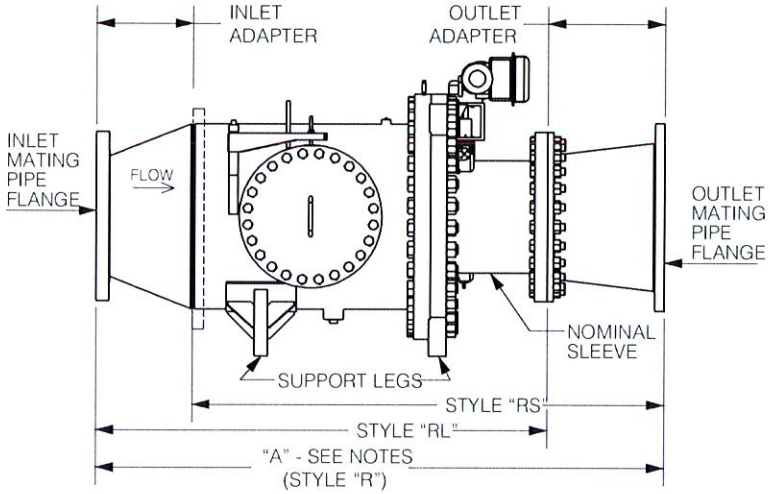


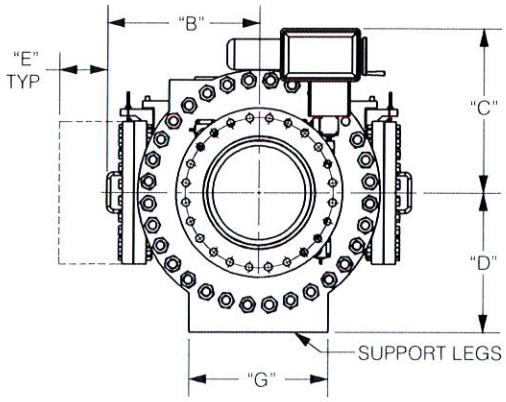
To determine the cavitation constant, use the following formula:

$$C = \frac{P_2 - P_V}{P_1 - P_2} = \frac{P_2 + 14.2}{\Delta P}$$

If $C \leq Ccr$, serious cavitation can occur.

C = Cavitation constant; dimensionless
Ccr = .15 to .25
P_1 = Upstream head; psi
P_2 = Downstream head; psi
ΔP = P_1-P_2 = Head loss across valve; psi
P_v = Adjusted water vapor pressure (-14.2 psi) at sea level





NOTES:
1. DIMENSIONS WILL VARY DEPENDING ON ACTUAL APPLICATION AND MATING PIPE SIZE.
2. MOTOR ACTUATED VALVE IS SHOWN AND RECOMMENDED, FOR OTHER ACTUATOR TYPES THE OVERALL VALVE LENGTH WILL INCREASE. CONTACT HENRY PRATT SALES.
3. THE TYPE 711 INLINE SLEEVE VALVE CAN BE FURNISHED IN 3 BODY STYLES DEPENDING ON THE MATING PIPE DIA. NOTE THAT BODY STYLE "R" DIM'S ARE SHOWN IN THE TABLE.
4. UPSTREAM AND DOWNSTREAM ISOLATION VALVES ARE RECOMMENDED. FOR PLACEMENT AND TYPE CONTACT HENRY PRATT SALES. DOWNSTREAM ISOLATION VALVE IF NOT FULL PORT SHOULD BE PLACED A MINIMUM OF 10-15 PIPE DIA'S DOWNSTREAM
5. ADEQUATE STRAIGHT INLET AND OUTLET PIPING SECTIONS ARE REQUIRED. KEEP PIPING ELBOWS, TEES, ETC. SUFFICIENT DISTANCE FROM VALVE. CONTACT HENRY PRATT SALES.

INLET/OUTLET ADAPTER NOTES
1. INLET ADAPTER LENGTH VARIES CONSIDERABLY BASED ON MATING PIPE TO SLEEVE RATIO. CONTACT HENRY PRATT SALES.
2. OUTLET ADAPTER LENGTH CAN BE ESTIMATED AT APPROXIMATE 1 OUTLET MATING PIPE DIA.

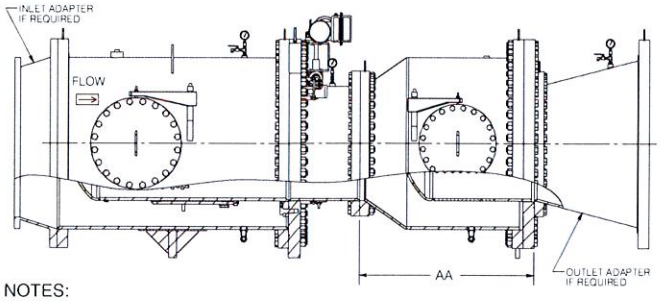
SLEEVE VALVE BODY STYLES
STYLE "R" = MATING PIPE AS NOTED.
STYLE "RL" = MATING PIPE AND SLEEVE SIZE EQUAL.
STYLE "RS" = MATING PIPE EXCEEDS TYPE R.

TABLE 4, Model 711 General Dimensions (Body Style "R")

STYLE "R" Mating Pipe Dia's	STYLE "RL" Mating Pipe Dia's	Nominal Sleeve Diameter		A SEE NOTE 1		B		C		D		E		G Weight		Estimated
SEE NOTE 1		IN	MM	IN	MM	IN	MM	IN	MM	IN	MM	IN	MM	IN	MM	Lbs.
14 to 20	12	12	300	85	2159	23	578	44	1111	20	502	27	686	18	506	7,500
16 to 24	14	14	350	90	2286	25	635	46	1168	22	559	27	686	20	507	7,800
18 to 24	16	16	400	94	2388	27	695	48	1229	24	619	27	686	22	508	8,200
20 to 30	18	18	450	110	2794	32	813	53	1346	29	737	32	813	24	584	8,500
24 to 36	20	20	500	115	2921	33	848	54	1381	30	772	32	813	26	635	8,700
30 to 36	24	24	600	125	3175	33	848	54	1381	30	772	32	813	30	762	9,000
36 to 48	30	30	750	150	3810	42	1070	63	1603	39	994	32	813	36	965	9,400
42 to 54	36	36	900	165	4191	46	1156	67	1689	43	1080	32	813	42	1143	10,500
48 to 60	42	42	1100	195	4953	49	1245	70	1778	46	1168	32	813	48	1346	12,000
54 to 66	48	48	1200	220	5588	52	1327	73	1861	49	1251	42	1067	54	1524	16,000
60 to 72	54	54	1400	240	6096	59	1495	80	2029	56	1419	42	1067	60	1727	20,000
72 to 96	60	60	1500	260	6604	62	1581	83	2115	59	1505	42	1067	66	1905	25,000

TABLE 5, Model 712 (Sleeve Valve with ED) (Add "AA" and "A" for overall length)

Minimum Upstream Pipe		Nominal ED Sleeve Diameter		ED Length AA	
in	mm	in	mm	in	mm
12	300	12	300	18	450
14	350	14	350	21	550
16	400	15	400	24	600
18	450	18	450	27	700
20	500	20	500	30	750
24	600	24	600	36	900
26	660	26	660	39	1000
30	800	30	800	45	1150
36	900	36	900	54	1400
42	1100	42	1100	63	1600
48	1200	48	1200	72	1850
54	1400	54	1400	81	2050
60	1500	60	1500	90	2300



NOTES:

1. THIS DIAGRAM SHOWS A VALVE REQUIRING AN ENERGY DISSIPATER (ED). THE ED IS TYPICALLY FITTED TO A STANDARD SLEEVE VALVE, OR CAN BE A SEPARATE DOWNSTREAM MODEL 211 UNIT. ADD THE ED LENGTH TO A STANDARD VALVE TO GET AN APPROXIMATE OVERALL VALVE LENGTH. NOTE THAT ACTUAL VALVE LAYING LENGTH WILL VARY DEPENDING ON WHICH STANDARD VALVE BODY STYLE IS USED AND PIPING INSTALLATION.
2. UPSTREAM AND DOWNSTREAM ISOLATION VALVES ARE RECOMMENDED. FOR PLACEMENT AND TYPE CONTACT HENRY PRATT SALES. DOWNSTREAM ISOLATION VALVE IF NOT FULL PORT SHOULD BE PLACED A MINIMUM OF 10-15 PIPE DIA'S DOWNSTREAM.
3. ADEQUATE STRAIGHT INLET AND OUTLET PIPING SECTIONS ARE REQUIRED. KEEP PIPING ELBOWS, TEES, ETC. SUFFICIENT DISTANCE FROM VALVE. CONTACT HENRY PRATT SALES.

Examples Sizing and Determining Model Number

Example 1: Known: A flow control valve is needed for the inlet of a treatment plant. The dynamic inlet head is 20 psi, the desired outlet pressure is 10 psi, a flow rate of 10 cfs is desired, a maximum velocity of 12 fps is allowed in the mating piping. Solution: Using 12 fps velocity, the size of the mating piping is found to be 12 inches. For the sleeve valve, checking available flow only per Table 1, an 8 inch sleeve is the smallest size exceeding the required flow. Next converting cfs to gpm flow units so that flow/pressure units match those in Table 2, Cv = (10 cfs x 450 gpm/cfs) / √(20psi-10psi) = 1423. Thus Cv(reqd) = 1423 x 1.2 = 1,707. Then using Table 2, the smallest sleeve with a Cv greater than Cv(reqd) is a 10 inch sleeve. Using the 10 inch sleeve size and checking Table 3, the maximum differential pressure is below the line for the 10 inch valve at the minimum down stream pressure, so no ED is required, thus a model 711. Use Table 4 to find the approximate dimensions of the valve. In this case the Model Number will be a Model 711 – 12x10x12 (Model No. - Inlet x Sleeve x Outlet).

Example 2: Known: A valve is needed to reduce the pressure of water being taken from a high elevation distribution system to a lower elevation distribution system. The dynamic inlet pressure at the sleeve valve will be 250 psi, the downstream pressure will be 0 psi because the valve will be filling a large trunk line to a ground reservoir a few feet below the valve vault, the desired flow rate is 45,000 gpm, the maximum velocity in the mating pipe is limited to 15 fps. Solution: Using 15 fps velocity, the size of the mating piping is found to be 36 inches. For the sleeve valve, checking available flow only per Table 1, a 24 inch sleeve is the smallest size exceeding the required flow. The calculated Cv is 45000gpm / √(250 psi – 0 psi) = 2846. Thus Cv(reqd) = 2846 x 1.2 = 3,415. Using Table 2, a 14 inch sleeve meets this requirement, however, the flow rate per Table 1 dictates a 24inch is needed, thus the larger of the two criteria must be used. Checking Table 3, with a 24 inch sleeve and a differential of 250 psi, a downstream pressure greater than 0 psi is needed. Therefore an additional second sleeve (ED) is needed, thus a model 712. Add the ED length from Table 5 to the valve length in Table 4 to get the overall valve length. In this case the Model Number will be a Model 712 – 36x24x36.

Example 3: Known: A valve is needed to by-pass a small energy recovery turbine. The dynamic inlet head is 130 psi, the outlet pressure is 10 psi, the maximum flow rate is 140 mgd. Mating pipes are going to be 36 inch. Based on maximum available flow rates in Table 1, a 36 inch sleeve can be used. The required Cv value is 140mgd / √(130 –10 psi) = 12.78. With the safety factor, Cv(reqd) = 12.78 x 1.2 = 15.34, and per Table 2 a 36 inch exceeds this. Checking Table 3, a 36 inch sleeve with 120 psi differential, requires a minimum downstream pressure of 9 psi. We have 10 psi indicating no ED is required, however, being so close to the boundary, a second energy dissipater (ED) would be recommended. Using Tables 4 & 5, the dimensions for the valve can be determined. The Model Number will be a Model 712 – 36x36x36.

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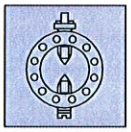
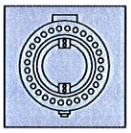
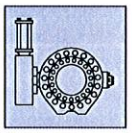
PRATT PRODUCT GUIDE


Model 2FII


Triton® XR70

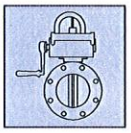
Triton® XL

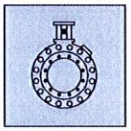
Rectangular

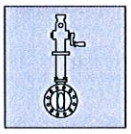

Rubber Seated Ball Valve

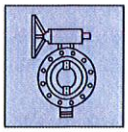
Groundhog® Valve

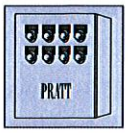
Monoflange MKII


Indicating Butterfly Valve UL & FM approved

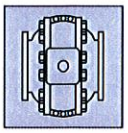

N-Stamp Nuclear Butterfly Valve

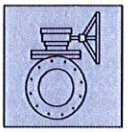

PIVA Post Indicating Valve Assembly UL & FM approved


Triton® HP250

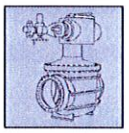


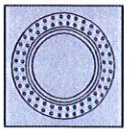
Control Systems

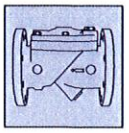

Metal Seated Ball Valve


Plug Valve

Tilting Disc Check Valve


Cone Valve


Sleeve Valve


Check Valve

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Summary of Surge Relief Valve Conversations with Fred Peirce, Senior Engineer GA Industries, LLC

LAN asked Golden Anderson for help sizing the surge relief valves. LAN provided GA with information from the model and the Scenario.

- The Scenario calls for a flow control valve closure on a 54-inch line with the user taking 45 MGD.
- With two 10-inch surge relief valves installed, each valve would relieve a maximum 14.5 MGD each. Two 10-inch surge relief valves keep the pressures within the design range.

Fred Peirce from GA responded with:

- The maximum flow velocity through a 10-inch surge relief valve is approximately 30 ft/sec (10.6 MGD). To relieve 29 MGD, it would take two 12-inch valves or three 10-inch valves to accommodate this total flow.
- The discharge from the relief valve is typically piped either to a pump suction well or suction tank. The discharge may be routed to a drainage ditch or holding pond. The design of the discharge (particularly if discharging into a ditch, stream or pond) must accommodate brief periods of high velocity discharge.

GA INDUSTRIES

Differential Piston Control Valves

Pressure, Level and Flow Control

VAG® Valve and Gate Group

GA INDUSTRIES

A Century of Experience

GA valves are known for long term reliability in the most demanding water and wastewater applications. Whether a simple check valve or a complex automatic control valve, each GA valve is built on over 100 years of design, manufacturing and application experience to ensure its dependability and superior performance.

Outstanding Technical Support

From the factory to the field, GA provides responsive and knowledgeable technical assistance and support. GA application engineers, and our team of trained and experienced sales representatives, work closely with designers to select the right valve from our broad product range to ensure the valve meets the system requirements. GA Industries is committed to serving our customers in all phases of the project.

Superior Quality

All GA valves are designed in accordance with AWWA and other industry standards and precision manufactured from the highest grade materials. Every valve is tested to ensure it meets our high standards and the latest industry requirements so you can be sure it will operate as expected from the minute it is put in service.

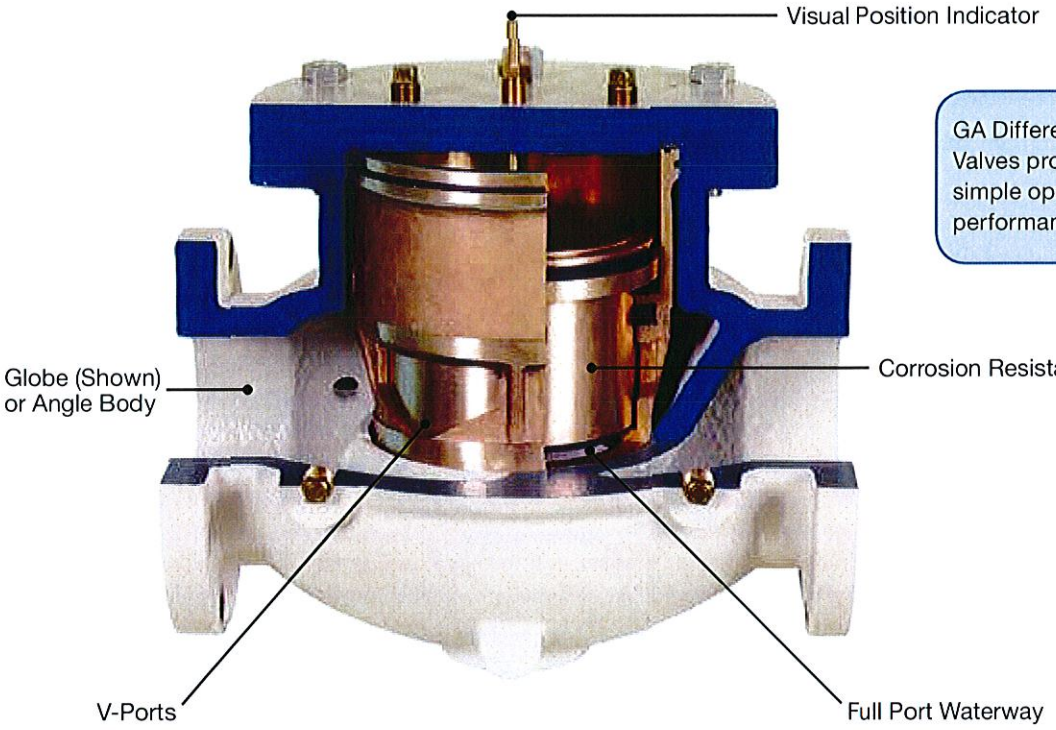
Comprehensive Product Range

We are continuously expanding and improving our product line to meet the ever-changing needs of the waterworks industry. From off-the-shelf standard butterfly and plug valves to sophisticated, highly engineered pump control, check and surge control valves, GA Industries offers one of the broadest ranges of valves specifically suited to the demanding needs of municipal waterworks. Please see the back cover for a complete listing of our product offering.

Differential Piston Control Valves

Pressure, Level and Flow Control

The GA Industries Differential Piston Control Valve is a heavy duty automatic water control valve. The rugged and versatile main valve construction is the heart of a countless number of pilot-operated control valve configurations designed to meet virtually any type of water pressure, flow, and level control requirement.



GA Differential Piston Control Valves provide superior design, simple operation, and maximum performance in water control.

Versatile Body Style

2" – 36" Heavy Duty Cast Iron Globe and Angle body, ANSI B16.1 Class 125 or 250 flanged.

Flow Efficient Full Port

The GA Differential Piston Control Valve's full port flow area provides low head loss in on/off applications, such as pump control, and the capacity to handle high flow in pressure reducing and other regulating applications.

Exclusive V-Port Design

Only the GA Differential Piston Valve provides the ideal combination of full port capacity and excellent low flow control. The long V-ports provide an ideal "throttling characteristic" by extending the controlling range over a large portion of the valve stroke for stable low flow control.

Cavitation Resistance

All throttling occurs through the long stationary V-ports that are located downstream of the seat, protecting critical seating surfaces from cavitation and wear.

Corrosion Resistant Materials

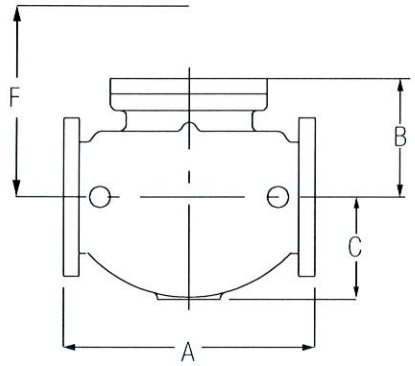
All critical internal components are made from corrosion resistant bronze for long term service.

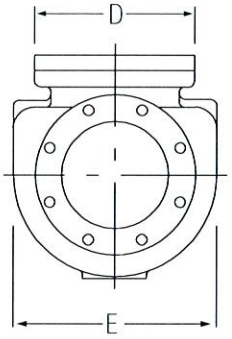
Visual Position Indicator

The standard visual position shows at a glance whether the valve is open or closed and can actuate electrical position switches for remote indication.

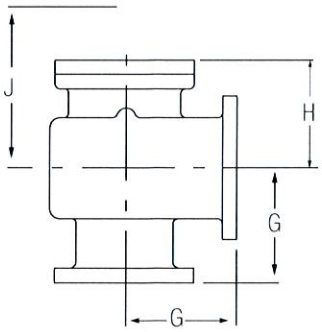
Long Term Service and Easy Maintenance

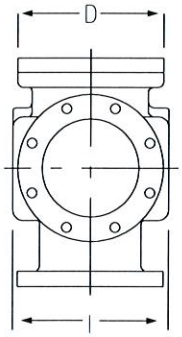
All parts are interchangeable between globe and angle body and removable through the top flange so the body stays in the line for all service. Many GA Differential Piston Valves have been in continuous service for 60+ years.





Globe Body





Angle Body

Dimensions (inches)

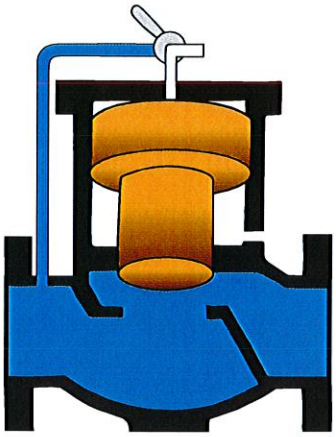
Size	2"	2 ½"	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"	30"	36"
A	9	12	12	13	18	24 ½	26	31	33	36	40	40	48	60	63
B	6 ⅝	6 ¾	6 ¾	7 11/16	9 ⅛	11 ⅝	13 5/16	16 ⅝	18 ⅜	22 ¼	25 ¼	25 ¼	31 ½	40 ½	47 ⅝
C	3	4 ¼	4 ¼	5 ¼	6 ½	8 ¼	9 ¾	13	12 ¼	13 ½	17	17	20 ¾	26	29 ¾
D	8	8 ⅝	8 ⅝	10	14	17	21	24	28	30 ½	35	35	33 ½	42	48 ½
E	6 ⅜	9	9	10	14	18	24	28	30	32	40	40	47	56 ¼	66
F	10	10	10	12	14	18	21	25	28	33	38	38	47	60	79
G	4 ½	6	6	6 ½	8 ¾	11 ¼	14 ¼	15 ½	16 ½	18	20 ½	20 ½	24	30	33
H	5 9/16	6 ⅜	6 ⅜	7 ¼	9 ⅛	11 11/16	13 5/16	15	17	21 ⅛	24 ⅝	24 ⅝	30 ¾	38 ½	43 ¾
I	5 ¾	9	9	11	16	20	24	26	30	36	40	40	44	50 ½	59
J	10	10	10	11	14	18	21	23	27	32	37	37	45	57	75
Wgt. (lbs)	260	260	260	300	450	800	1300	1600	1800	2400	3700	3900	6000	11000	17000

Note: 1. Dimensions F and J are the distance required to remove the piston
2. Dimensions and weights are approximate, please consult factory for specific information

Standard Materials

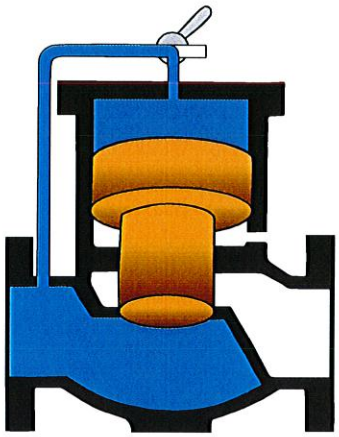
Body	Cast Iron, ASTM A126 Class B (NSF-61 Epoxy Coated)
Cover	Steel, ASTM A36 (NSF-61 Epoxy Coated)
Cover Fasteners	Steel, ASTM A307
Piston, Liner, Seat Ring	Bronze, ASTM B62
Seals	Buna-N or Composition
Renewable Seat	Buna-N
Internal Fasteners	Stainless Steel, Type 304

How it Works



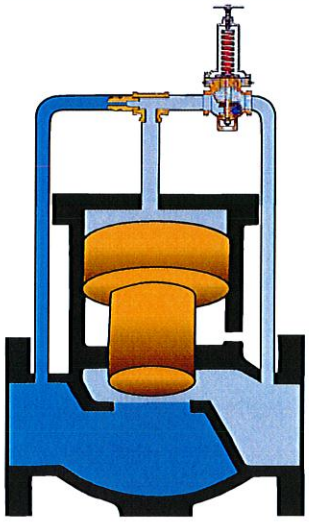
Valve Fully Open

When the area above the piston is exhausted to atmosphere, the inlet pressure acting on the underside of the piston exerts an opening force which lifts the piston and opens the valve.



Valve Fully Closed

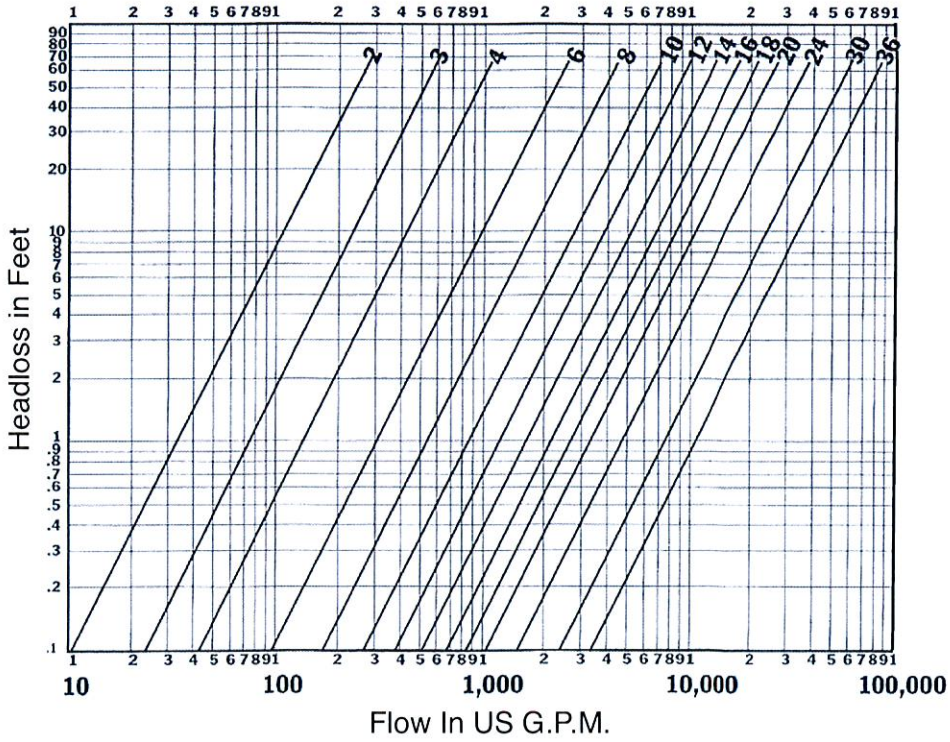
When the inlet pressure simultaneously acts on both the underside and on top of the piston, the larger area on top produces a net closing force which closes the valve. The differential piston valve uses line pressure to close the valve against line pressure, regardless of the line pressure or the pressure drop across the valve.



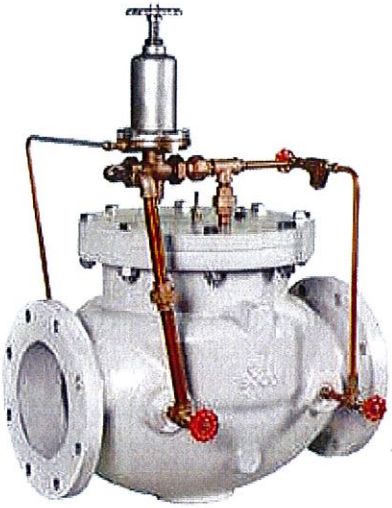
Valve Modulating

Inlet pressure is applied to the underside of the piston while a regulating pilot controls the pressure applied to the top of the piston to "balance" the opening and closing forces and position the main valve in an intermediate position to control pressure, flow or level.

Globe Body Headloss Chart



*Angle body headloss is approximately half that of Globe body. Consult factory for more information.

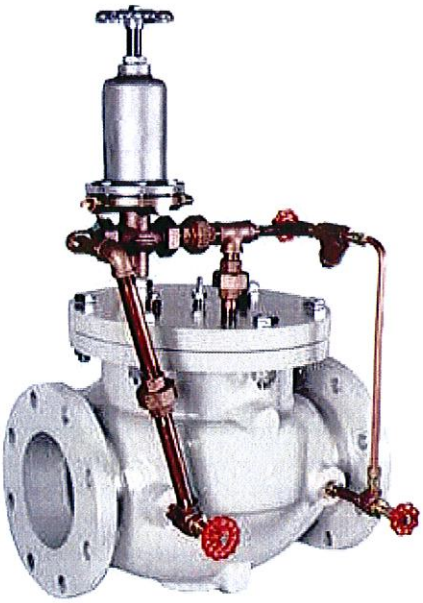


Pressure Reducing Valves

The GA Pressure Reducing Valve functions to reduce a higher upstream pressure to a lower, downstream pressure regardless of fluctuations in pressure or variations in flow. The pressure reducing pilot senses the downstream pressure and throttles the main valve as necessary to satisfy demand, without allowing the downstream pressure to rise above the pilot's setting. The main valve will close when the downstream pressure reaches the setting of the pressure reducing pilot.

Common Variations:

- Dual Pilot (high/low) Pressure Reducing
- Pressure Reducing and Sustaining
- Pressure Reducing and Solenoid Shutoff
- Pressure Reducing and Check
- Pressure Reducing and Equalizing

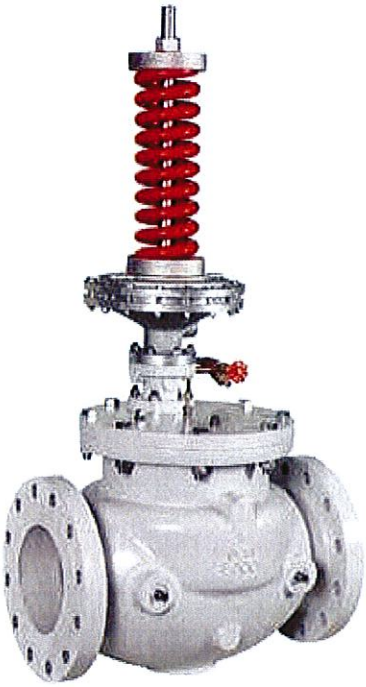


Pressure Sustaining Valves

The GA Pressure Sustaining Valve protects the pressure integrity of the upstream system. The valve will remain fully open as long as the inlet pressure exceeds the minimum pressure setting on the pilot. Should the upstream pressure fall to the minimum pressure setting on the pilot, the valve will throttle to hold back (sustain) the pressure and will close if the inlet pressure falls below the pilot setting. The upstream system pressure is protected by reducing or cutting off the flow to the downstream system.

Common Variations:

- Pressure Reducing and Sustaining
- Pressure Sustaining and Solenoid shutoff
- Pressure Sustaining and Check
- Pressure Reducing and Equalizing

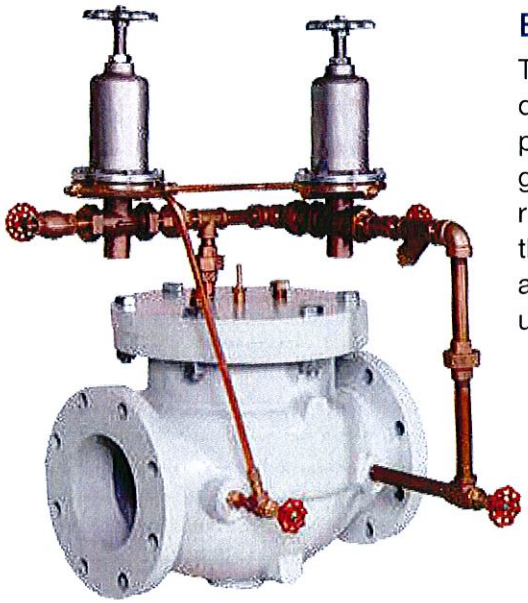


Altitude Valves

The GA Altitude Valve is used on the inlet of water tanks, standpipes and reservoirs to prevent overflow when the supply head is greater than the maximum water level. A single acting altitude is a "one-way" flow valve, where water must be drawn from the tank through another pipe (tank supplies downstream system) or a check valve in parallel to the altitude valve (tank is filled through the altitude valve and supplies system through the check valve when system head falls below tank head). A double acting altitude valve is "two-way" flow and not only fills the tank, but also re-opens when system head falls below tank head to allow the tank to supply the system through the altitude valve.

Common Variations:

- Altitude with Check
- Altitude with Solenoid Shutoff
- Altitude with Sustaining
- Altitude with Relief



Emergency Cut-In Valves

The GA Emergency Cut-In Valve automatically opens to introduce a supplemental source of water when the downstream pressure falls below a pre-set minimum, typically due to an emergency. Once open, the cut-in valve does not close until the outlet rises to a pre-set, independent higher pressure. While open, the valve will throttle the outlet pressure between the opening and closing pressures. Once closed, the valve will not re-open unless the outlet pressure falls below the opening pressure.

Common Variations:

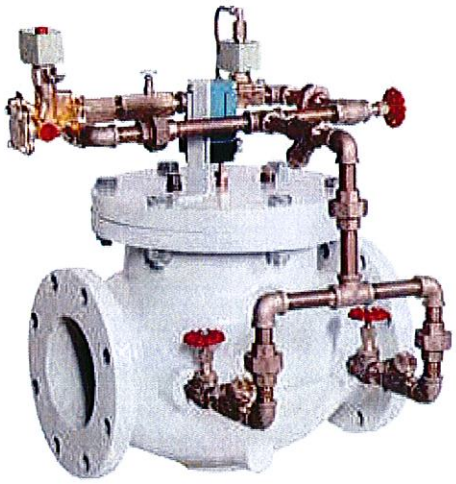
- Cut-in with Check
- Cut-in with Solenoid Shutoff
- Cut-in with Sustaining
- Cut-in with Reducing

Solenoid Valves

The GA Solenoid valve opens and closes by remotely energizing/de-energizing the solenoid pilot. A normally closed solenoid valve opens fully when the solenoid pilot is energized and closes tight when de-energized. A normally open solenoid valve opens fully when the solenoid pilot is de-energized and closes tight when it is energized. Throttling solenoid valves have two solenoid pilots and can be opened fully, closed tight, or held in a partially open position to "throttle" by energizing/de-energizing one or both of the solenoids.

Common Variations:

- Solenoid with Check
- Open and/or Closed Limit Switch
- Valve Position Feedback Transmitter (throttling solenoid)

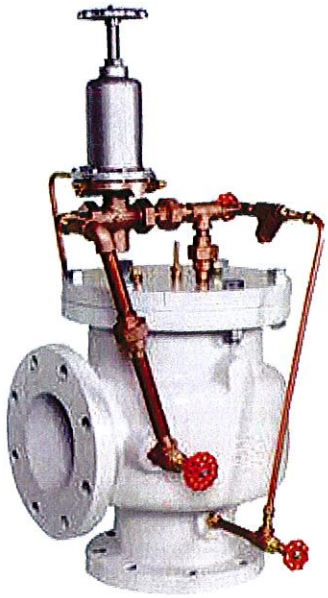


Pump Control Valves

Electric Check Pump Control Valves are installed on the discharge of a water pump to control surges associated with the starting and stopping of the pump. Valve operation is sequenced with the pump motor through a system of electro-hydraulic controls to slowly open and close the valve during normal pump operation without excessive surge. In emergency situations, such as loss of power, pump, or motor failure, the valve will automatically close quickly, protecting the system.

Common Variations:

- Electric Check with Pump Discharge Pressure Sustaining
- Electric Check with Pump Suction Pressure Sustaining
- Electric Check with Pump Differential Pressure Sustaining
- Electric Check with Pump Discharge Pressure Reducing
- Electric Check with Integral Mechanical Check



Surge Relief Valves

The GA Surge Relief Valve protects the system from an excessive rise in pressure subsequent to a stoppage of pumping or a sudden valve closure. The valve is normally closed, but opens quickly if the pressure at the inlet rises above the setting of the pilot. Once open, it will discharge water at a rate sufficient to prevent a further rise in pressure. The valve closes at an adjustable speed when the pressure subsides below its setting. This type of valve is typically installed on the side outlet of a tee, in the discharge header after the pump check valves, or just ahead of a fast closing valve.

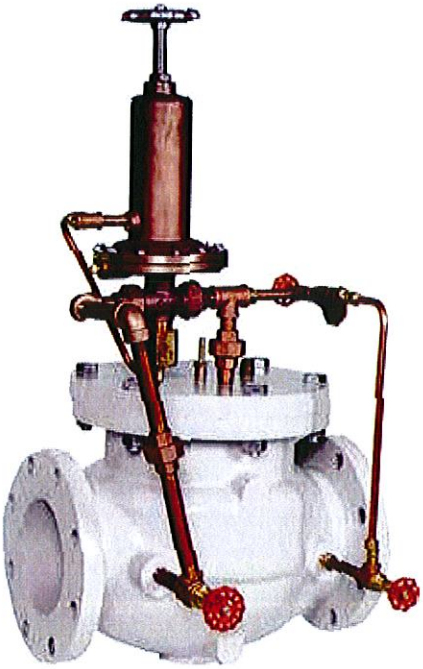
Common Variations:

- Surge Relief with Solenoid Override

Surge Sentinel
Electronic Control Panel

Surge Anticipator Valves

The GA Surge Sentinel Anticipator Valve is a surge relief valve with the added function of immediately and fully opening upon power outage or other surge producing events in "anticipation" of the resulting pressure surge. The valve's simple yet versatile electronic control panel eliminates the complicated pilot system normally associated with anticipator valves and allows the valve to be "tuned" to meet the needs of a particular pumping system and easily tested to ensure its operation.



Flow Control Valves

The GA Rate of Flow Control Valve limits the flow to the downstream system, regardless of fluctuations in upstream or downstream line pressure. The upstream orifice plate produces a small differential pressure at a given maximum flow rate, which is sensed by a pressure pilot that in turn throttles the main valve as needed to prevent the flow rate from exceeding a pre-set maximum.

Common Variations:

- Flow Control with Downstream Pressure Reducing
- Flow Control with Upstream Pressure Sustaining
- Flow Control with Solenoid Shutoff
- Flow Control with Check

Options and Accessories

- **Stop-Check Piston** - prevents reverse flow independent of the pilot controls.
- **Limit Switch** - electrically indicates if the valve is open or closed. A single switch indicates "closed/not closed" while dual switches indicate "full closed" and "full open." Various NEMA rating switches are available.
- **Pressure gauge** - indicates the pressure at the valve inlet and/or outlet.
- **Special Flanges** - faced and drilled per EN1092, BS4504 or AS4087 PN10, 16 or 25.

Specification

GA Industries Differential Piston Control Valve

DESIGN

A. The main valve shall be pilot-controlled, hydraulically operated, differential piston actuated and full ported.

B. The control valve shall be "self-contained" and incorporate a system of pilot controls, factory assembled to and tested with the main valve. The valve shall be operated by line pressure and utilize the pilot system to open, close or throttle the differential piston main valve to perform the specified function(s).

CONSTRUCTION

A. The main valve body shall be [globe][angle] style, constructed of high-strength cast iron conforming to ASTM A126 Class B with integral flanges, faced and drilled per ANSI B16.1 Class [125][250].

B. The valve shall be "full-ported" so that when fully open the flow area through the valve is no less than the area of its nominal pipe size. Globe body valves shall have an integral bottom pad or feet to permit support directly beneath the body.

C. The main valve shall operate on the differential piston principle such that the area on the underside of the piston is no less than the pipe area and the area on the upper surface is greater than that of the underside. There shall be no diaphragms or springs in the main valve.

D. The valve piston shall be fully guided on its outside diameter and all guiding and sealing surfaces shall be bronze. To minimize the consequences of throttling, throttling shall be by long, stationary vee-ports located downstream of the seat and not by the seat itself. Sawtooth attachments or other add-on devices are not permitted.

E. The valve shall be fully capable of operating in any position without the need of springs and shall not incorporate stems, stem guides or spokes in the waterway. A visual position indicator shall be provided.

F. The main valve shall be serviceable in the line through a single flanged top cover that provides easy access to all internal components.

G. The valve shall be shop coated with NSF-61 certified epoxy on internal surfaces in accordance with American Water Works Association Standard C550 (latest revision).

PILOT SYSTEM

A. The valve shall be operated by a system of pilot controls necessary to perform the specified function(s).

B. The pilot system shall be factory pre-piped, installed on the main valve and tested as an assembly.

C. In addition to the necessary pressure regulating and/or electrically operated pilots, the system shall incorporate a wye-strainer and opening and/or closing speed control valves.

D. Sufficient isolating valves and pipe unions shall be provided to facilitate removal and maintenance of the pilot system without disturbing the main valve.

E. Pilots, controls, piping and fittings shall be corrosion resistant copper, bronze or brass.

MANUFACTURER

A. Valve shall be manufactured by GA Industries, LLC, Cranberry Township, PA USA.

GA Industries offers a broad range of valves designed specifically for the waterworks market

AWWA C504
Rubber Seated Butterfly Valves
- Flanged and Mechanical Joint Ends
- Manual and Automatic Actuation

AWWA C507
Ball Valves
- Metal Seated
- Resilient Seated
- Hydraulic, Pneumatic, or Electric Motor Actuation

AWWA C508
Check Valves
- Cushioned Swing Check
- Rubber Flapper Check
- Globe and Wafer Silent Check
- Ball Check
- Foot Valves

AWWA C512
Air Valves for Water and Sewage
- Air Release
- Air and Vacuum
- Combination
- Vacuum Breaking

AWWA C517
Eccentric Plug Valves
- Flanged, Threaded, and Mechanical Joint Ends
- Manual and Automatic Actuation

AWWA C530
Control Valves
- Pump Control for Water and Sewage
- Surge Relief for Water and Sewage
- Level Control
- Pressure Regulating
- Solenoid Operated
- Anti-Cavitation

For more information about GA Industries' products, or to contact a sales representative, visit the GA website (**www.gaindustries.com**).

GA Industries, LLC • 9025 Marshall Road • Cranberry Township, PA 16066-3696 USA
Phone: 724-776-1020 • Fax: 724-776-1254 • E-mail: **ga@gaindustries.com**

Appendix D

Existing System Results

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Scenario 1a – Simultaneous All Pump Failure

Scenario 1b – Simultaneous All Pump Failure without Surge Tanks

Scenario 1c – Simultaneous All Pump Failure with LHCS Line

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Scenario 3a – Normal Pump Start Up

Scenario 3b – Normal Pump Start Up without Surge Tanks

Scenario 4a – Single Pump Failure with Five Pumps Running

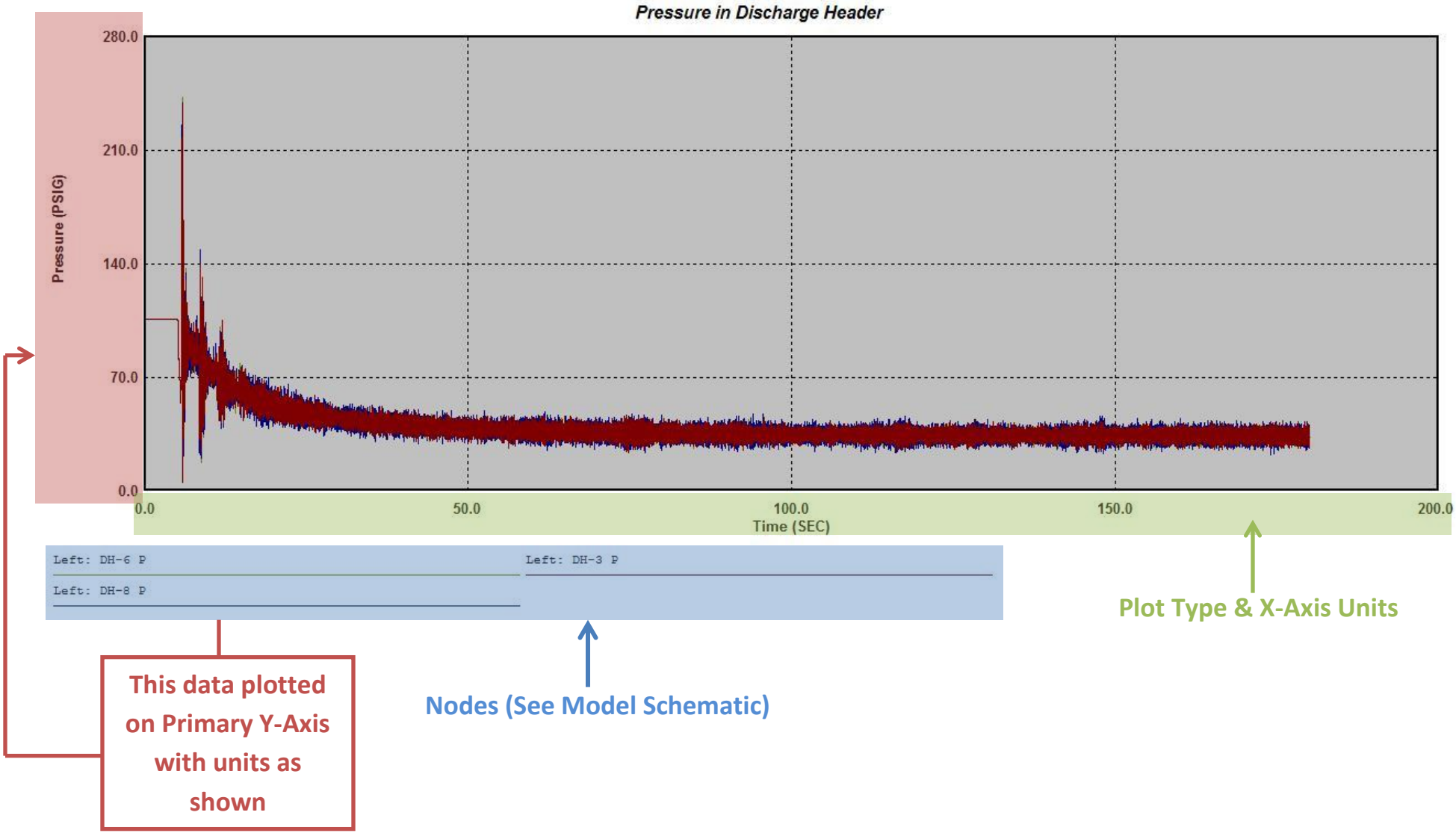
Scenario 4b – Single Pump Failure with Five Pumps Running without Surge Tanks

Scenario 4c – Single Pump Failure with Five Pumps Running with LHCS Line

Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD

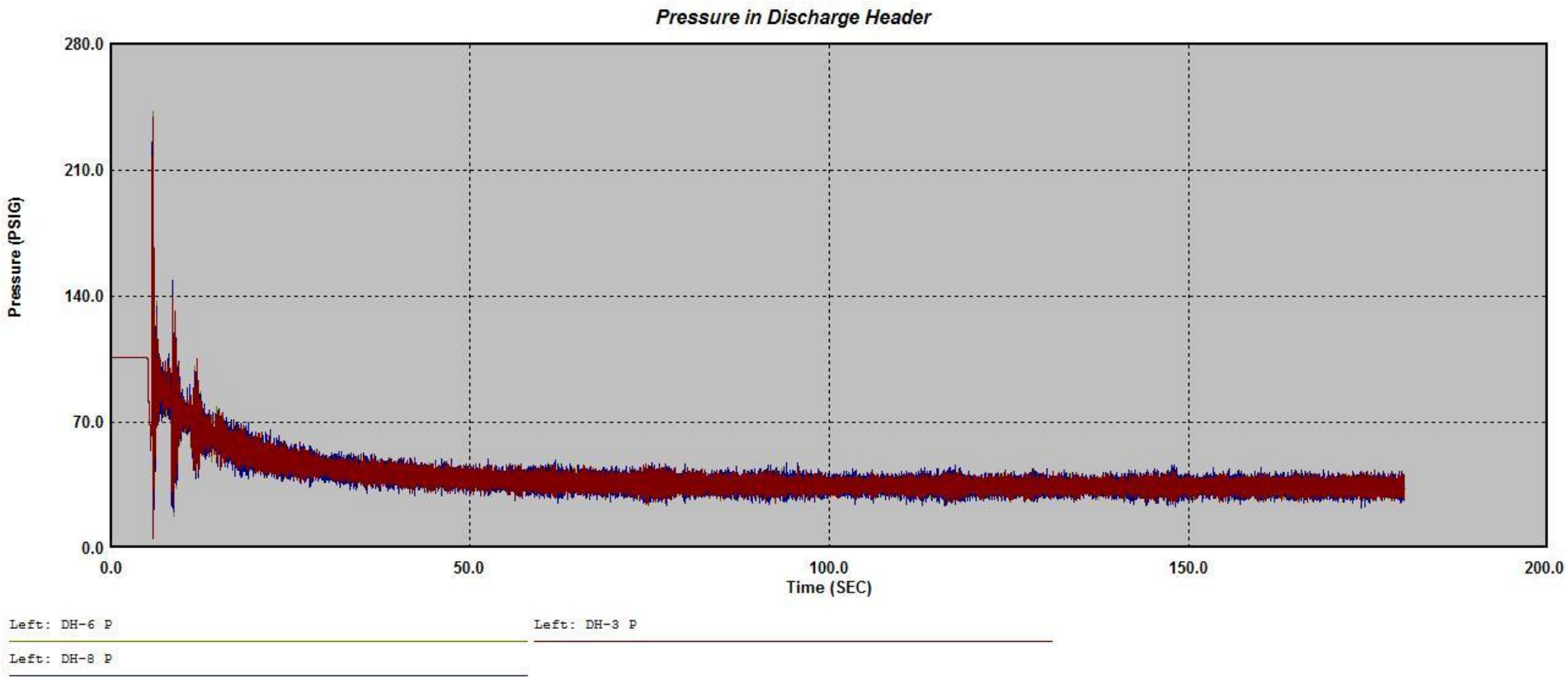
How To Read a Time Plot from LIQT

A TIME Plot in LIQT displays variables as a function of simulation time for a given node.

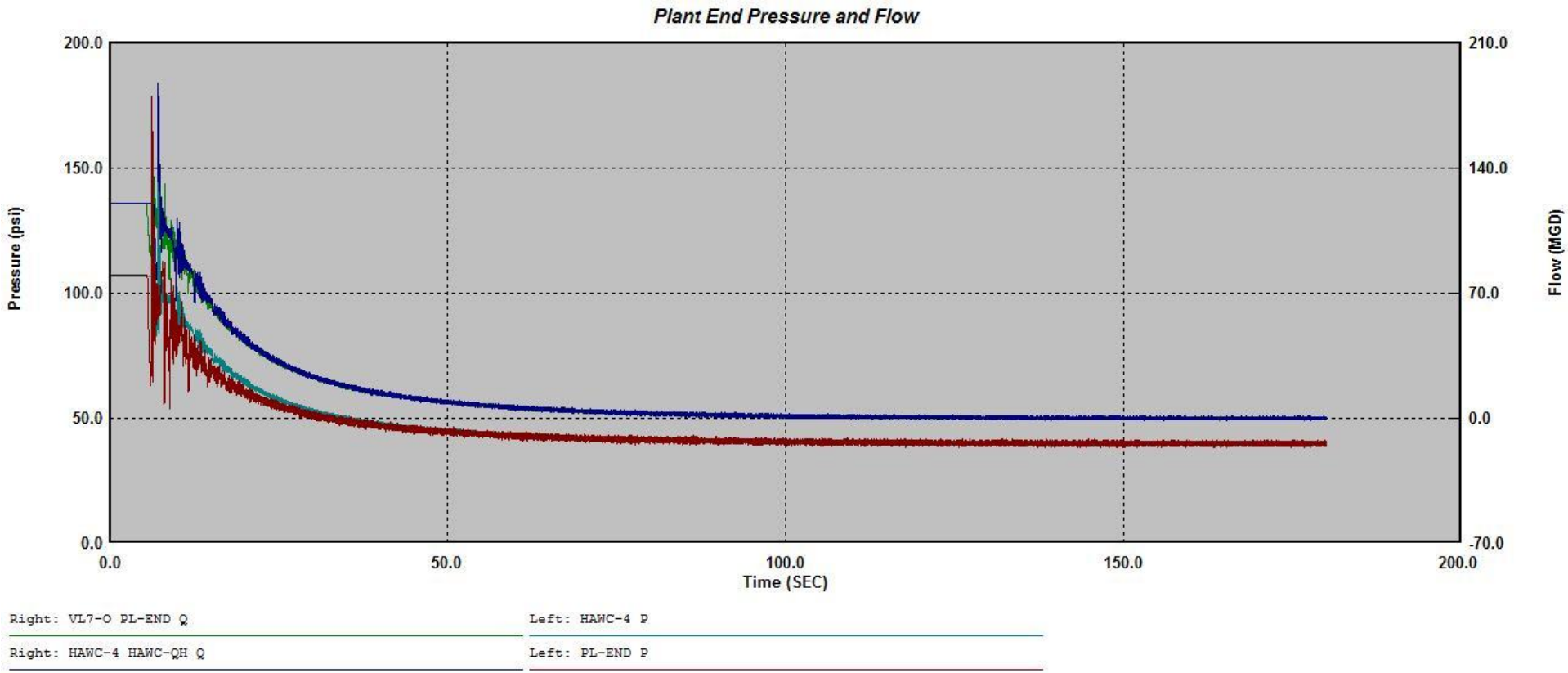


Scenario 1a – Simultaneous All Pump Failure

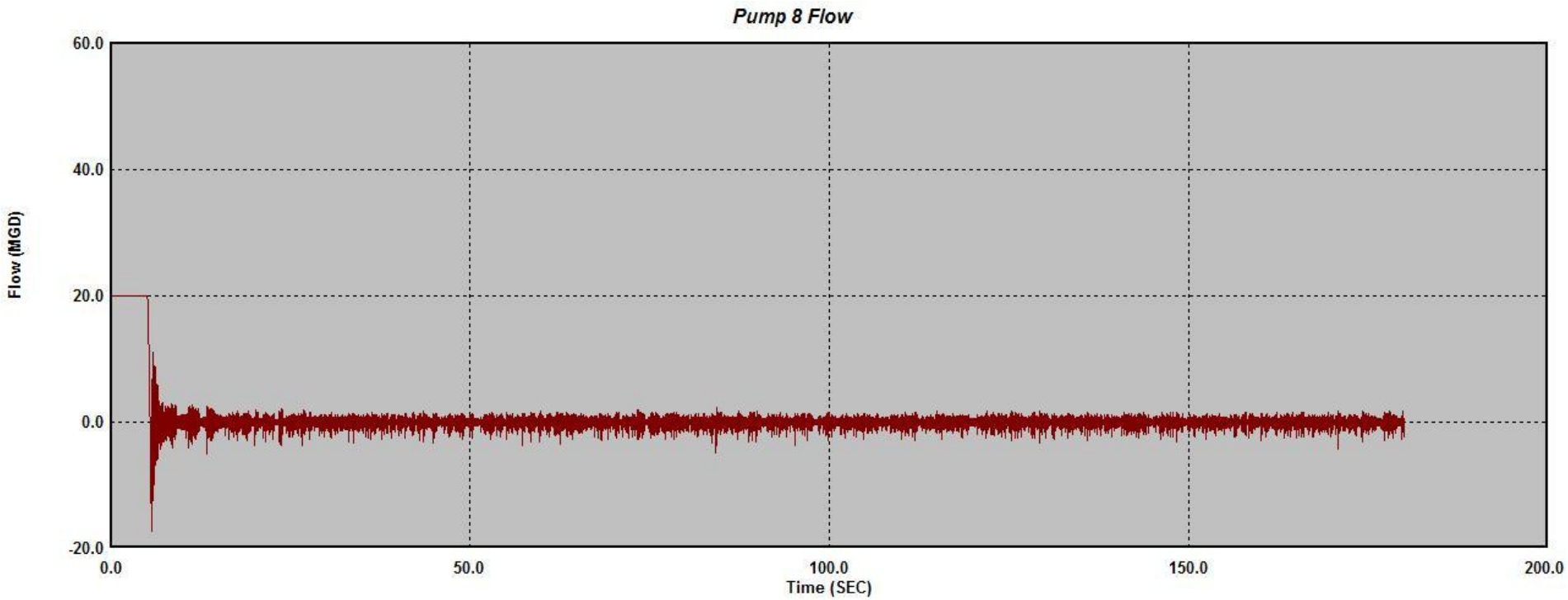
Existing System Conditions
Scenario 1a – Simultaneous All Pump Failure



Existing System Conditions
Scenario 1a – Simultaneous All Pump Failure

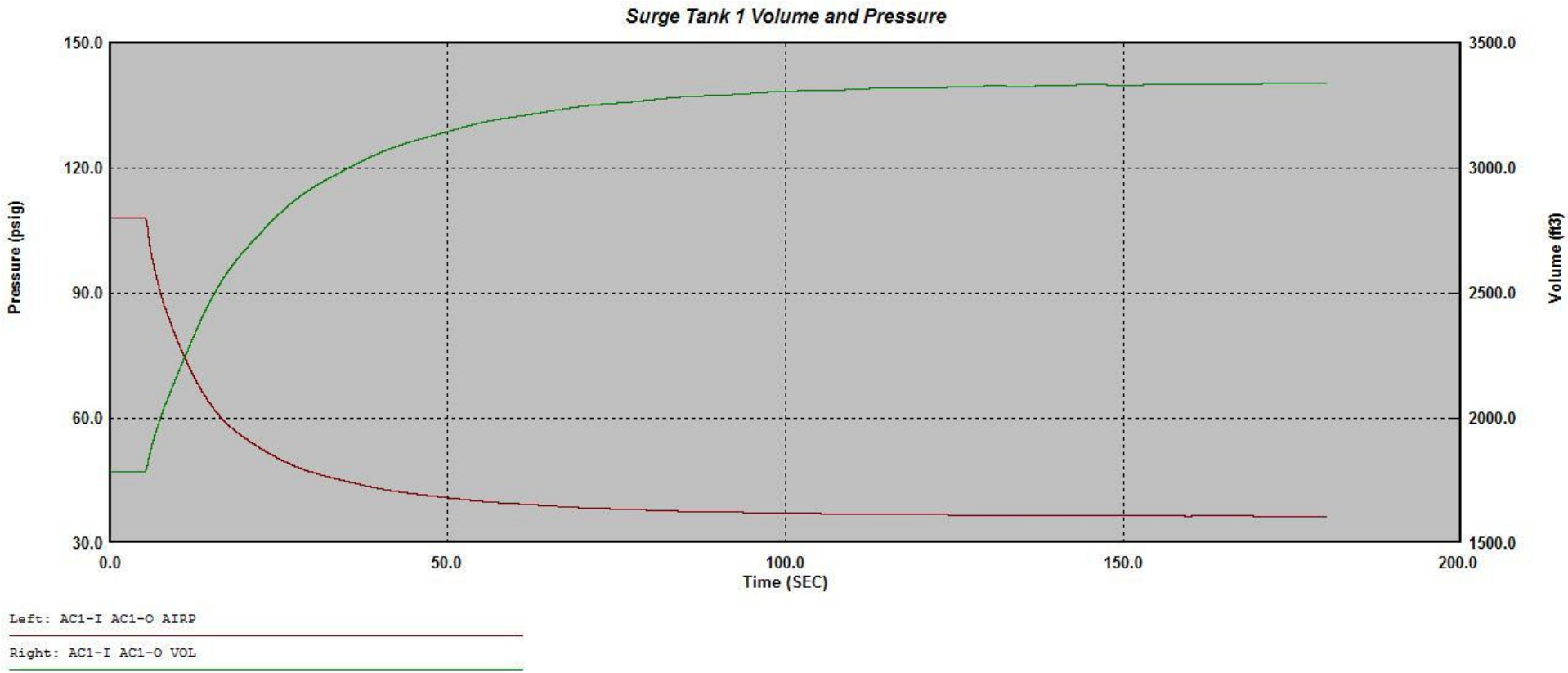


Existing System Conditions
Scenario 1a – Simultaneous All Pump Failure



Left: WELL-8 PUMP-8 Q

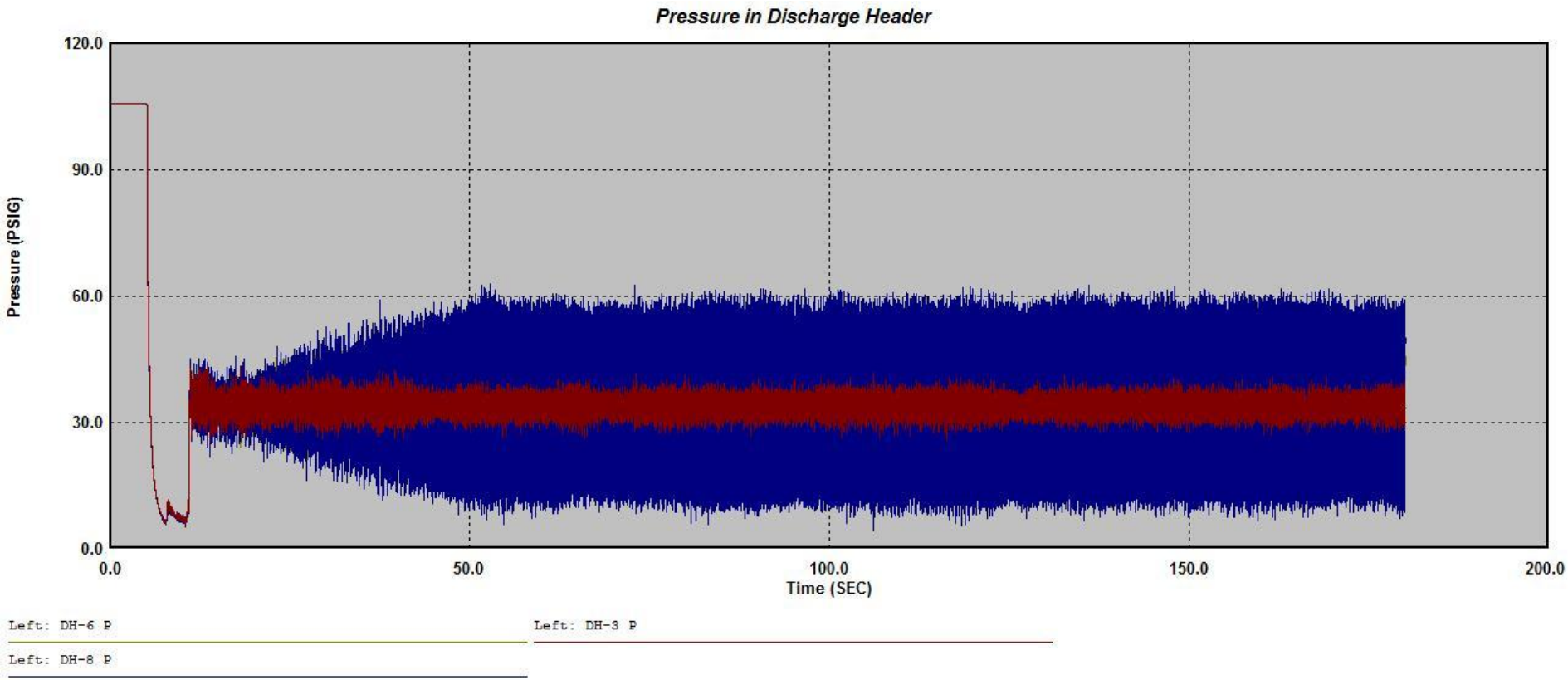
Existing System Conditions
Scenario 1a – Simultaneous All Pump Failure



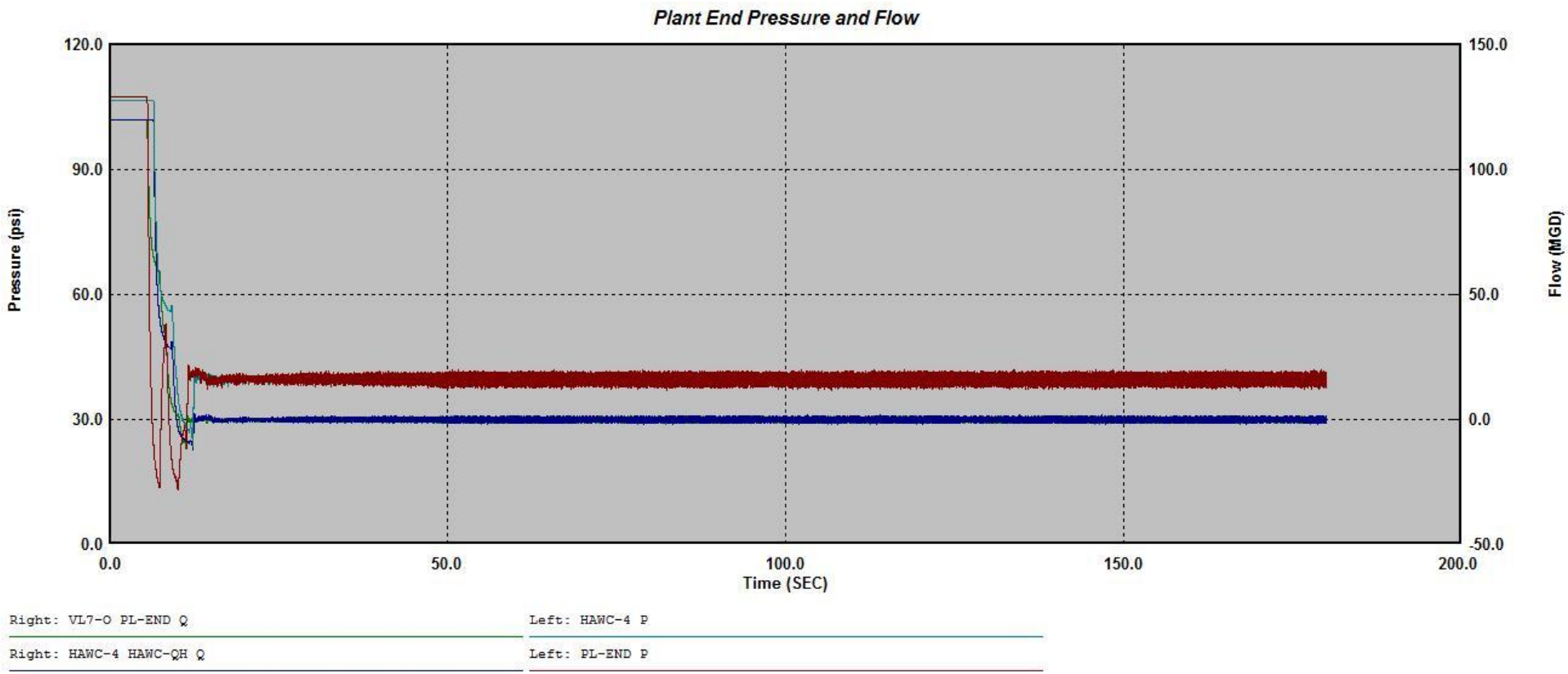
AIRP – Air Pressure in Surge Tank
VOL – Volume of Air in Surge Tank

Scenario 1b – Simultaneous All Pump Failure without Surge Tanks

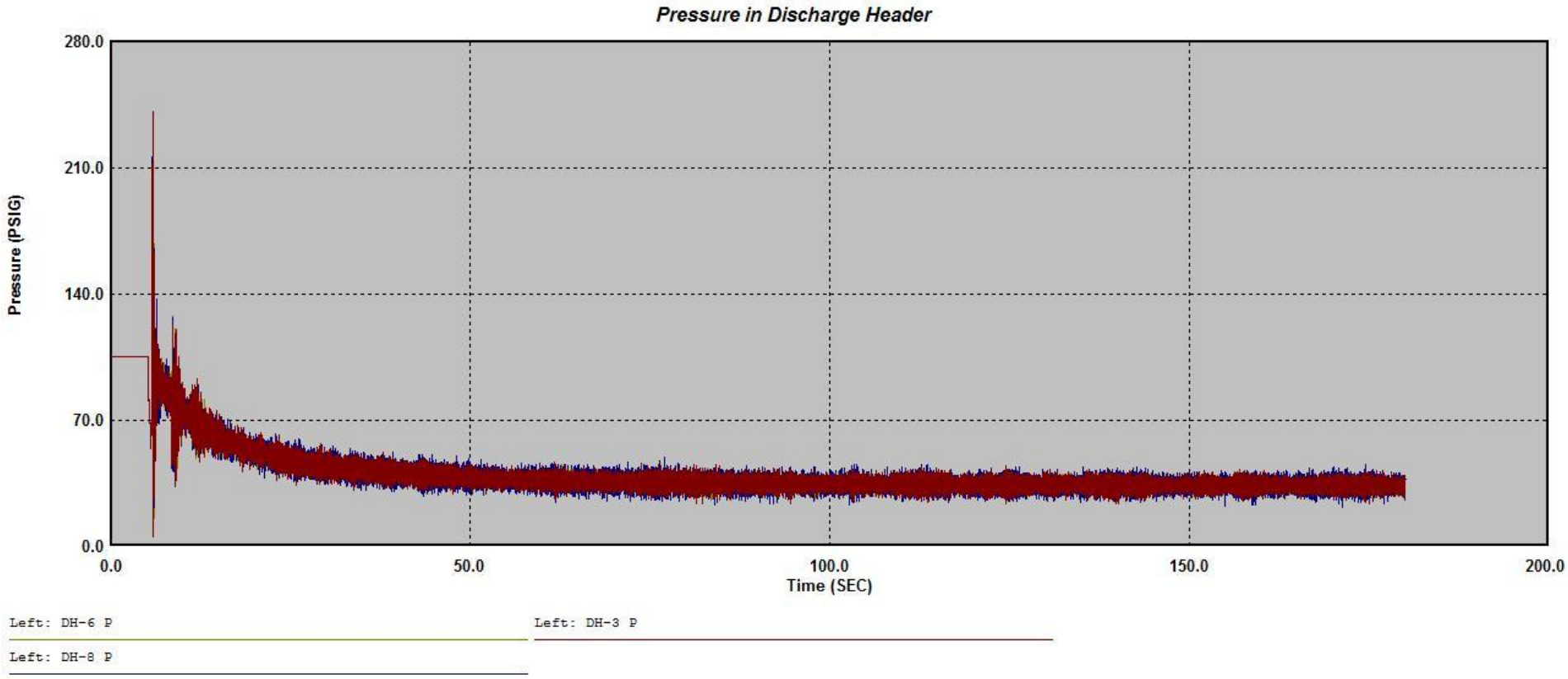
Existing System Conditions
Scenario 1b – Simultaneous All Pump Failure without Surge Tanks



Existing System Conditions
Scenario 1b – Simultaneous All Pump Failure without Surge Tanks

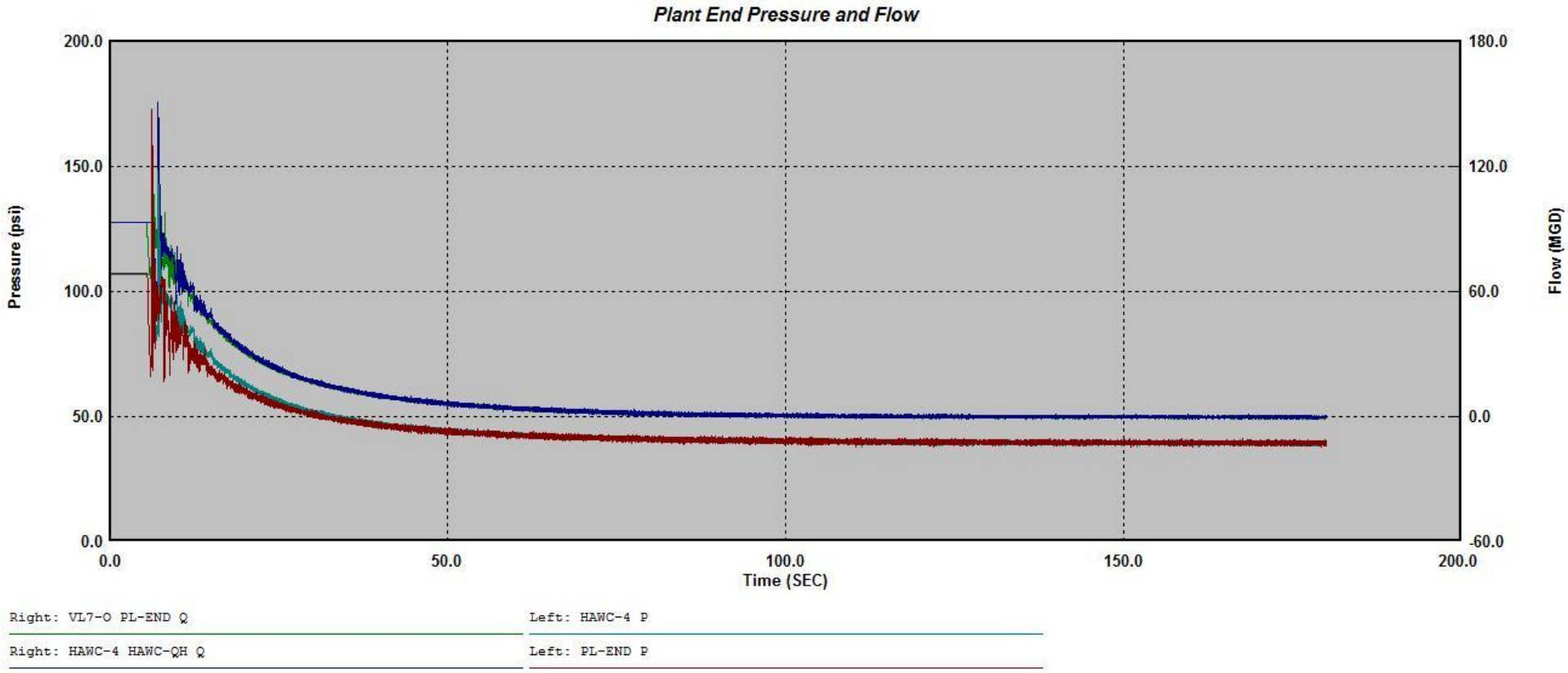


Existing System Conditions
Scenario 1c – Simultaneous All Pump Failure with LHCS Line

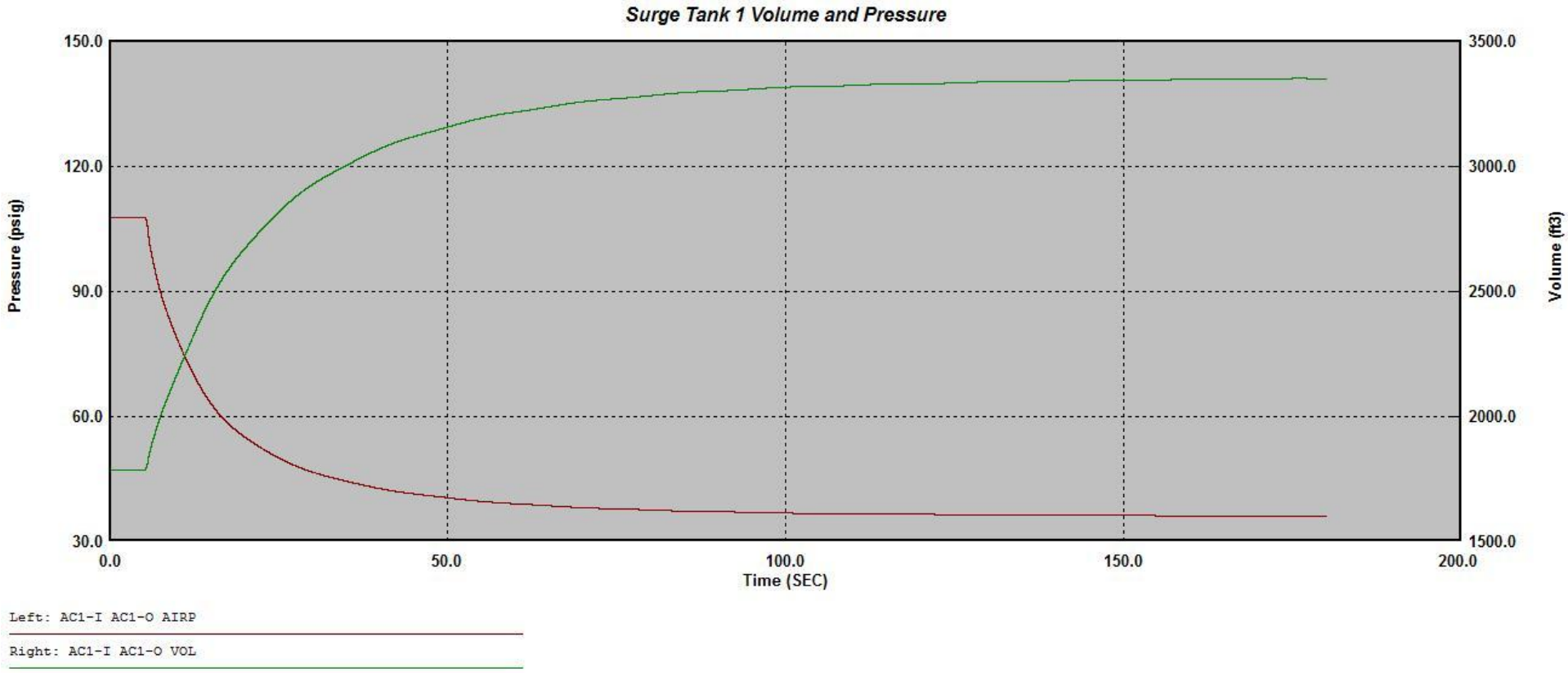


Scenario 1c – Simultaneous All Pump Failure with LHCS Line

Existing System Conditions
Scenario 1c – Simultaneous All Pump Failure with LHCS Line

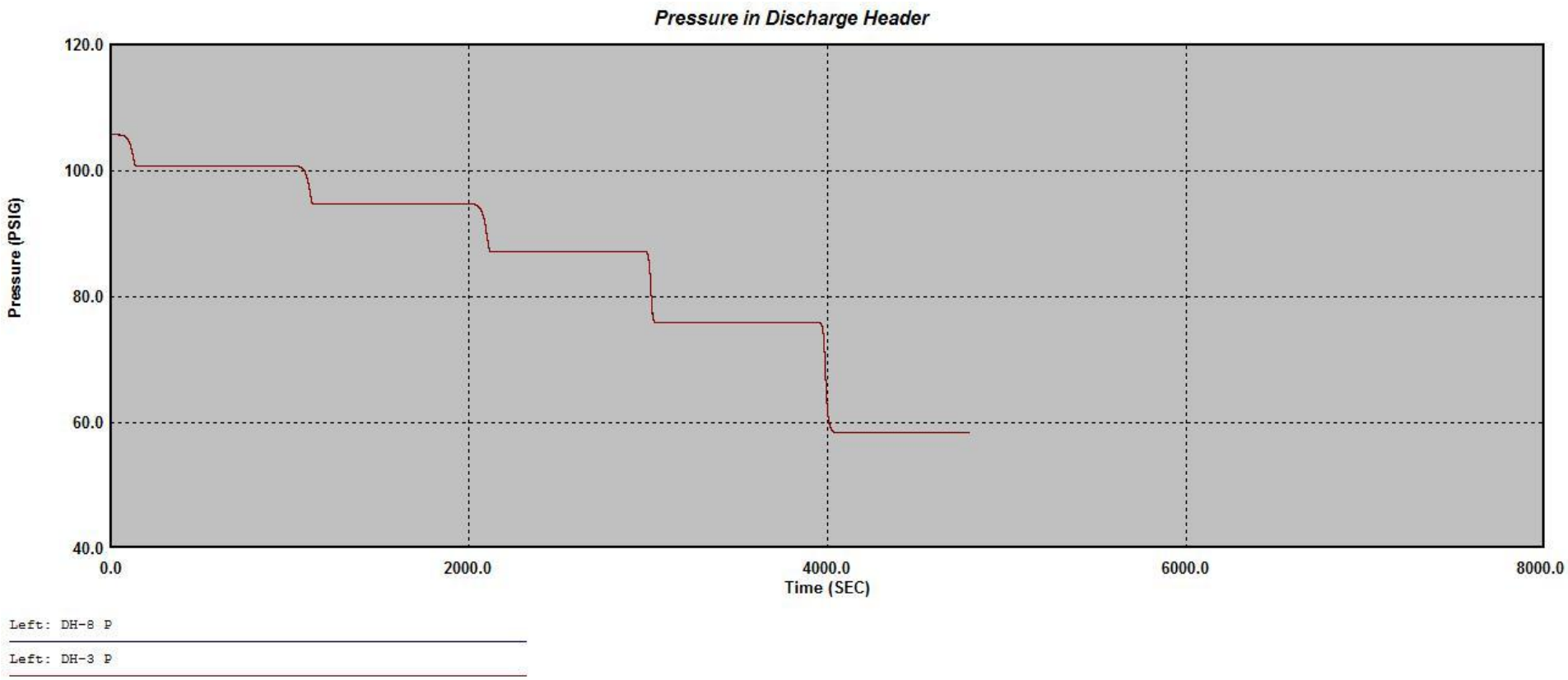


Existing System Conditions
Scenario 1c – Simultaneous All Pump Failure with LHCS Line



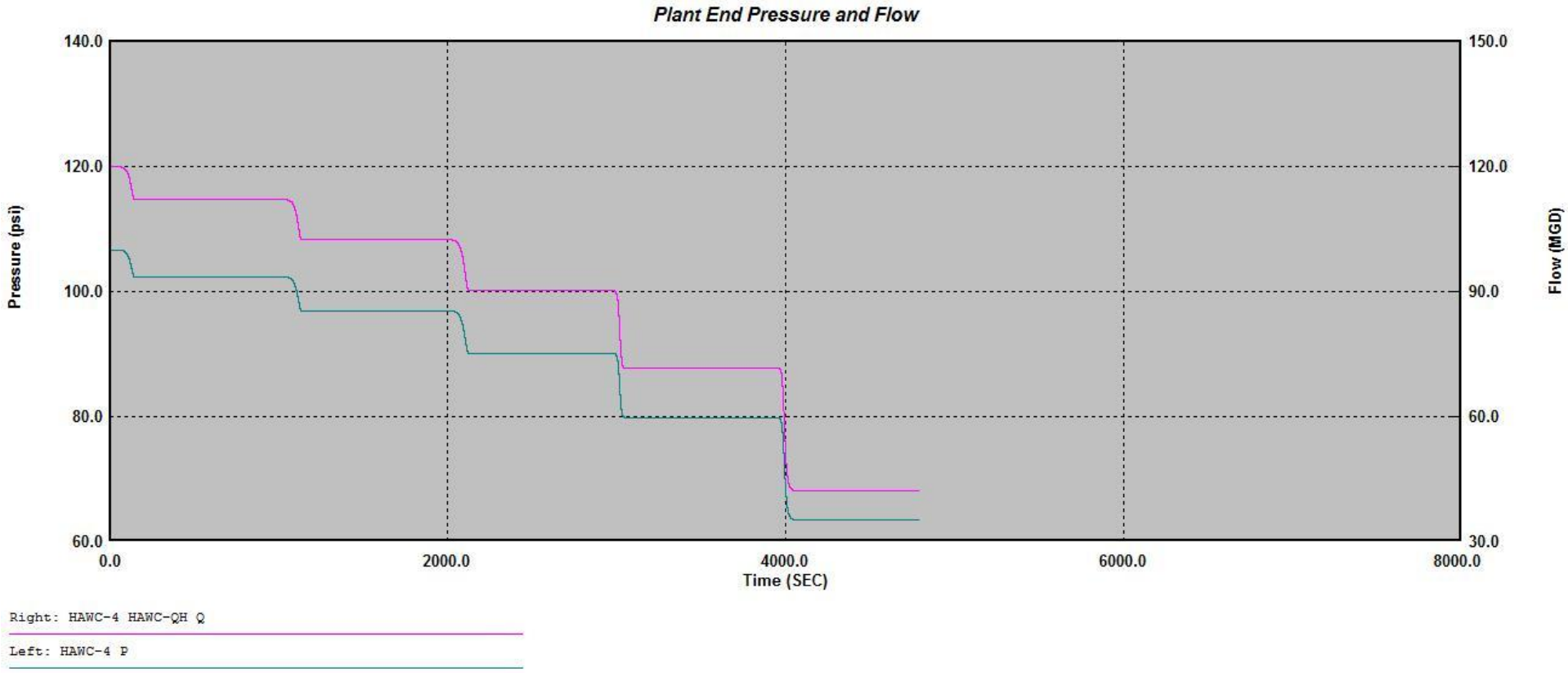
AIRP – Air Pressure in Surge Tank
VOL – Volume of Air in Surge Tank

Existing System Conditions
Scenario 2 – Normal Pump Shut Down

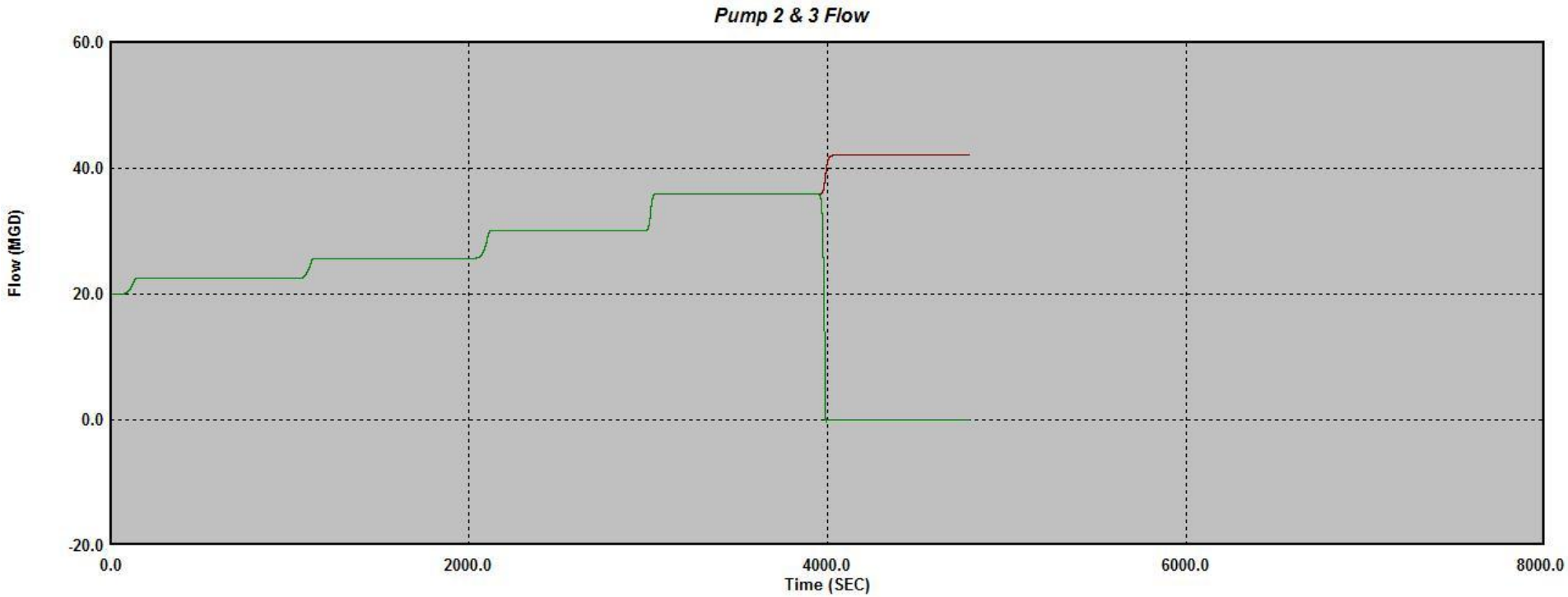


Scenario 2a – Normal Pump Shut Down

Existing System Conditions
Scenario 2a – Normal Pump Shut Down



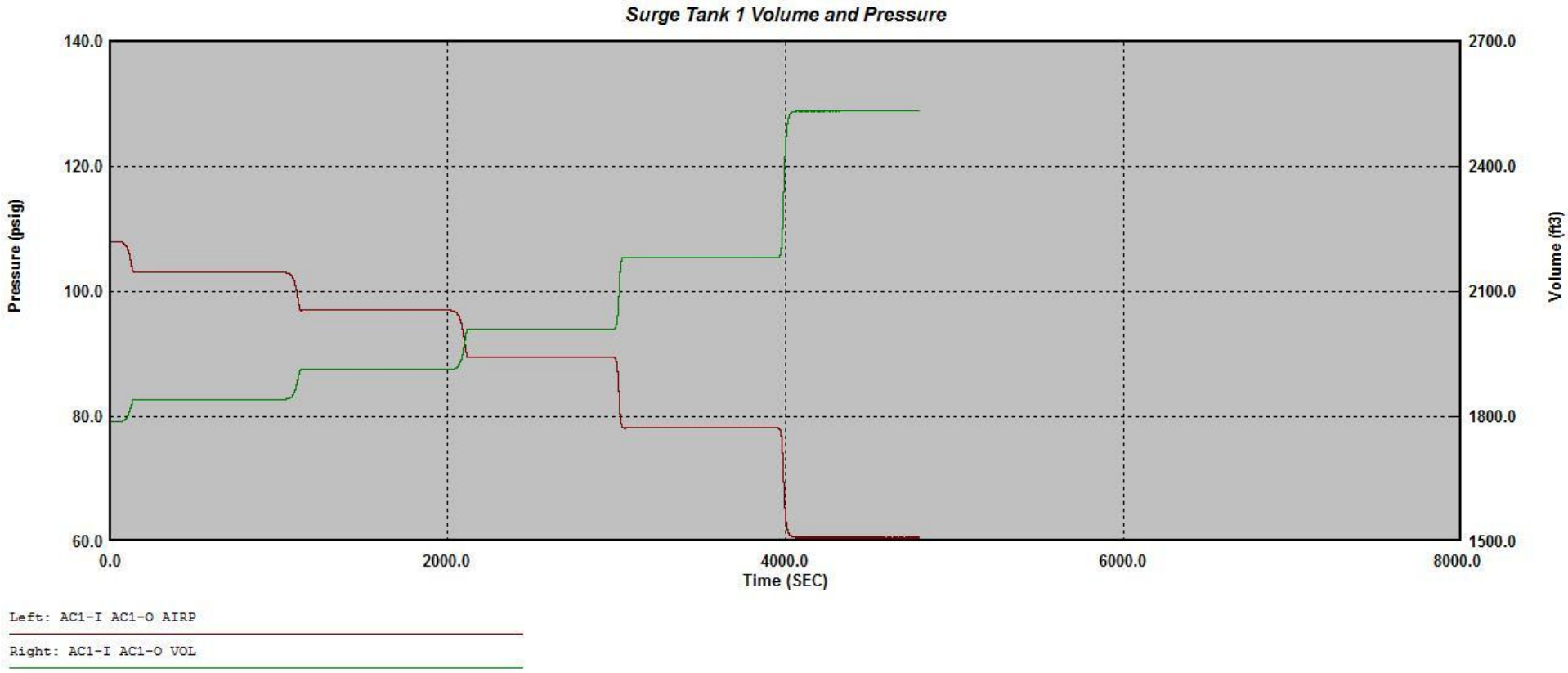
Existing System Conditions
Scenario 2a – Normal Pump Shut Down



Left: WELL-2 PUMP-2 Q

Left: WELL-3 PUMP-3 Q

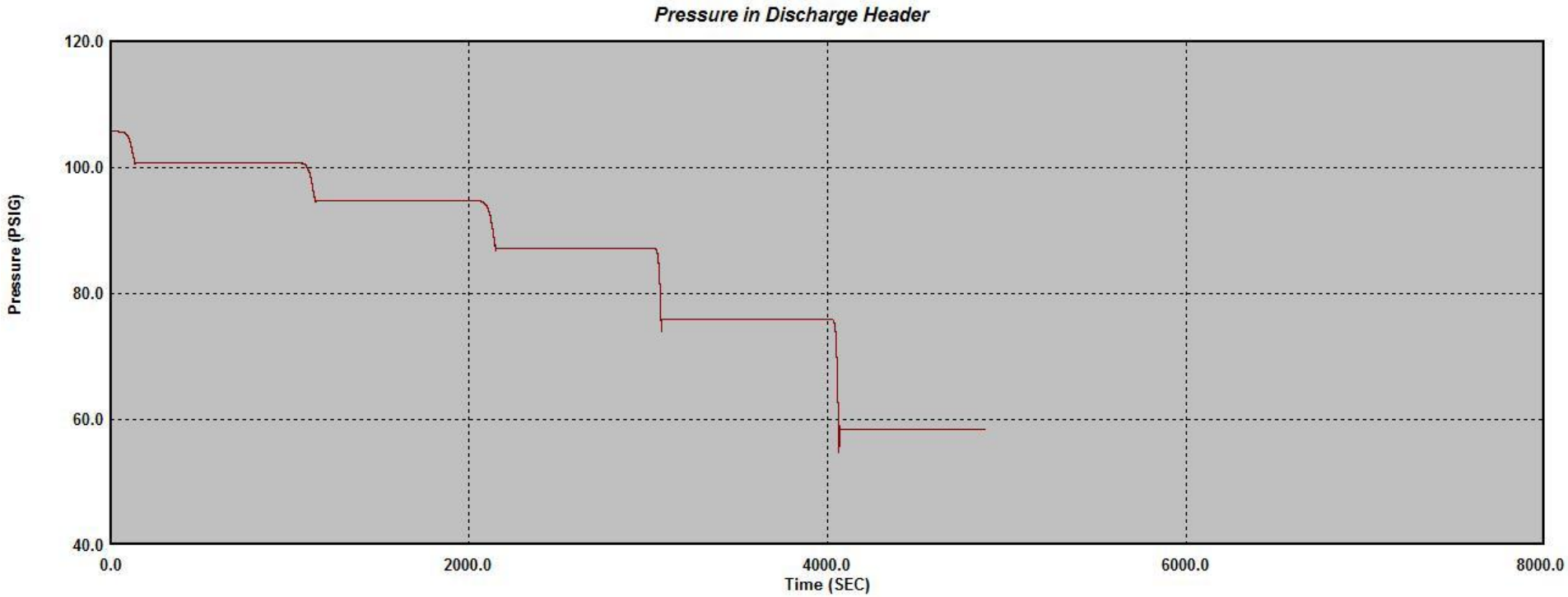
Existing System Conditions
Scenario 2a – Normal Pump Shut Down



AIRP – Air Pressure in Surge Tank
VOL – Volume of Air in Surge Tank

Scenario 2b – Normal Pump Shut Down without Surge Tanks

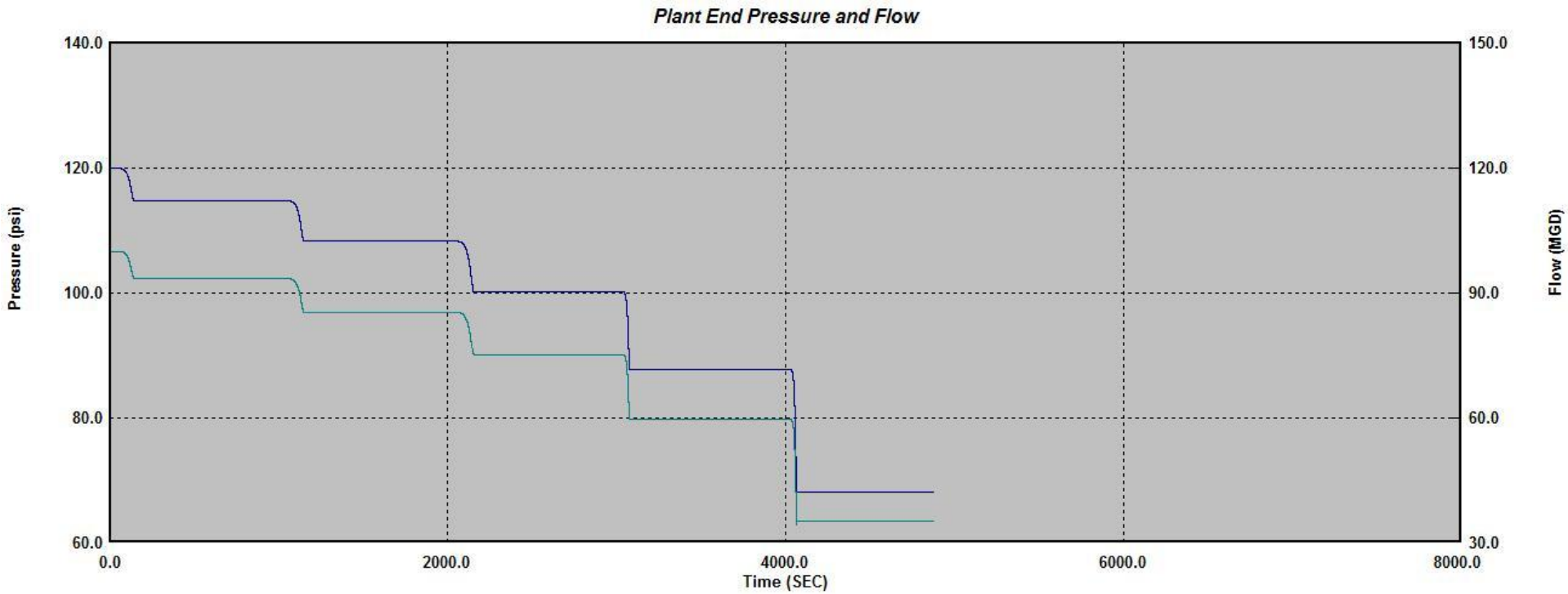
Existing System Conditions
Scenario 2b – Normal Pump Shut Down without Surge Tanks



Left: DH-8 P

Left: DH-3 P

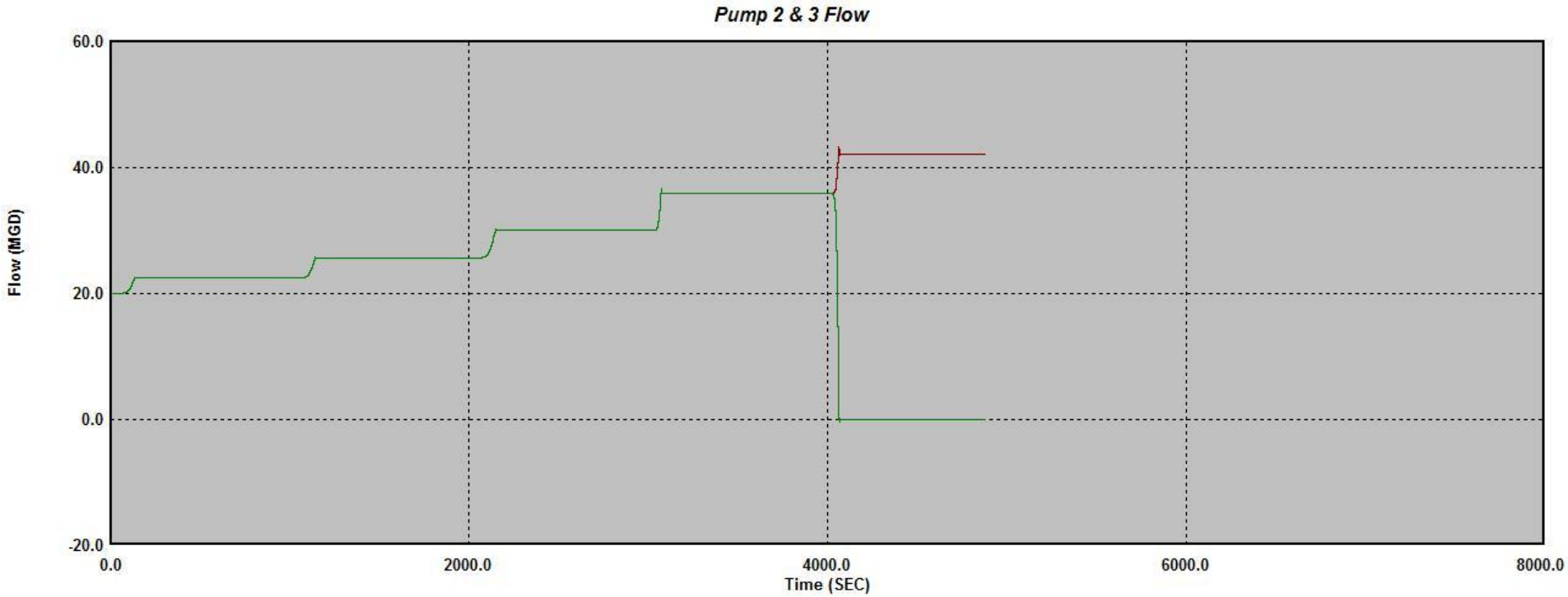
Existing System Conditions
Scenario 2b – Normal Pump Shut Down without Surge Tanks



Right: HAWC-4 HAWC-QH Q

Left: HAWC-4 P

Existing System Conditions
Scenario 2b – Normal Pump Shut Down without Surge Tanks

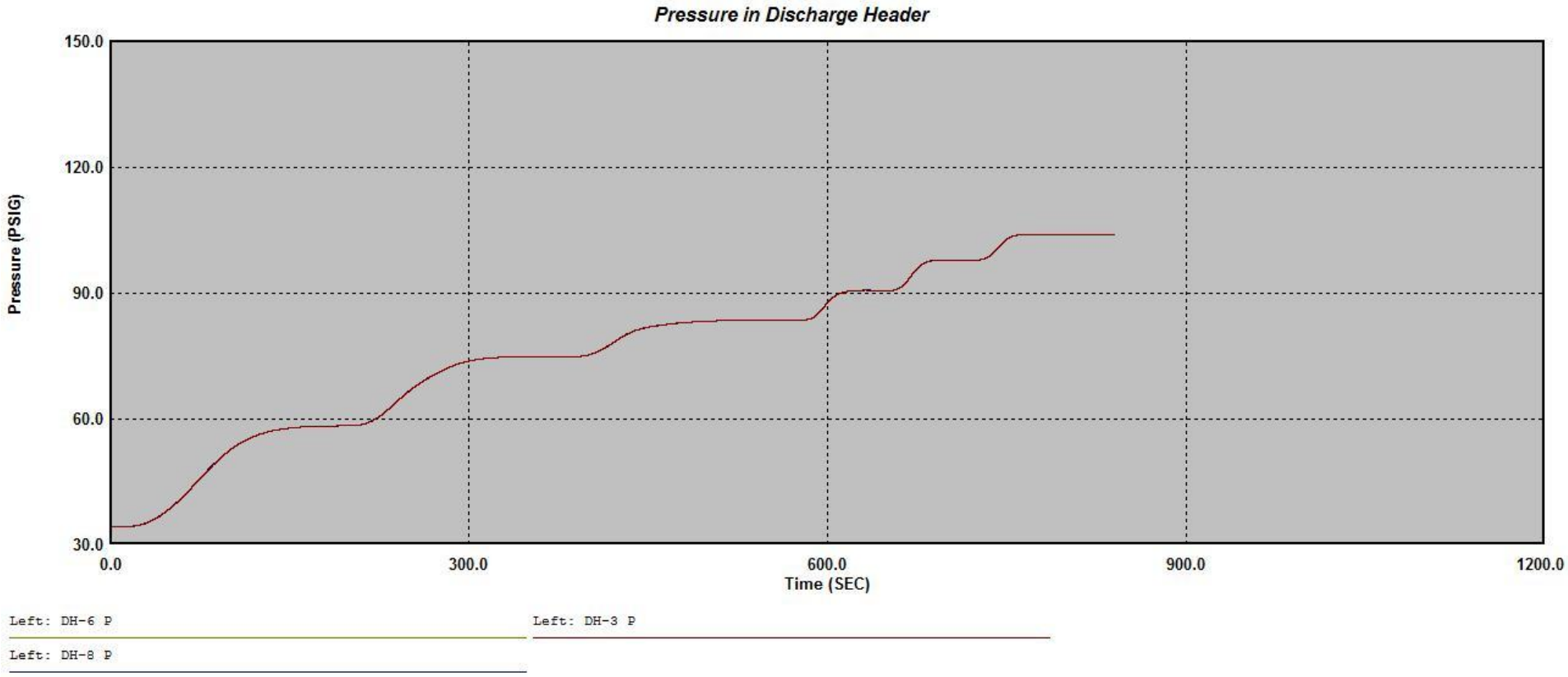


Left: WELL-2 PUMP-2 Q

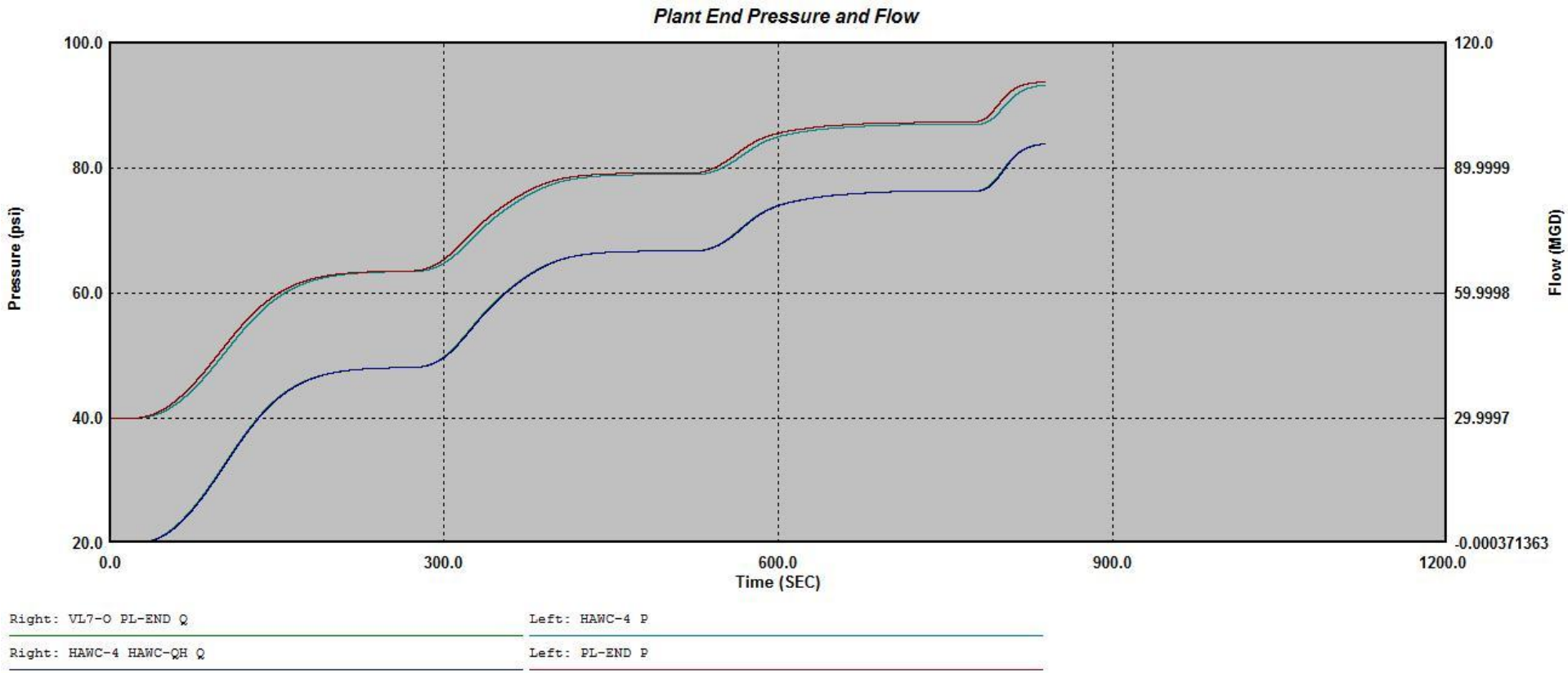
Left: WELL-3 PUMP-3 Q

Scenario 3a – Normal Pump Start Up

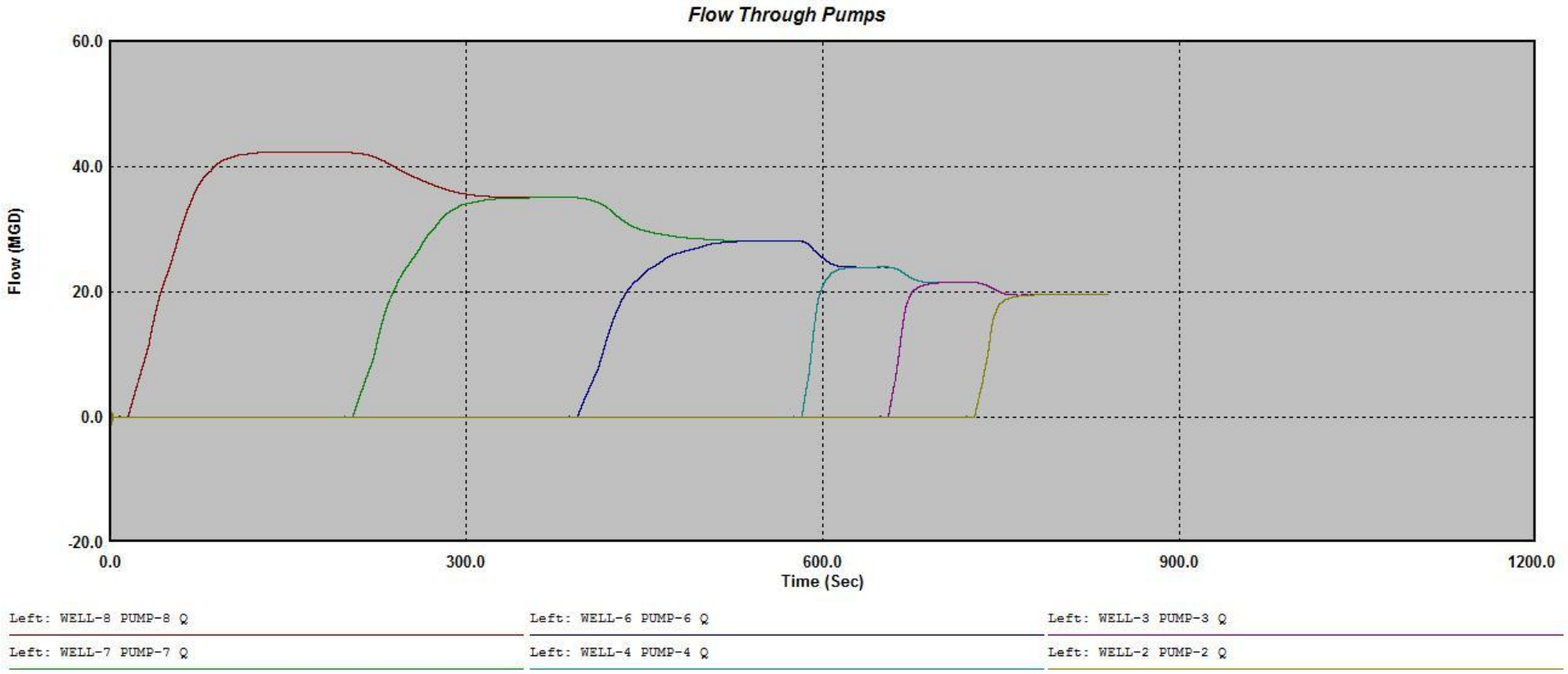
Existing System Conditions
Scenario 3a – Normal Pump Start Up



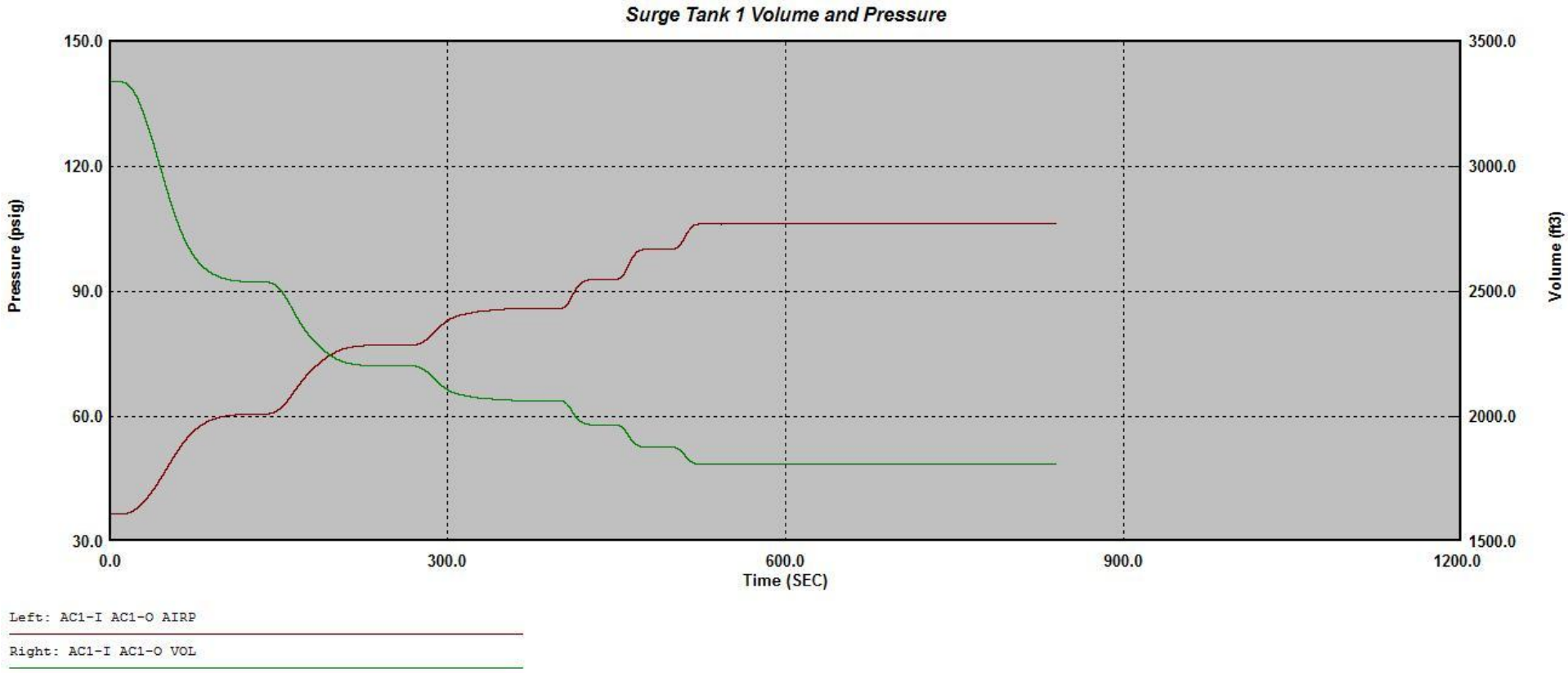
Existing System Conditions
Scenario 3a – Normal Pump Start Up



Existing System Conditions
Scenario 3a – Normal Pump Start Up



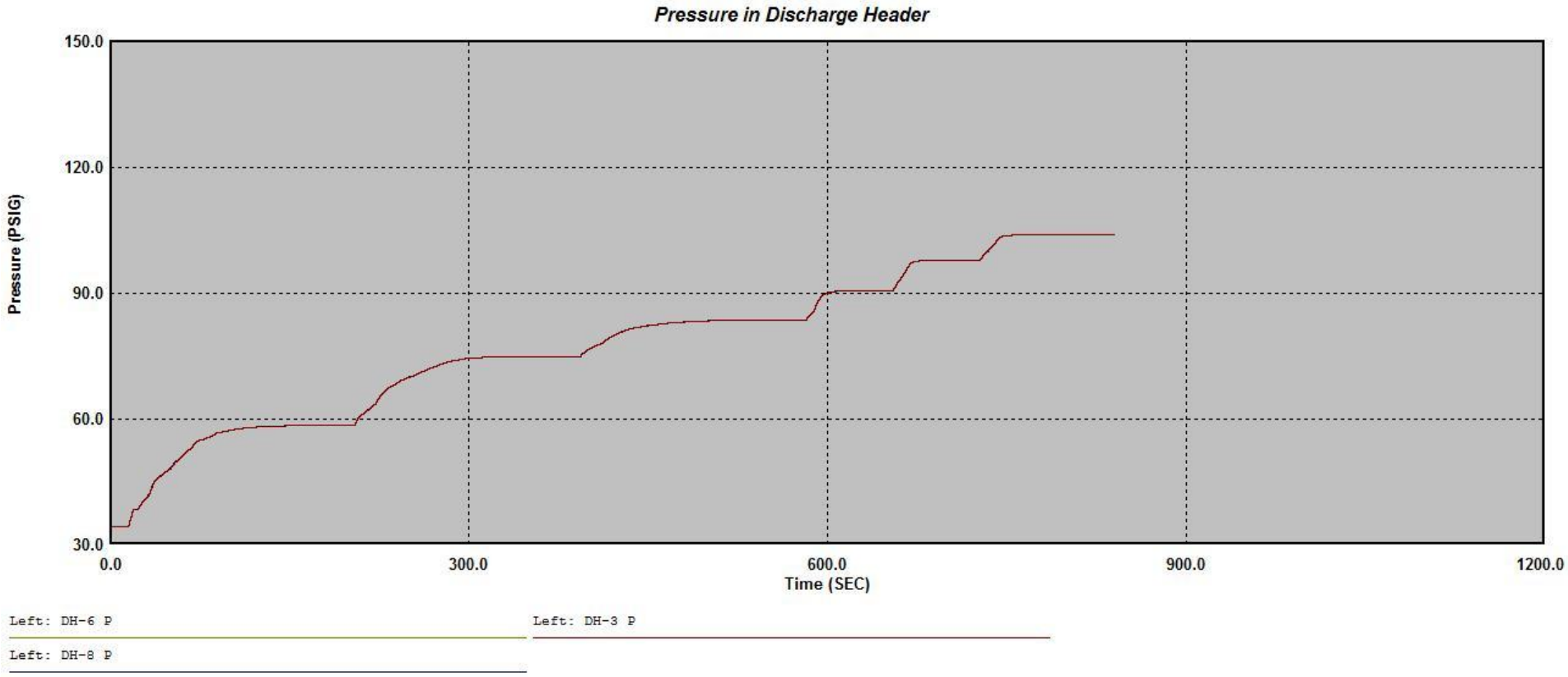
Existing System Conditions
Scenario 3a – Normal Pump Start Up



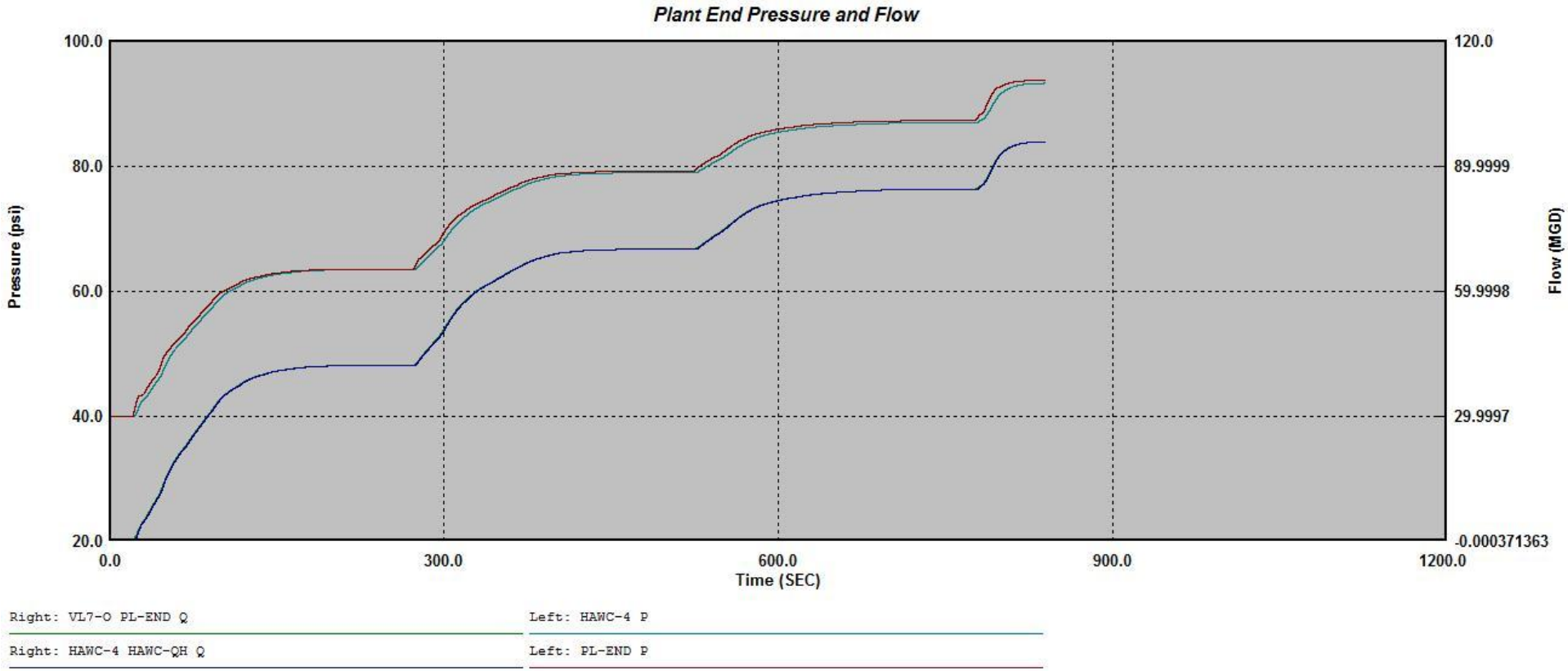
AIRP – Air Pressure in Surge Tank
VOL – Volume of Air in Surge Tank

Scenario 3b – Normal Pump Start Up without Surge Tanks

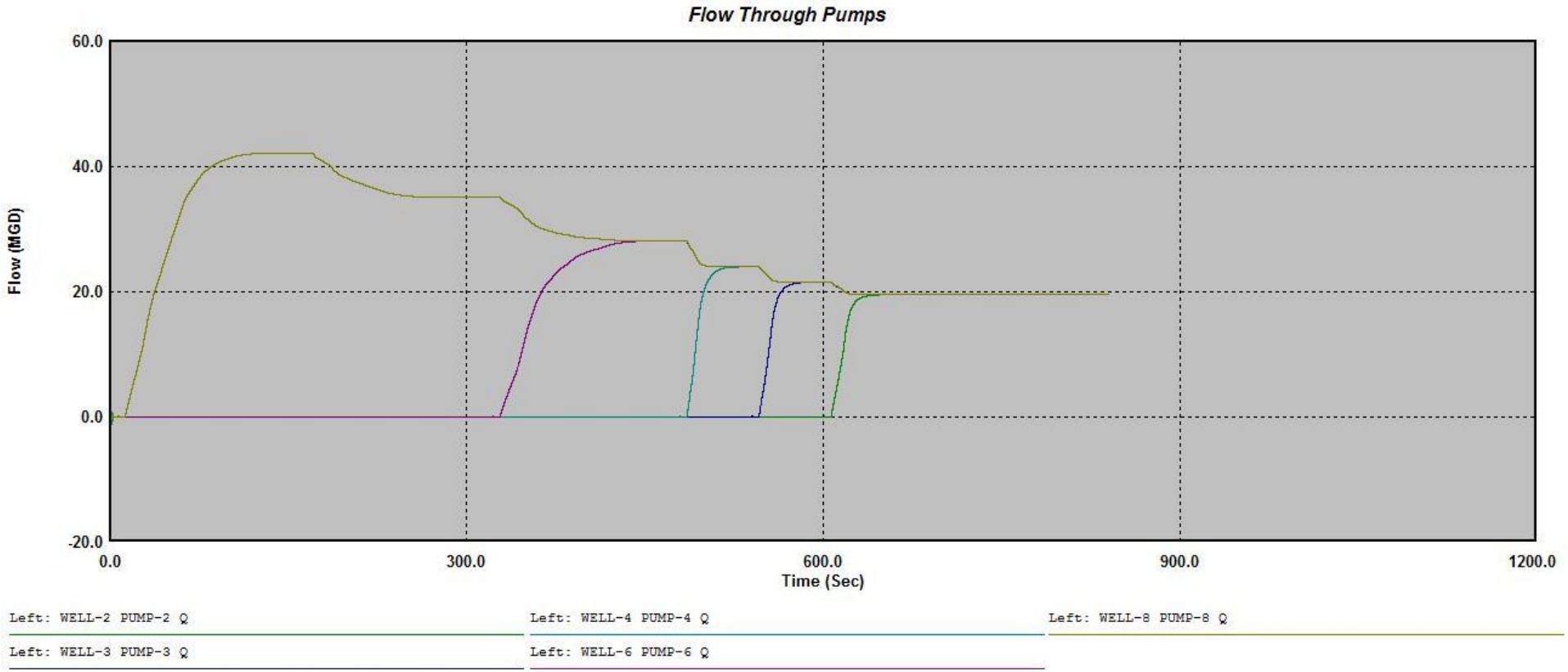
Existing System Conditions
Scenario 3b – Normal Pump Start Up without Surge Tanks



Existing System Conditions
Scenario 3b – Normal Pump Start Up without Surge Tanks

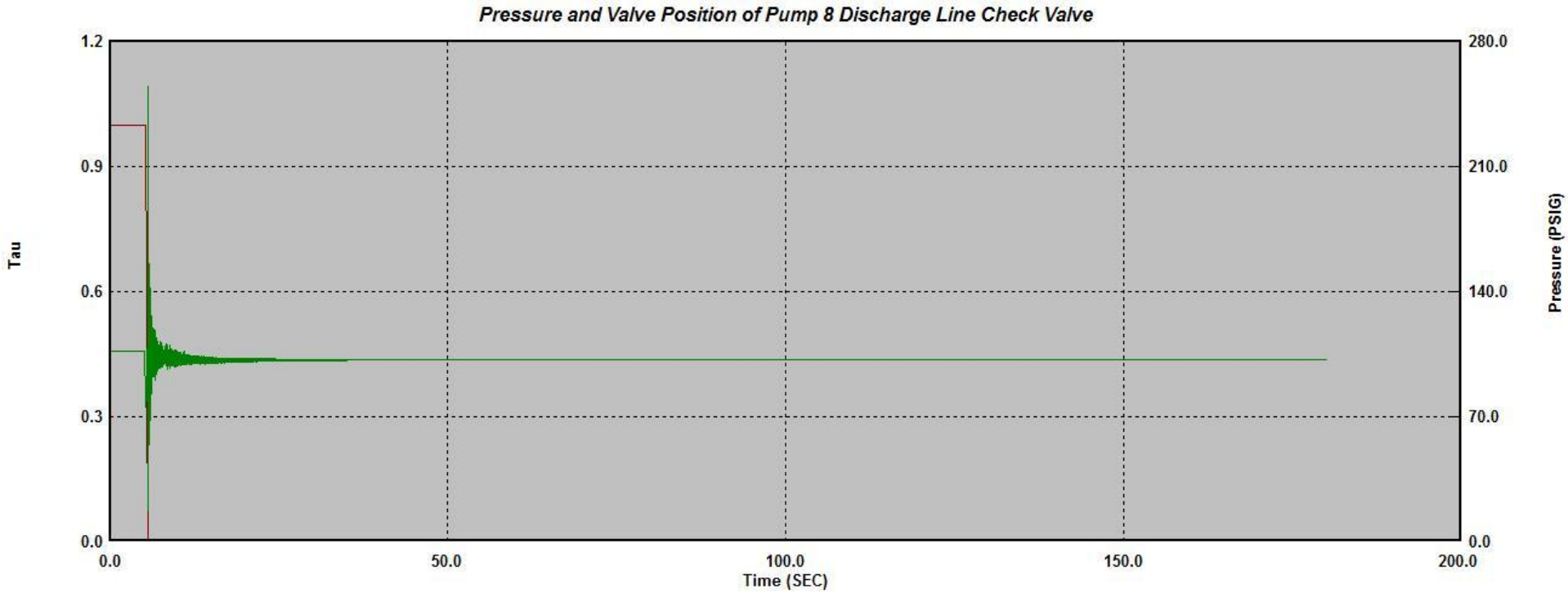


Existing System Conditions
Scenario 3b – Normal Pump Start Up without Surge Tanks



Scenario 4a – Single Pump Failure with Five Pumps Running

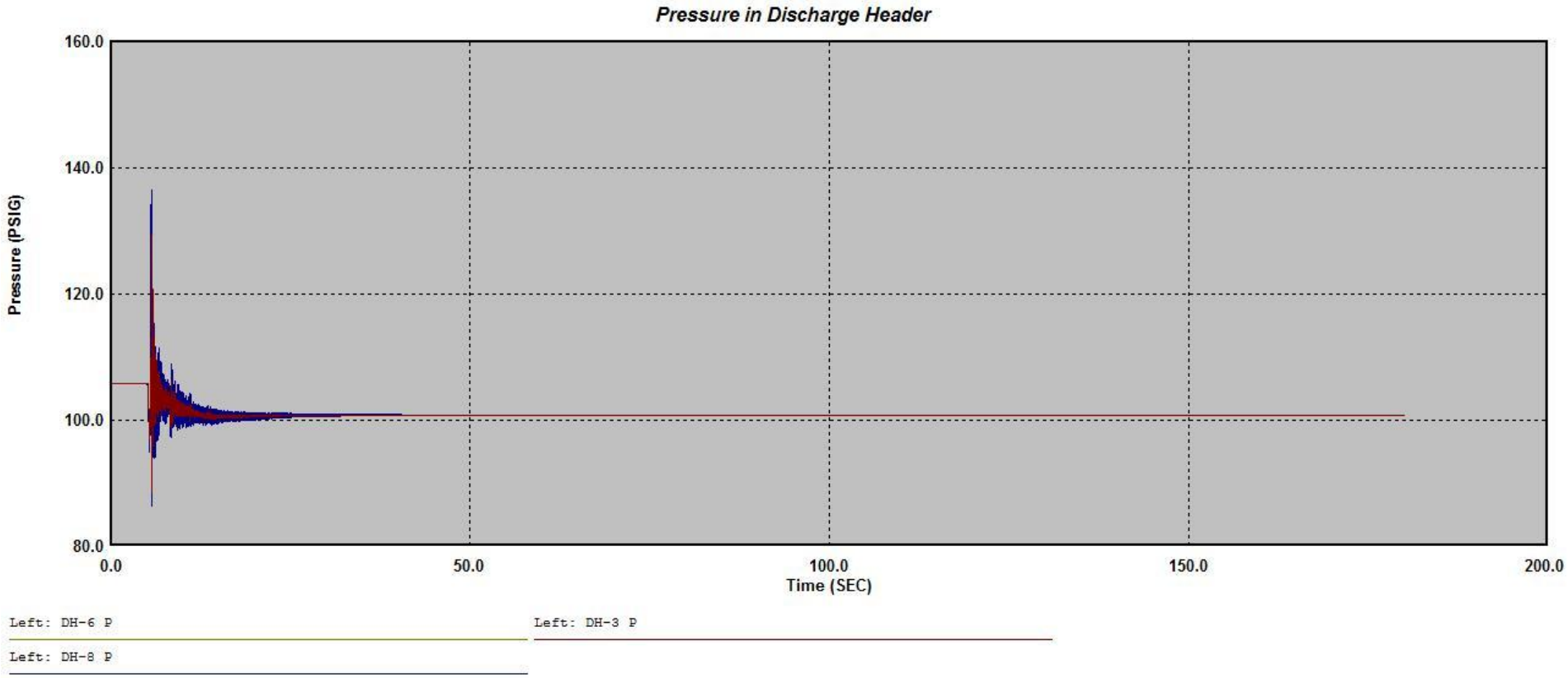
Existing System Conditions
Scenario 4a – Single Pump Failure with Five Pumps Running



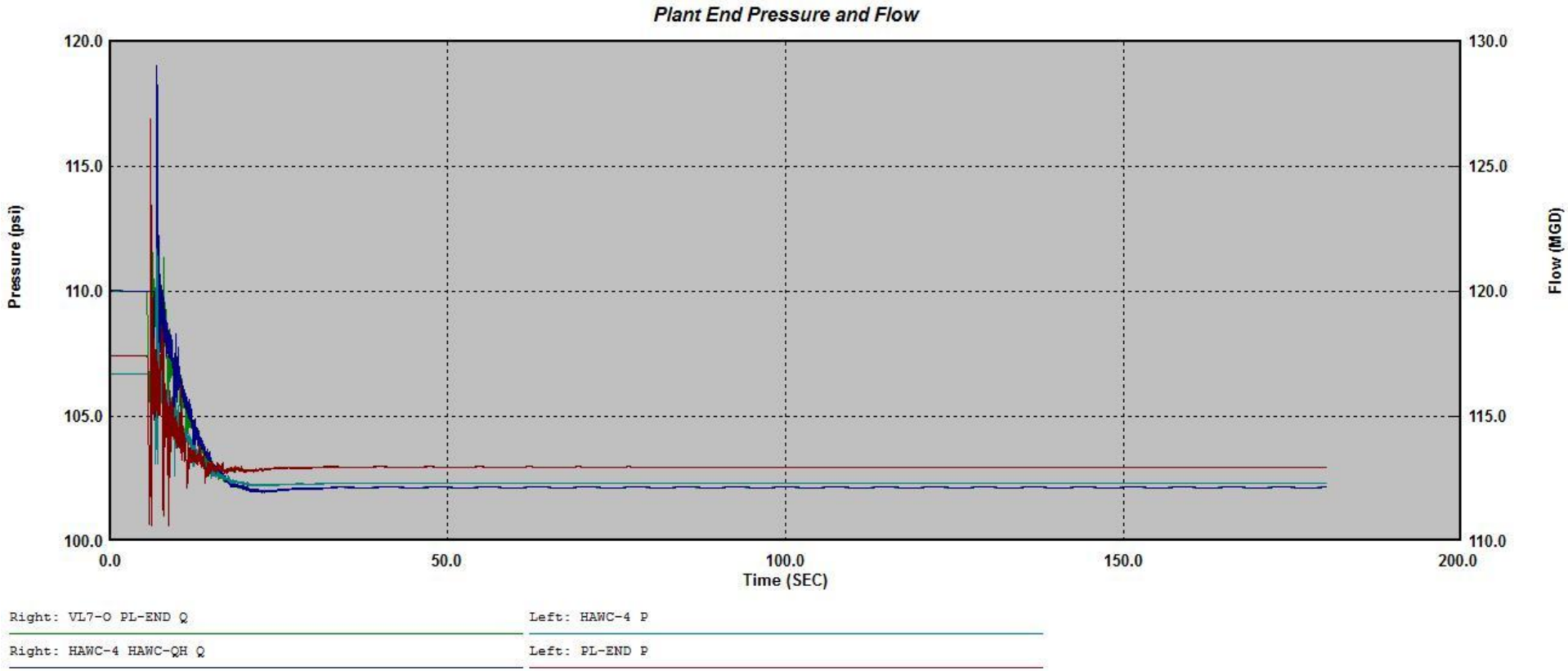
Left: CK8-I CK8-O TAU

Right: CK8-O P

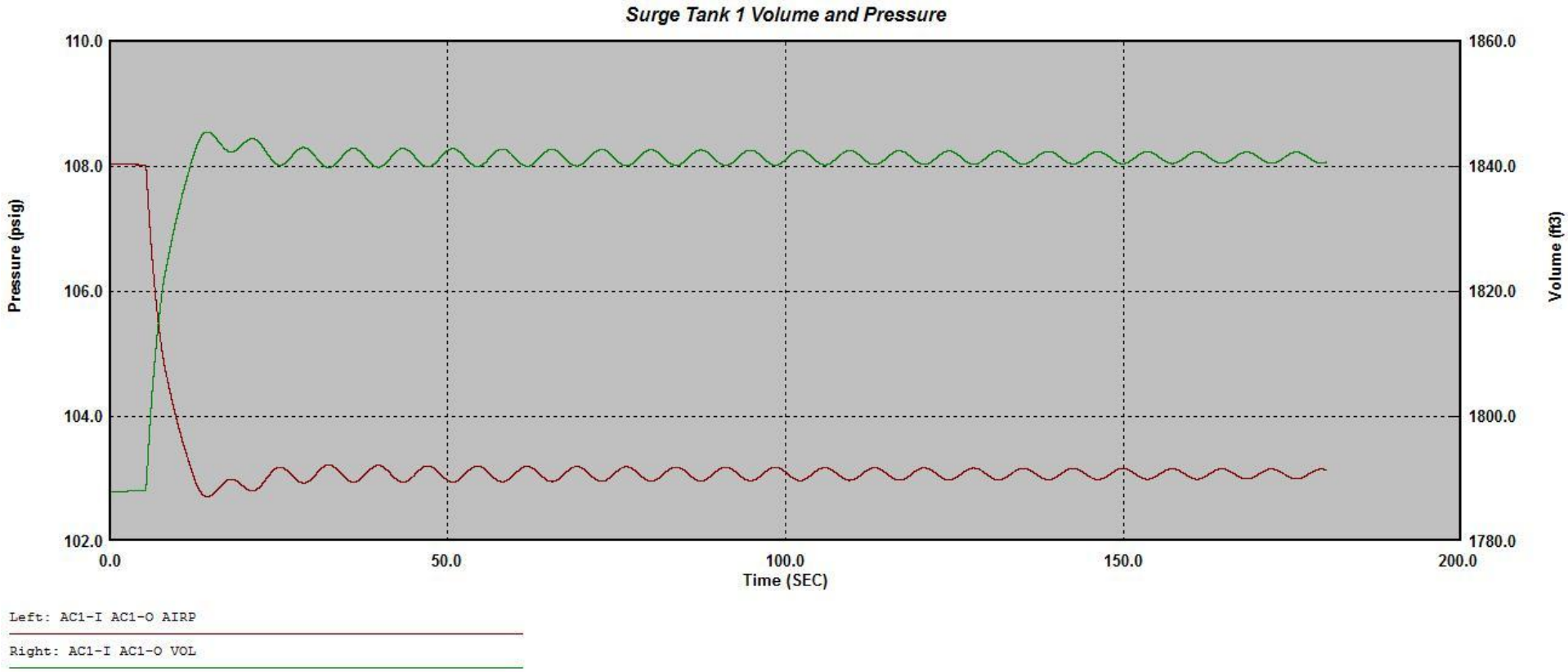
Existing System Conditions
Scenario 4a – Single Pump Failure with Five Pumps Running



Existing System Conditions
Scenario 4a – Single Pump Failure with Five Pumps Running



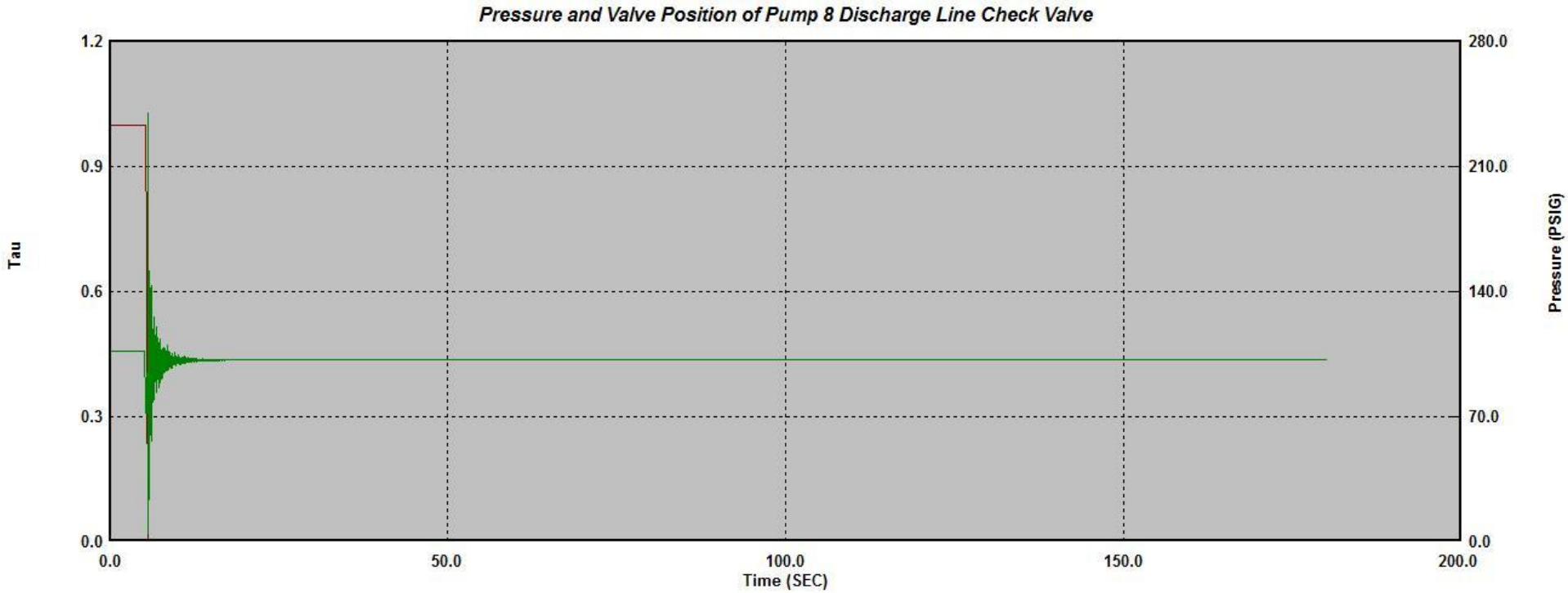
Existing System Conditions
Scenario 4a – Single Pump Failure with Five Pumps Running



AIRP – Air Pressure in Surge Tank
VOL – Volume of Air in Surge Tank

Scenario 4b – Single Pump Failure with Five Pumps Running without Surge Tanks

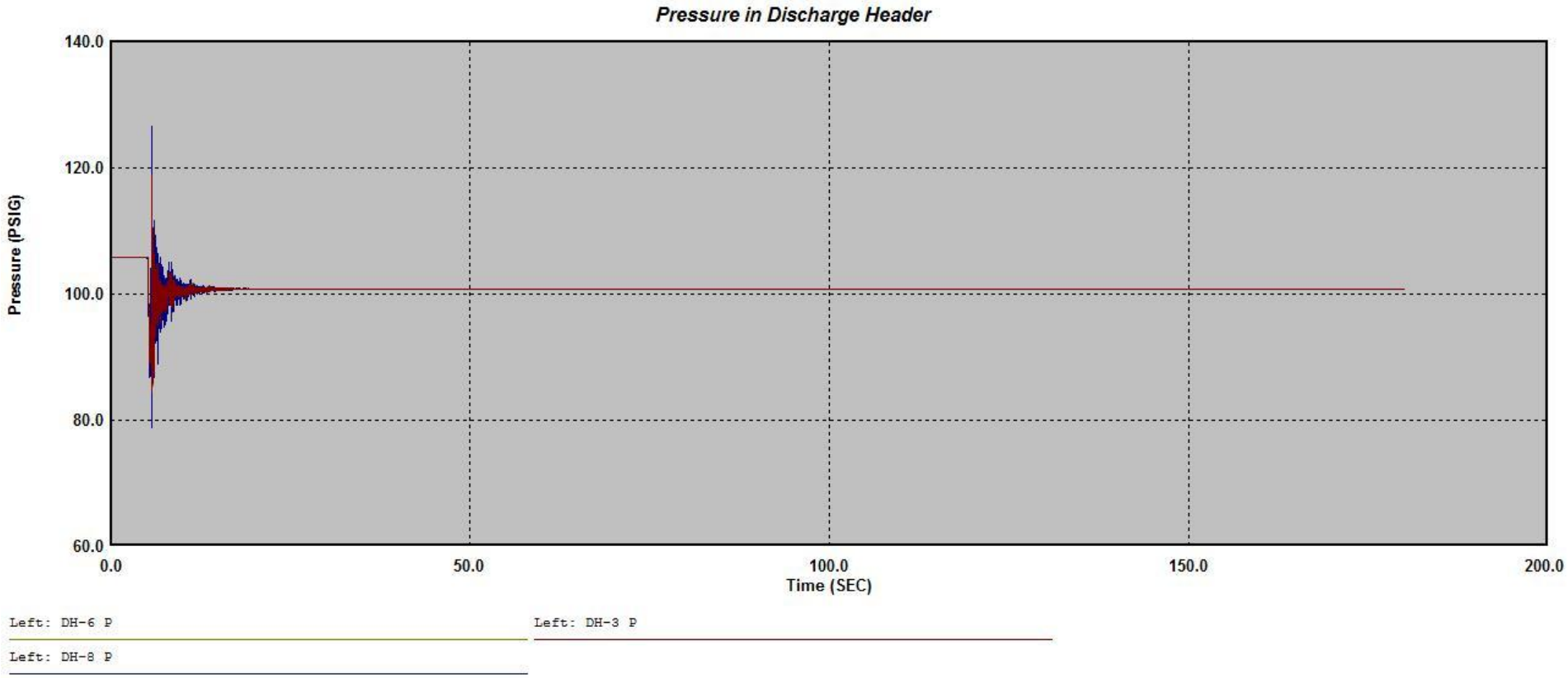
Existing System Conditions
Scenario 4b – Single Pump Failure with Five Pumps Running without Surge Tanks



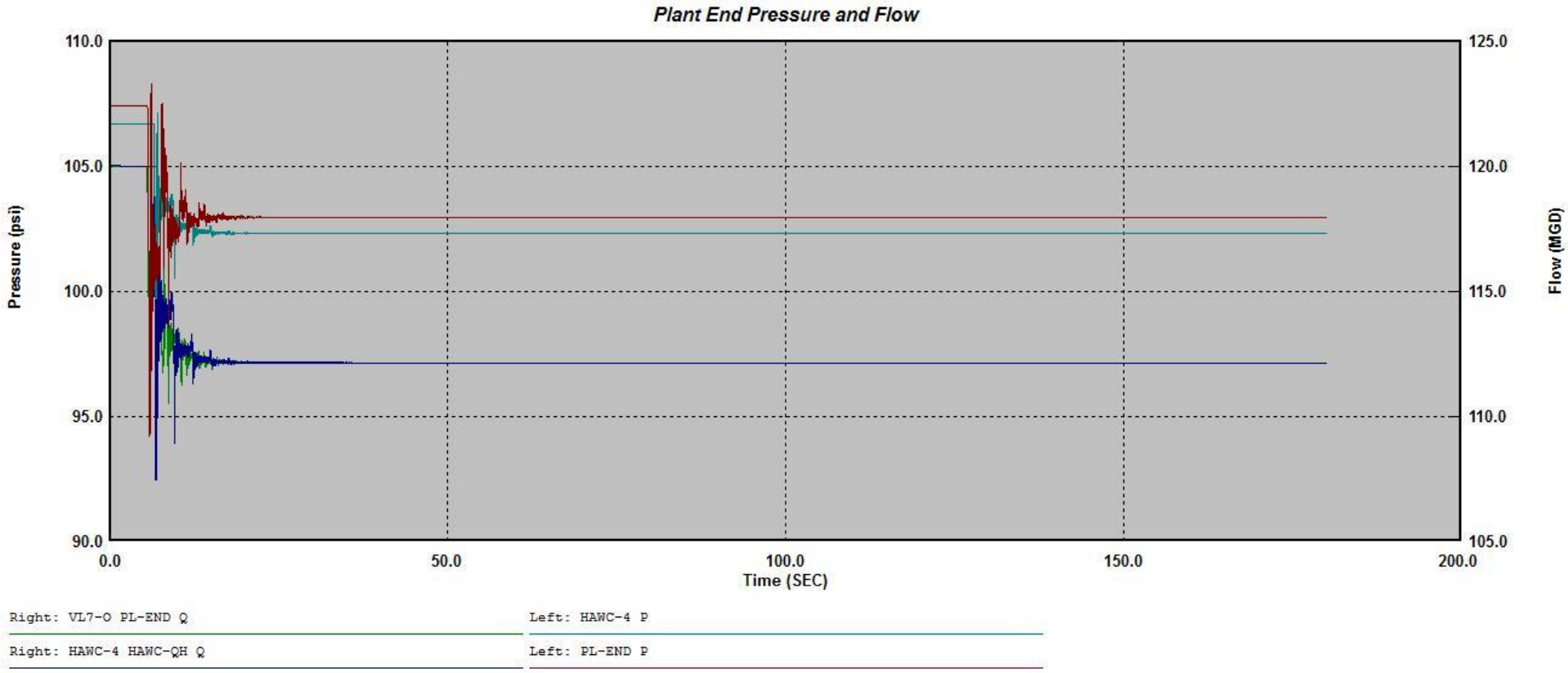
Left: CK8-I CK8-O TAU

Right: CK8-O P

Existing System Conditions
Scenario 4b – Single Pump Failure with Five Pumps Running without Surge Tanks

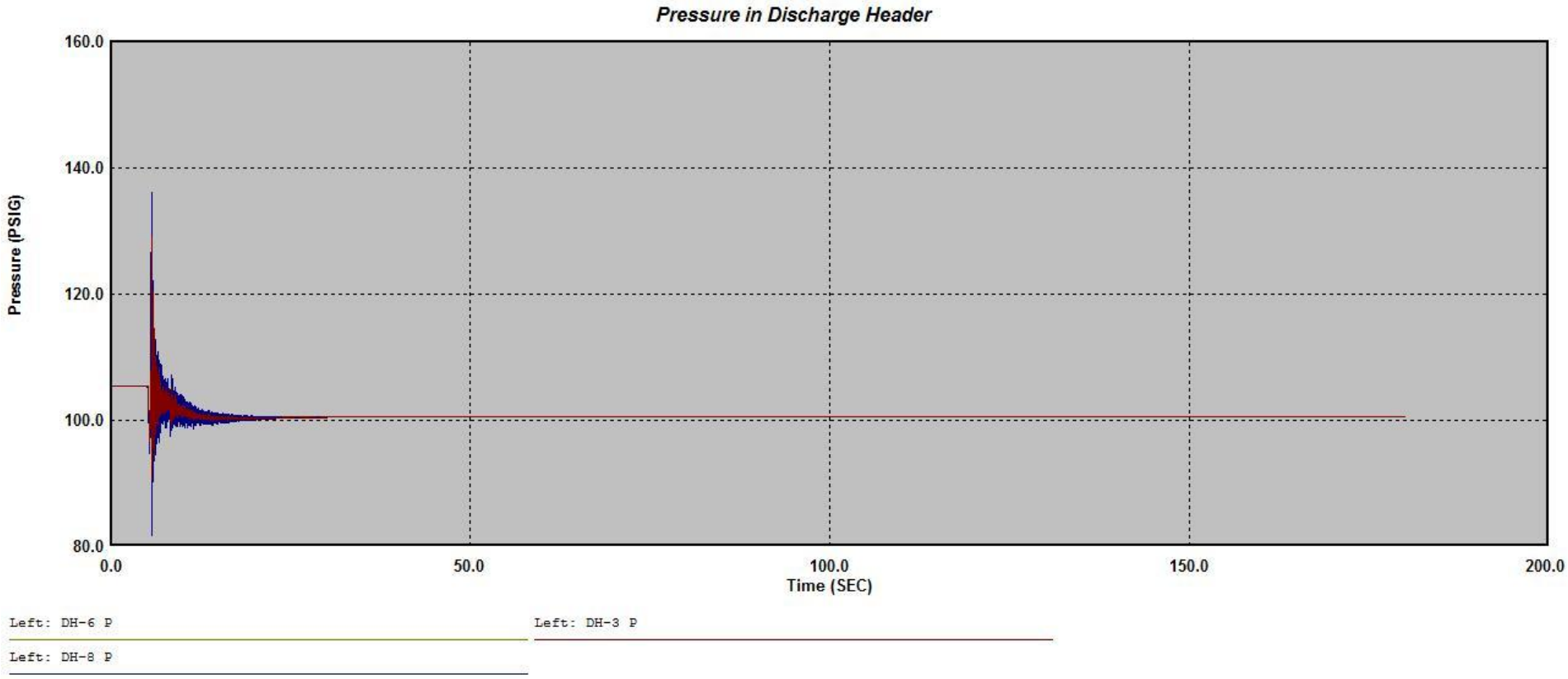


Existing System Conditions
Scenario 4b – Single Pump Failure with Five Pumps Running without Surge Tanks

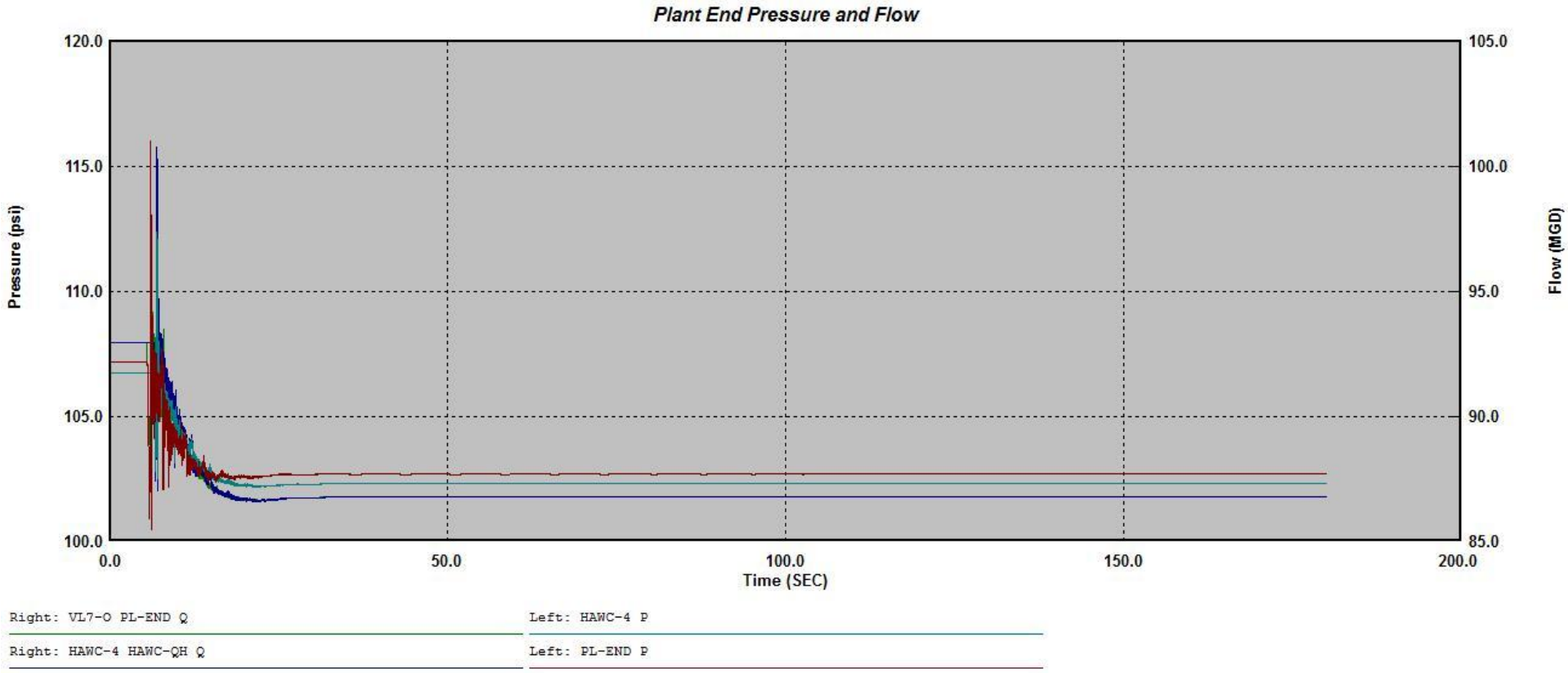


Scenario 4c – Single Pump Failure with Five Pumps Running with LHCS Line

Existing System Conditions
Scenario 4c – Single Pump Failure with Five Pumps Running with LHCS Line

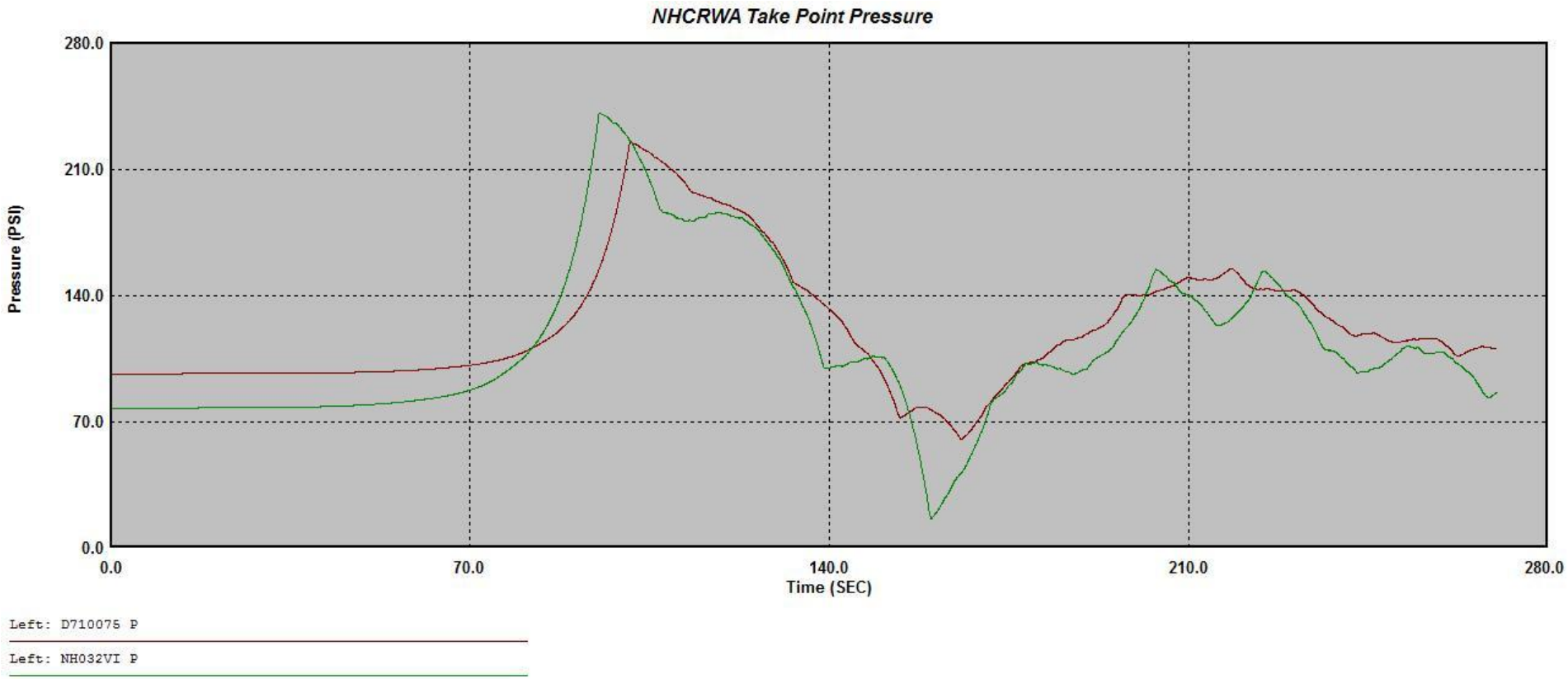


Existing System Conditions
Scenario 4c – Single Pump Failure with Five Pumps Running with LHCS Line

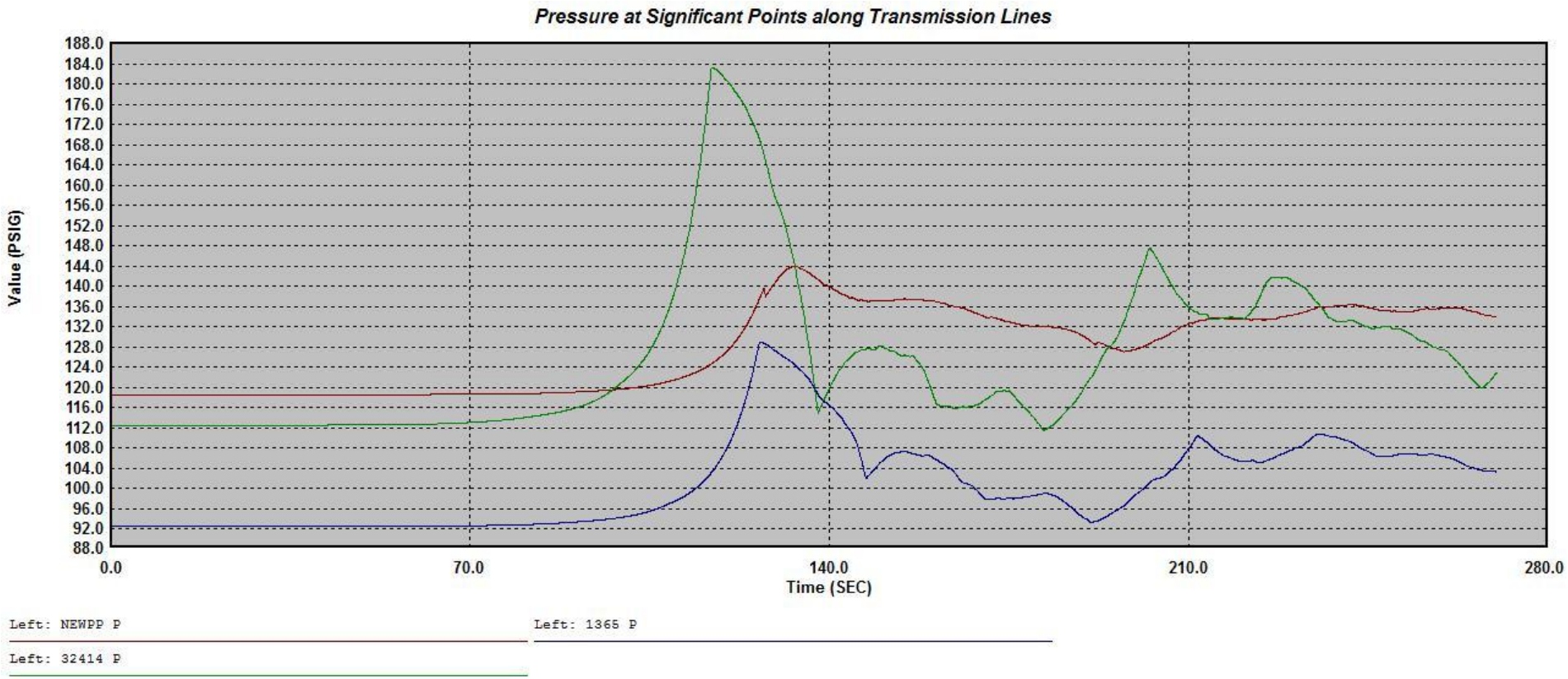


Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD

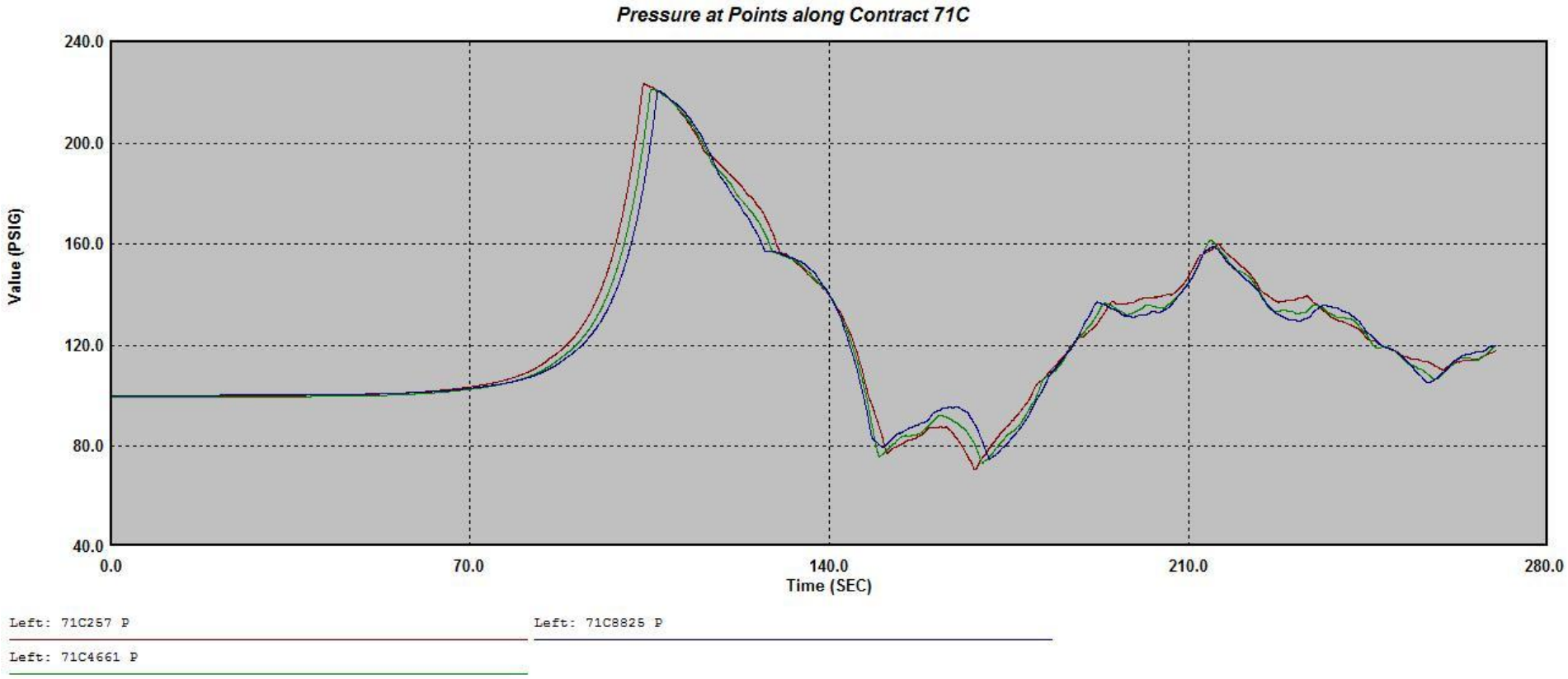
Existing System Conditions
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD



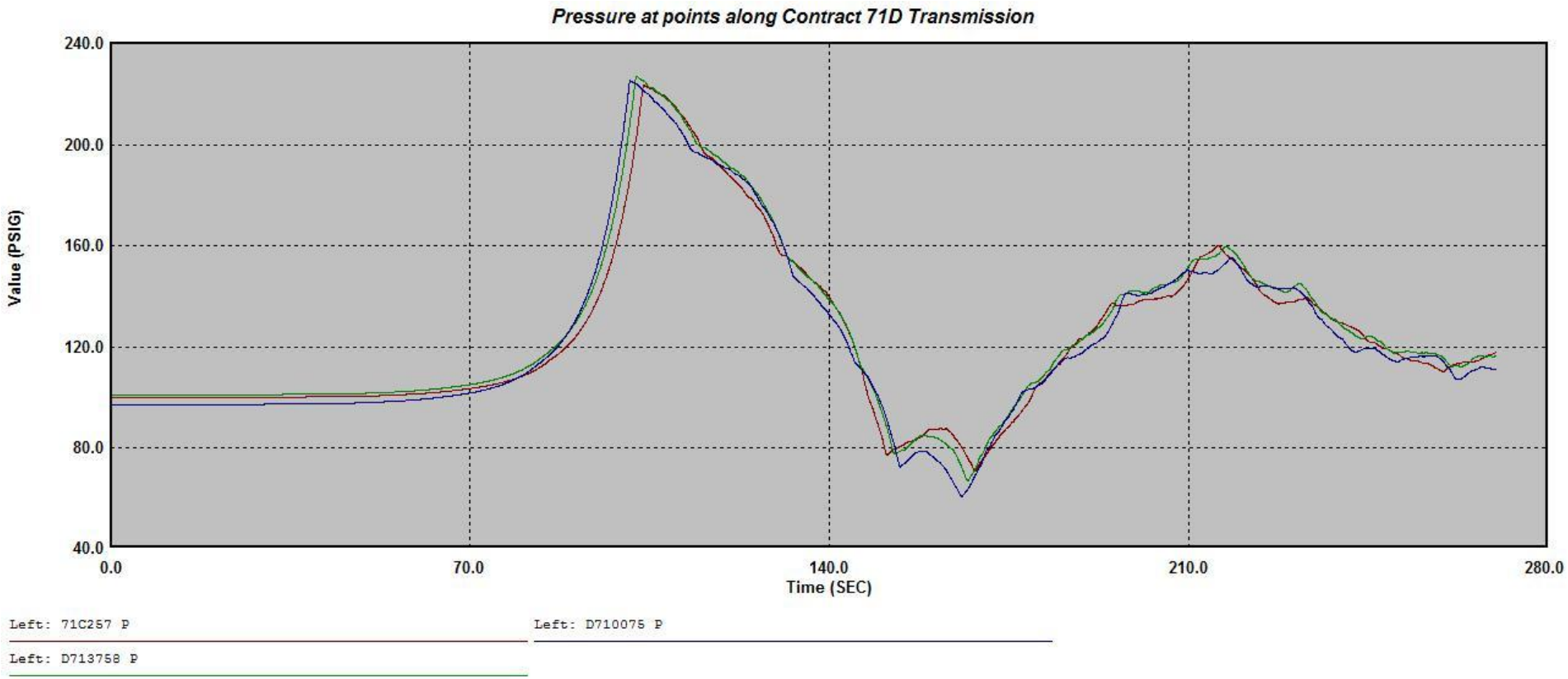
Existing System Conditions
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD



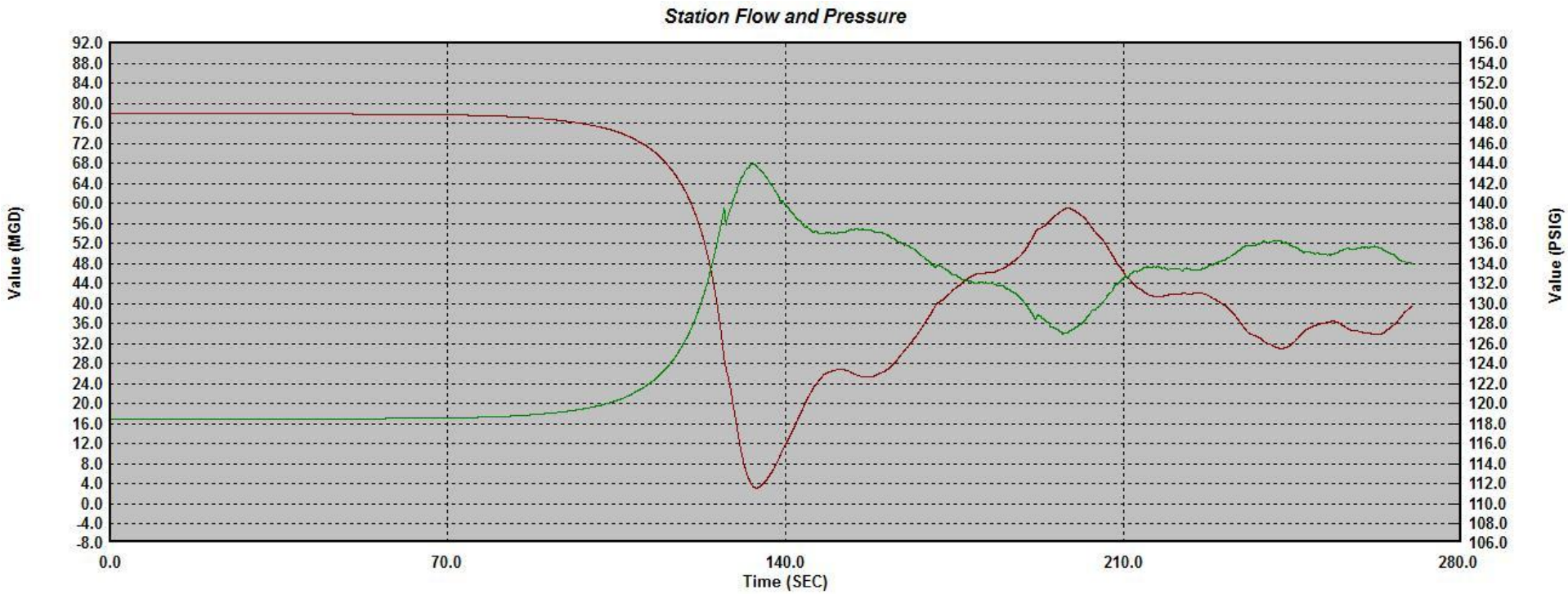
Existing System Conditions
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD



Existing System Conditions
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD



Existing System Conditions
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD



Left: SHEADER NEWPP Q

Right: NEWPP P

Appendix E

Proposed Pump Control Valve Information

Index

Hand Sketches from CDM Smith – Proposed Pump Control Valve Improvements

Adams Triple Offset Disc Valve Information

Adams Triple Offset Disc Valve CV Values

Adams Triple Offset Disc Valve Closure Profile

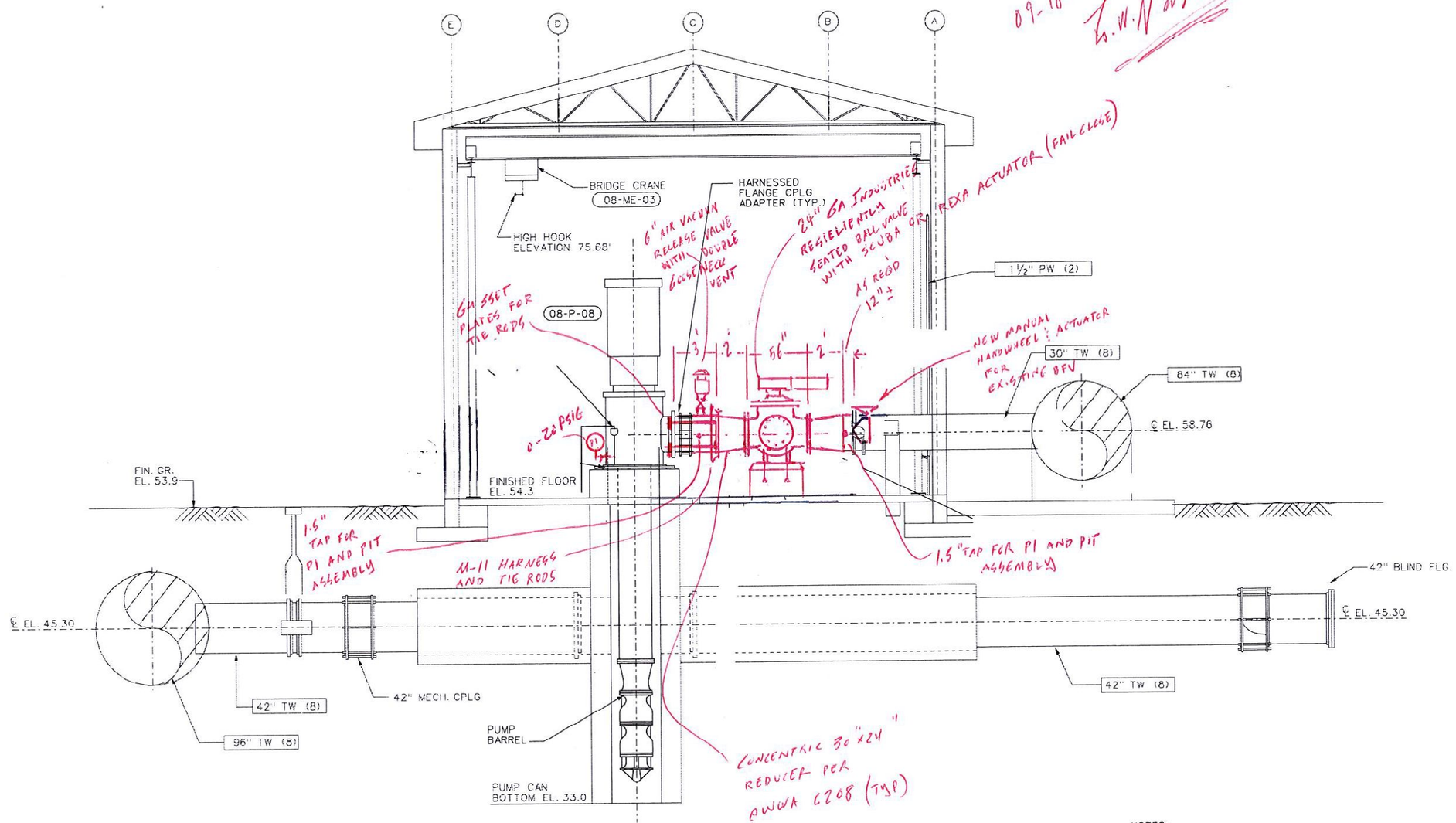
Golden Anderson Resilient Seated Ball Valve Information

Golden Anderson Resilient Seated Ball Valve Closure Profile

Golden Anderson Wye CHECKtronic Valve Information

Golden Anderson Wye CHECKtronic Valve Closure Profile

Job No: 16S0285 File: \\inpuntgent\data\houston record drawings - phase ii\newwp\80exp\wtp\08HiServicePumps_2\Mec\BM-4_2.dgn User: Yogita B Negi Plot Date: 06-FEB-2006 14:31



09-19-13

NOTES:
1. * INDICATES DIMENSION TO BE DETERMINED BY EQUIPMENT PROVIDED.

SECTION A
¼" = 1'-0"
8M-2

REV	DATE	BY	DESCRIPTION
1	2-6-06	YBN	RECORD DRAWING
0	4-13-04	TAV	IFC AND PERMITTING
B	3-23-04	TAV	CLIENT REVIEW
A	3-2-04	TAV	INTERNAL QA/QC REVIEW

SCALE ¼" = 1'-0"

WARNING 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED S. MENDOZA
DRAWN J. THORNE
CHECKED J. VISOSKY

SUBMITTED BY
(RECOMMENDED) LICENSE NO. DATE
LICENSE NO. DATE

MWH MONTGOMERY WATSON HARZA
5100 Westheimer, Suite 580
Houston, TX 77056

Houston Area Water Corporation

NORTHEAST WATER PURIFICATION SYSTEM
PHASE 2 EXPANSION

HIGH SERVICE PUMP STATION
SECTION

SHEET 8M-4

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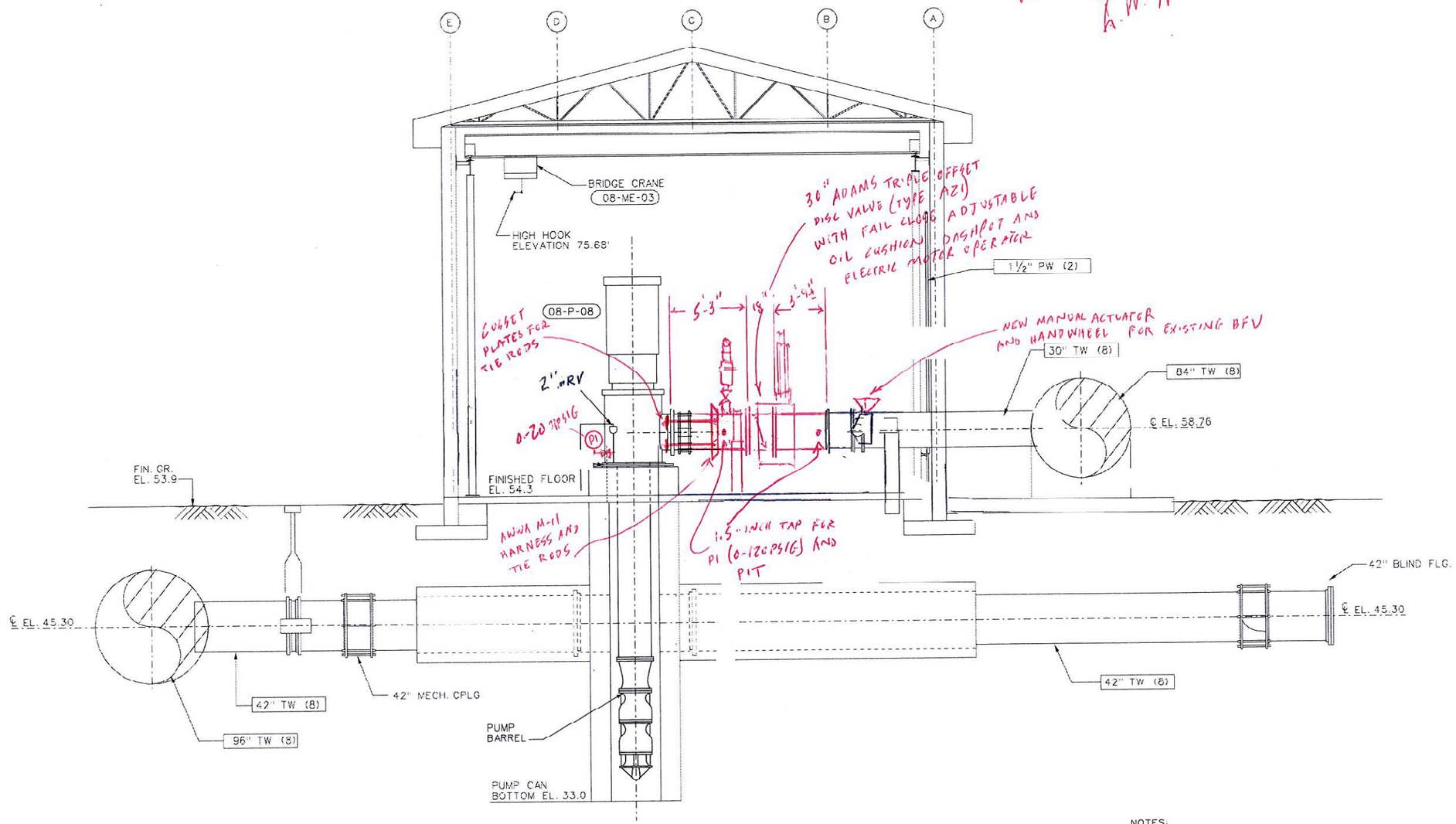
09-18-13 K.W. Nathan



NOTES:
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SECTION A
1/4" = 1'-0" 8M-2

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0	4-13-04	TAV	IFC AND PERMITTING
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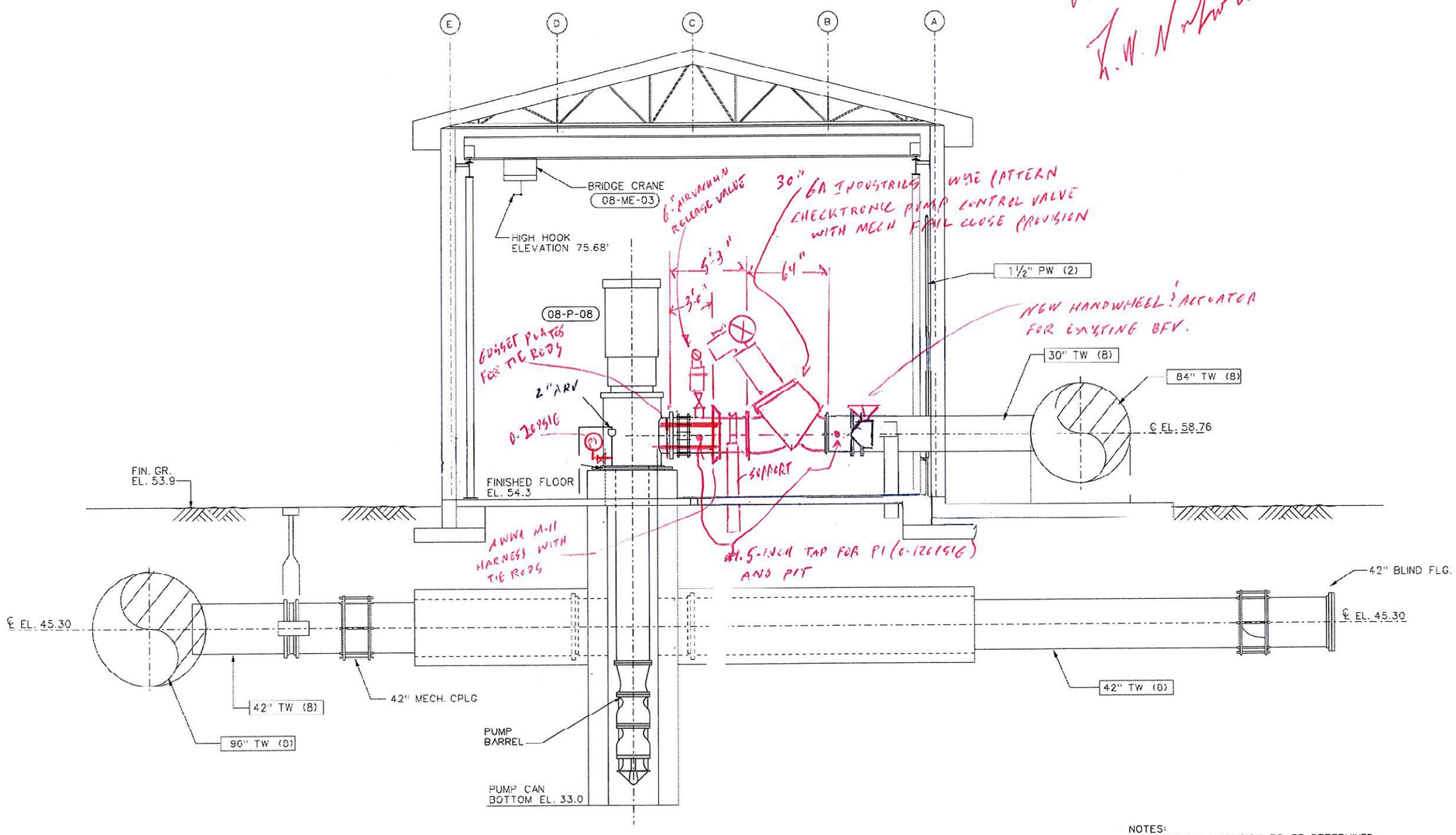
SHEET 8M-4

User: Yogita B Negi Plot Date: 06-FEB-2006 14:31
File: \\hpuntgent\data\houston record drawings - phase ii\newop\80exp\wtp\08HiServicePumps_2\Mec\8M-4_2.dgn
Job No: 1650285

09-18-13
K.W. Nathan



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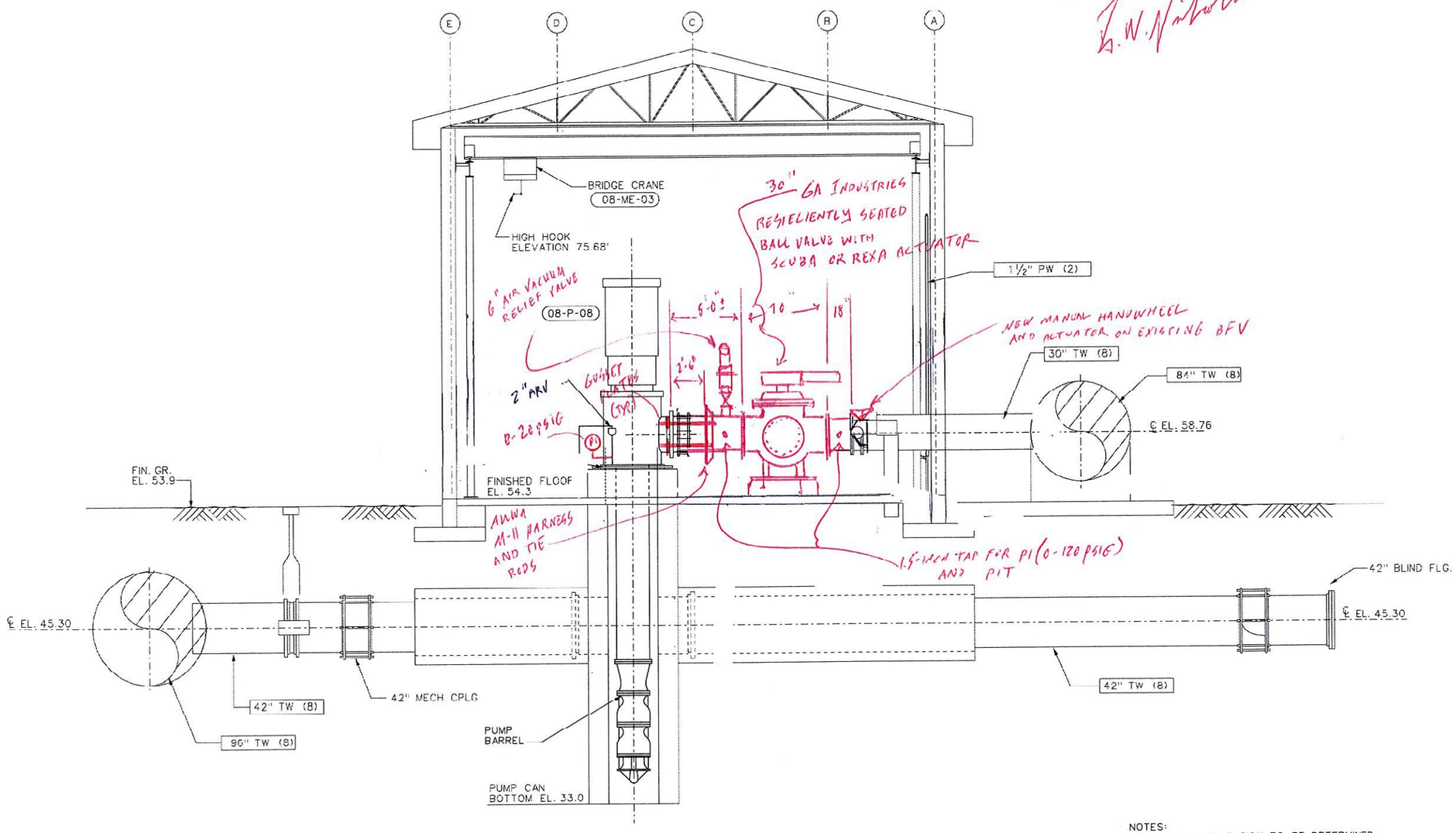

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Houston Area Water Corporation

NORTHEAST WATER PURIFICATION SYSTEM
PHASE 2 EXPANSION

HIGH SERVICE PUMP STATION SECTION

SHEET 8M-4

Job No: 1650285 File:\\inpuntgen1\data\houston record drawings - phase ii\newop\80exp\wtp\08HiServicePumps_2\Mec\8M-4_2.dgn

GBZ / AZI

Nominal Diameters:
GBZ: 100 mm / 4 inches to 800 mm / 32 inches
AZI: 500 mm / 20 inches to 3000 mm / 120 inches

Temperature Range:
-50 °C / -58 °F to +200 °C / +392 °F

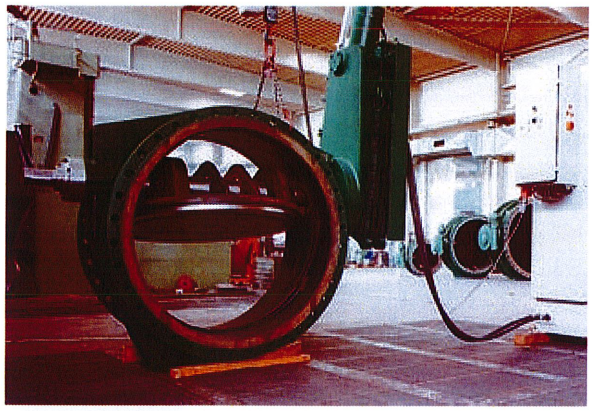
Pressure Class:
PN 2,5/6/10/16/25/40
ANSI 150/300

Features
- *3 in 1 combination valve for tight shut-off, control, and non-return function in one compact unit*
- *resilient seal or laminated metal-to-metal sealing*
- *triple offset design with inclined conical sealing system*
- *auto-closing*
- *minimum pressure loss in open position*
- *GBZ: multirate adjustable hydraulic damping system, located externally and separated from the media*
- *AZI: multi-rate adjustable interval damping system*

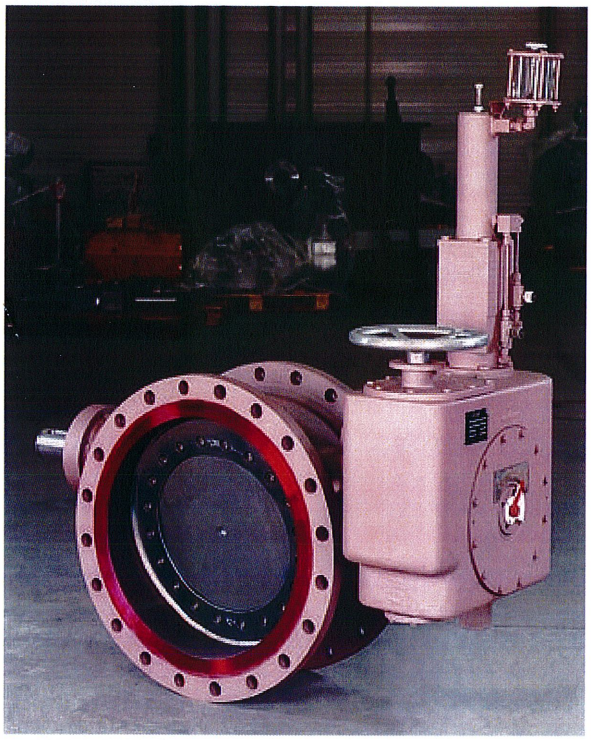
Advantages
- *multi-function*
- *compact design*
- *minimum pressure loss*
- *stable operation*
- *controlled, non-slam closure*
- *additional screw safety device*
- *prepared for retro-fitting of counterweights if flow conditions change*

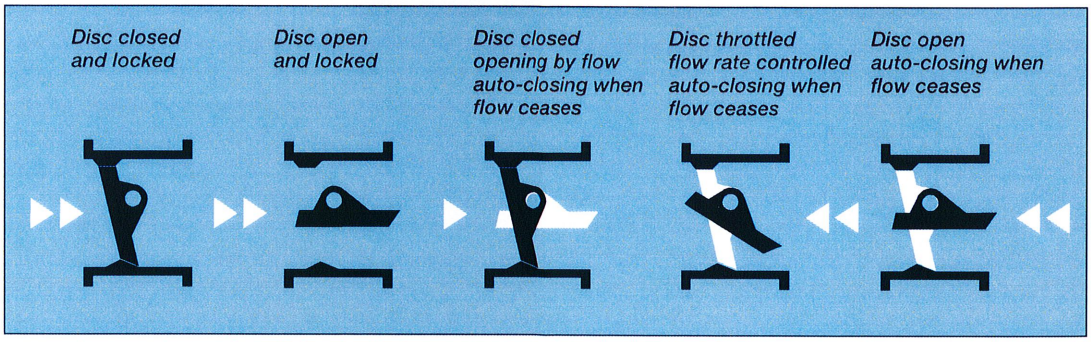
Options
- *wide choice of actuators and control systems*
- *disc locking device, mansafe design*
- *additional counterweight*
- *vulcanized hard rubber coating*
- *butt weld ends*
- *AZI: complete hydraulic unit*

AZI with hydraulic unit



These combination valves developed from RZN and RZI basic types provide multi-function operation as tight shut-off, flow control, and non-return valves in a single, compact unit. They can take the place of shut-off and check valves and fulfill multiple application requirements most economically.
The isolating and control actuator operates through a free travel coupling so that the free-acting hydraulically damped disc can close automatically without slamming, if the pump should fail.





ADAMS ARMATUREN

DURCHFLUSS- UND WIDERSTANDSBEIWERTE
RESISTANCE AND FLOW COEFFICIENTS
RÜCKSCHLAGKLAPPEN / CHECK VALVES
TYPES RZI + AZI

DN	Kva (m³/h)					Zeta / K					Cv (U.S.g.p.m.)				
	PN 2.5	PN 6	PN 10	PN 16	PN 25	PN 2.5	PN 6	PN 10	PN 16	PN 25	PN 2.5	PN 6	PN 10	PN 16	PN 25
500		12 000	11 000	8 700	7 400		0.66	0.88	1.29	1.77		14 000	13 000	10 000	8 700
600		19 000	16 000	14 000	13 000		0.55	0.77	1.02	1.29		22 000	19 000	16 000	15 000
700		27 000	24 000	21 000	17 000		0.51	0.65	0.82	1.26		32 000	28 000	25 000	20 000
750		31 000	28 000	25 000	20 000		0.50	0.63	0.81	1.20		36 000	33 000	29 000	23 000
800	40 000	36 000	32 000	28 000	24 000	0.40	0.50	0.62	0.80	1.15	47 000	42 000	37 000	33 000	28 000
900	51 000	48 000	42 000	36 000	31 000	0.40	0.45	0.58	0.80	1.10	60 000	56 000	49 000	42 000	36 000
1000	64 000	59 000	52 000	46 000	38 000	0.38	0.45	0.57	0.74	1.10	75 000	69 000	61 000	54 000	44 000
1100	78 000	71 000	66 000	56 000		0.38	0.45	0.53	0.73		91 000	83 000	77 000	66 000	
1200	94 000	87 000	78 000	67 000		0.37	0.43	0.53	0.73		110 000	100 000	91 000	78 000	
1300	110 000	100 000	92 000			0.37	0.43	0.53			130 000	120 000	110 000		
1400	130 000	120 000	110 000			0.37	0.41	0.52			150 000	140 000	130 000		
1500	150 000	140 000	120 000			0.37	0.41	0.52			180 000	160 000	140 000		
1600	170 000	160 000				0.37	0.39				200 000	190 000			
1800	210 000					0.37					250 000				
2000	260 000					0.36					300 000				
2200	320 000					0.36					370 000				
2400	390 000					0.34					460 000				

Kva: Durchfluß von Wasser bei vollgeöffneter Armatur in m³/h bei 5 °C bis 40 °C, der einen Druckverlust von 1 bar hervorruft

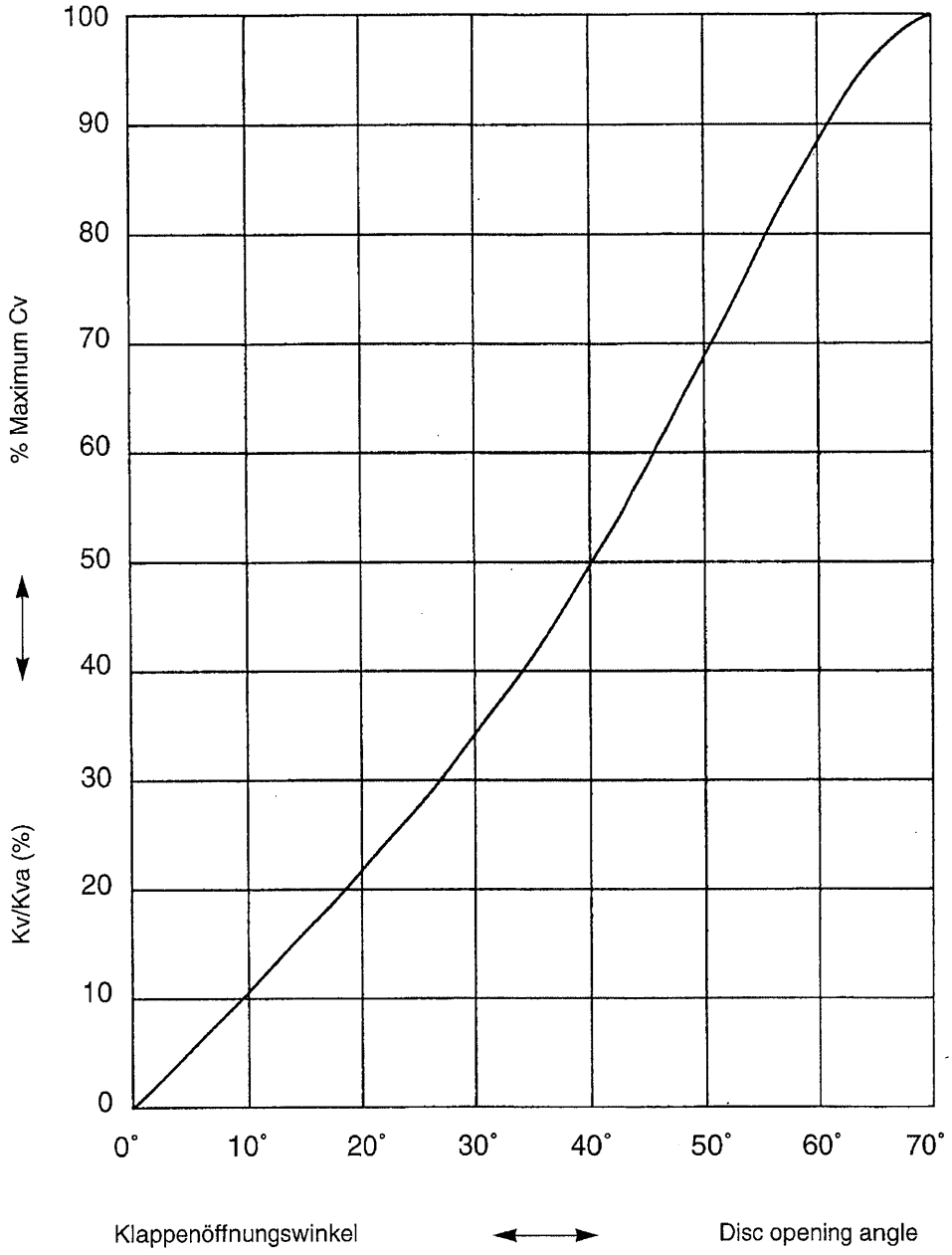
Flow coefficient – expressing flow rate in m³ per hour at 5 °C to 40 °C water through fully open valve with 1 bar pressure drop across the valve

Zeta / K: Widerstandsbeiwert (–) der vollgeöffneten Armatur bezogen auf den Nennquerschnitt

Resistance coefficient of fully open valve based on nominal valve cross section

Cv: Durchfluß von Wasser bei vollgeöffneter Armatur in U.S.-Gallonen/Minute bei 40 °F bis 100 °F, der einen Druckverlust von 1.0 psi hervorruft

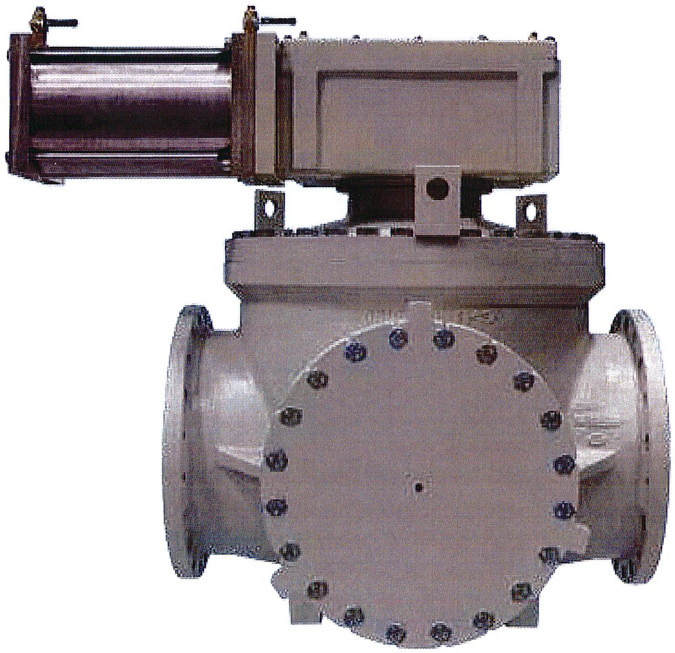
Flow coefficient – expressing flow rate in U.S. gallons per minute of 40 °F to 100 °F water through fully open valve with 1.0 psi pressure drop across the valve


100
90
80
70
60
50
40
30
20
10
0
% Maximum Cv
Kv/Kva (%)
0°
10°
20°
30°
40°
50°
60°
70°
Klappenöffnungswinkel
Disc opening angle

GA INDUSTRIES

Rotary Pump Control Valve

AWWA Resilient Seated Ball Valve



GA INDUSTRIES

A Century of Experience

GA valves are known for long term reliability in the most demanding water and wastewater applications. Whether a simple check valve or a complex automatic control valve, each GA valve is built on over 100 years of design, manufacturing and application experience to ensure its dependability and superior performance.

Outstanding Technical Support

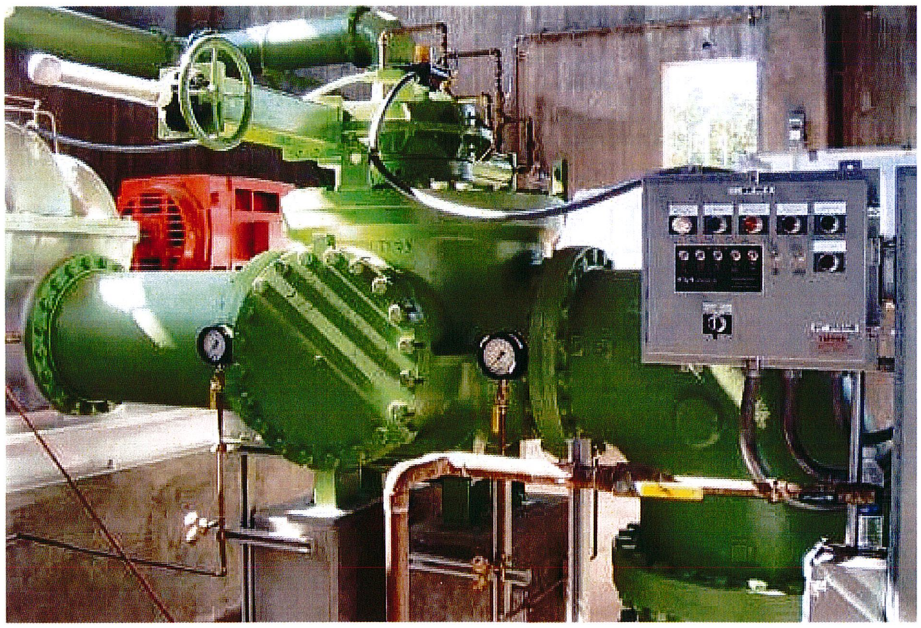
From the factory to the field, GA provides responsive and knowledgeable technical assistance and support. GA application engineers, and our team of trained and experienced sales representatives, work closely with designers to select the right valve from our broad product range to ensure that it meets the system requirements. GA Industries is committed to serving our customers in all phases of the project.

Superior Quality

All GA valves are designed in accordance with AWWA and other industry standards and are precision manufactured from the highest grade materials. Every valve is tested to ensure it meets our high standards and the latest industry requirements so you can be sure it will operate as expected from the minute it is put in service.

Comprehensive Product Range

We are continuously expanding and improving our product line to meet the ever-changing needs of the waterworks industry. From standard butterfly and plug valves to sophisticated, highly engineered pump control, check and surge control valves, GA Industries offers one of the broadest ranges of valves specifically suited to the demanding needs of municipal waterworks. Please see the back cover for a complete listing of our product offering.

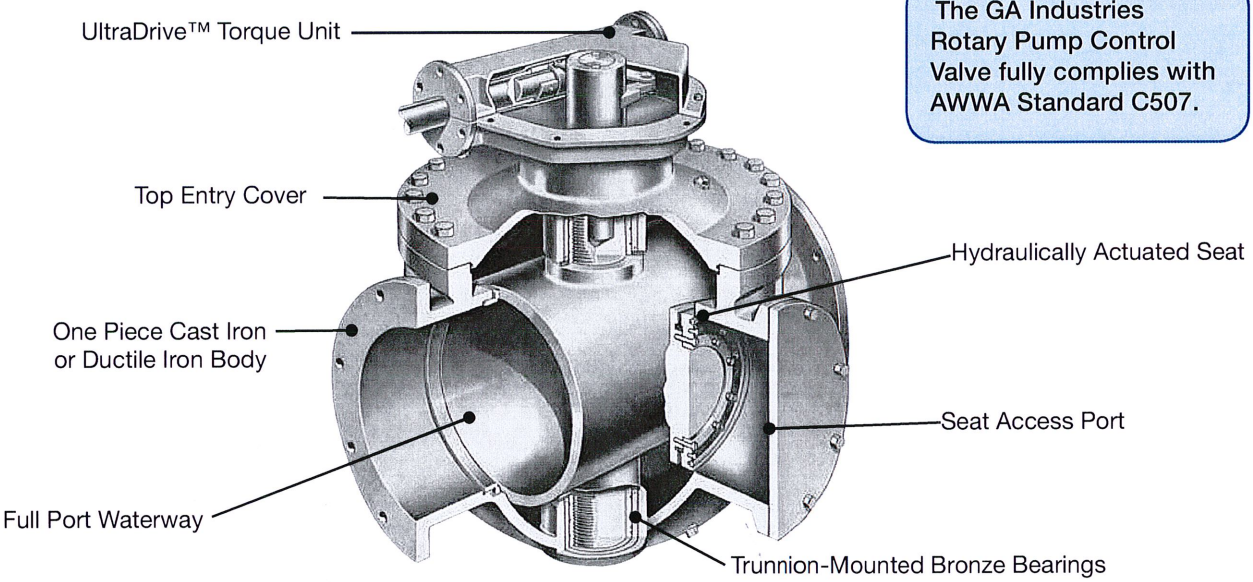


Rotary Pump Control Valve

AWWA Resilient Seated Ball Valve

The GA Industries Rotary Pump Control Valve is the only AWWA C507 Ball Valve specifically designed for pump control service. With advanced technology and a proven design, the GA Rotary Pump Control Valve offers the ideal combination of surge control during pump start-up/shutdown and virtually zero headloss during pump operation. Its heavy-duty trunnion-mounted design and hydraulically actuated resilient seat provide dependable long-term service under the most severe conditions.

The GA Industries Rotary Pump Control Valve fully complies with AWWA Standard C507.



Top Entry Body

Rugged one-piece body with bolted cover, available in ASTM A126 Class B cast iron with integral ANSI Class 125 flanges or ASTM A536 Grade 65-45-12 cast iron with ANSI Class 150, 250 or 300 flanges, sizes 6" to 36".

Trunnion-Mounted Bearings

Integrally cast hubs on the ductile iron rotor are fitted with heavy bronze bearings that ride in precision machined bushings in the body and cover for long-term, low-friction operation. The rigid trunnion-mounted design removes all hydraulic loads from the shaft so that the shaft only transmits rotational forces.

Hydraulically Actuated Seat

The "floating" resilient seat allows the valve to rotate open and closed without seat contact for long-term drop tight seating, whether operating at low or high pressure.

Full Port Waterway

The full pipe diameter and smooth, unobstructed waterway affords virtually zero headloss and thus, reduced pumping costs.

UltraDrive™ Torque Unit

The UltraDrive™ Torque Unit converts the linear motion of the cylinder actuator into a 90-degree rotation of the rotor, providing superior surge control at critical pump start-up and shutdown.

Seat Access Port

The unique side access port allows the resilient seat to be inspected, adjusted or replaced using common tools and without a lengthy disruption of service.

Proven Design

The GA Rotary Pump Control Valve has successfully undergone proof of design testing as required by AWWA C507 and every valve is rigorously tested before it leaves the factory.

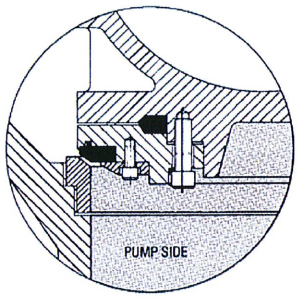
Design Features

The GA Rotary Pump Control Valve is a full ported valve with unique design features that make it dependable and easy to maintain.

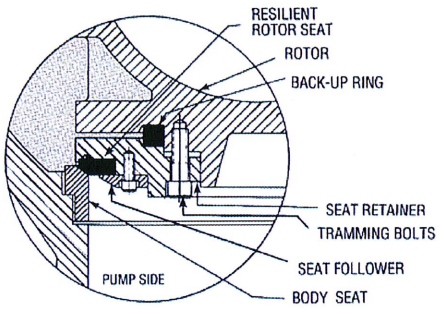
Hydraulically Actuated Seat

Unlike rubber seated ball valves that seal by deforming the rubber seat, GA's innovative UHMWPE hydraulically actuated resilient seat is "position" seated for prolonged seat life and reduced operating torque.

Valve Opening/Closing - Pump Running



Valve Closed - Pump Off



Pump Startup - Valve Opening
The pump starts against a closed valve. The high pump discharge pressure pushes the seat retainer away from the body seat before the valve starts to rotate open so the valve rotates open without seat contact.

Normal Pump Shutdown - Valve Closing
The valve rotates closed against the running pump. Pump discharge pressure increases and system pressure decreases as the valve approaches the seat. The resulting differential pressure keeps the seat retainer away from the body seat allowing the valve to rotate closed without the resilient seat contacting the body seat.

Valve Closed - Pump Off
The pump switches off only after the valve is closed. Downstream pressure pushes the seat retainer toward the pump pressing the resilient seat against the body seat. Seat compression is controlled by the adjustment of "tramming bolts" so that the valve seats drop tight even at very low static pressures.

Maintenance and Seat Accessibility

The GA Rotary Pump Control Valve is the only "top-entry" AWWA ball valve, permitting complete valve disassembly while the valve body remains in the line (Figure 1). Further, its resilient seat can be inspected, adjusted and, if necessary, replaced without disassembling the valve or removing any associated piping. After isolating the valve, relieving internal pressure and rotating it to the fully open position (Figure 2) the resilient seat is accessible by removing the flanged cover on the side port. The resilient seat then can be easily and quickly replaced using common tools. Figure 2 also illustrates the valve's full port unobstructed waterway providing the lowest possible pumping cost.

Figure 1

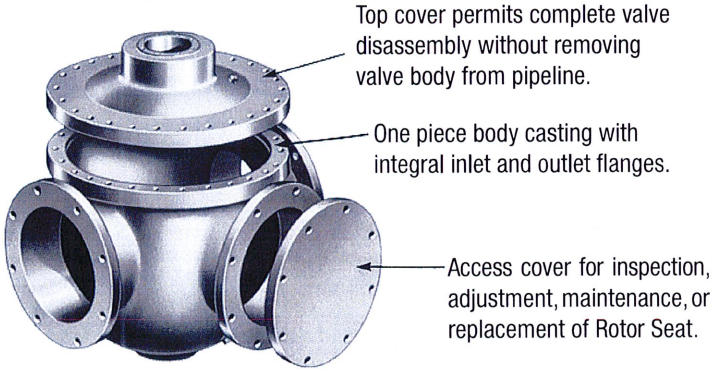
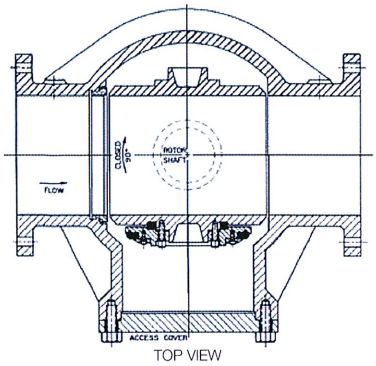
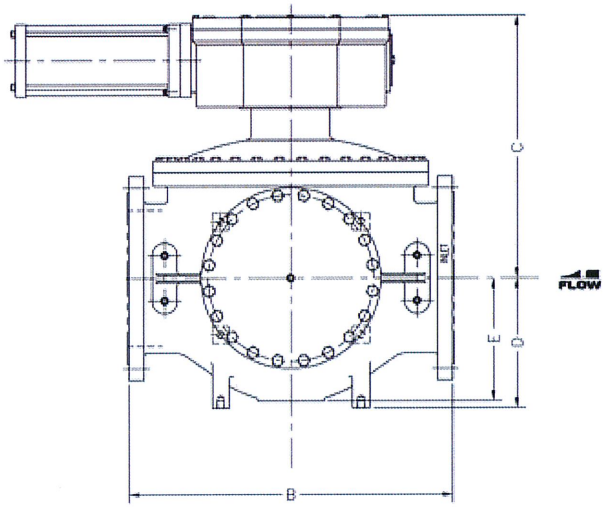
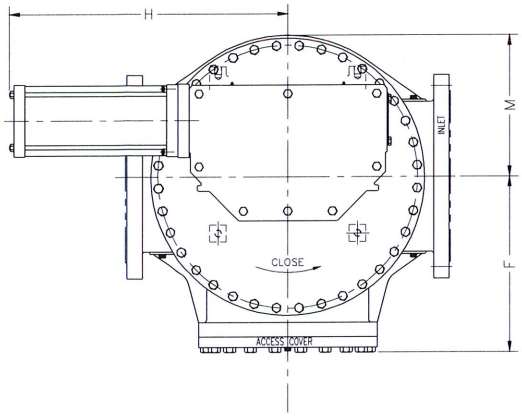


Figure 2





Side View



Top View

Dimensions (inches)

Size	B (See Note 1)		C	D	E	F	H (See Note 2)	M	Approx. Weight (lbs)
	ANSI Class 125/150	ANSI Class 250/300							
6"	20	20	23	6½	6½	10	41	7	1,100
8"	23½	23½	24	8¼	7¾	12½	41	9¾	1,300
10"	28⅛	28⅛	25	9⅝	9	15	41	10½	1,600
12"	31	32½	26	10⅞	10¾	15½	41	13	2,200
14"	37	37	35	13	12⅞	18½	43	15	3,000
16"	39	41	37	15	12½	22	43	16¼	4,200
18"	43¼	43¼	40	16½	15	23	43	20	4,500
20"	47	49	41	18	16	26½	43	21	5,500
24"	56	57¾	49	21¾	23	31¼	50	25	9,600
30"	70	70	55	27¼	24	40½	50	30	16,000
36"	78	78	57	29	26¾	41½	50	35	24,000

Note:
1. Dimension B for valves with raised face flanges does not include the raised face height.
2. Dimension H may vary based on the application.
3. Access port can be on either side, cylinder actuator can rotate in 90° increments about the valve shaft.
4. Request certified drawings if dimensions are critical.
5. Cylinder operated valve depicted. Consult factory for information on valves operated by an air/oil cylinder or an electric motor actuator.

Standard Materials

Body and Cover	Cast Iron, ASTM A126 Class B Ductile Iron, ASTM A536 Grade 65-45-12
Body Seat Ring	Bronze, CDA 83600 Optional: Stainless Steel, Type 304 or 316
Rotor	Ductile Iron, ASTM A536 Grade 65-45-12
Rotor Seat	Ultra High Molecular Weight Polyethylene (UHMWPE)
Bearings/Bushings	Bronze, CDA 93200
Shaft	Stainless Steel, Type 303
Shaft Packing & Seals	Buna-N Optional: EPDM

Other materials are available on special order, consult factory for more information.

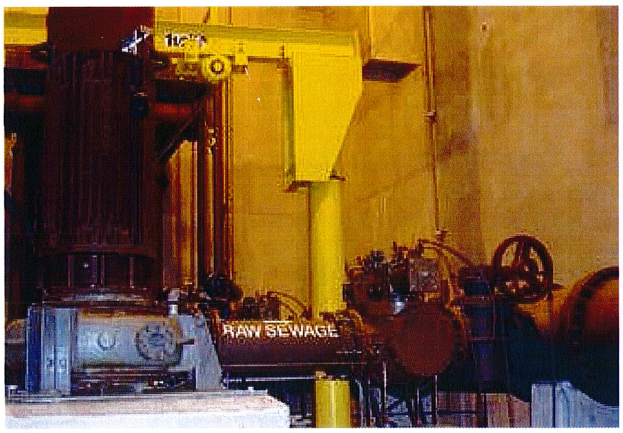
Projects

GA Industries Rotary Pump Control Valves provide the ideal combination of excellent surge control and the lowest possible headloss with a dependable and easily maintainable design. These AWWA ball valves can be used in all types of water and sewage applications. Here are a few of our many installations.

Etowah River Water Treatment Plant, Georgia, USA
6-16" GA Ball Valves with water cylinder actuator

James T. Quarles Water Treatment Plant, Georgia, USA
2-16", 3-20", 2-36" GA Ball Valves with oil cylinder actuator

McLean Booster Pump Station, Saskatchewan, Canada
2-20" GA Ball Valves with air/oil cylinder actuator



Meadowville Sewage Pump Station, Virginia, USA
3-12" GA Ball Valves with air/oil cylinder actuator

Options

Pump Director™

- **Pump Director™** – Model 7600 (relay-logic) or Model 7700 (PLC) pre-wired control panel to sequence operation of pump motor with the Figure R201 Rotary Pump Control Valve.
- **Double Seats** – Provide drop tight shutoff in either direction. Typically required only when Figure R201 is used as an isolating valve and not for pump control service.
- **Mounting Base** – Facilitates installation on support pier.
- **Manual Operator** – Provides method to close the valve in the event of inoperative hydraulic/pneumatic controls.
- **Electric Motor Actuation** - Quarter-turn with gearbox or multi-turn with UltraDrive, open/close or modulating, AC or DC electric motor actuation is available.

Specification

Rotary Pump Control Valve with Cylinder Actuator AWWA C507 Ball Valve Sizes 6" to 36"

DESIGN

A. The Rotary Pump Control Valve shall be a trunnion-mounted, resilient seated ball valve especially designed, manufactured and tested for pump control service in accordance with the latest revision of AWWA Standard C507.

B. The ball valve shall be rotated open and closed by a cylinder actuated link and lever drive mechanism and sequenced with the operation of the pump motor by a system of pilot controls. The ball valve, drive mechanism, cylinder actuator and controls shall be factory assembled, tested as a system and ready for installation.

C. The ball valve shall be Pressure Class 150, 250 or 300 and have integral flanged ends per ANSI Class 125, 250 or 300 as listed in the schedule or shown on the plans.

D. When open, the ball valve shall have a full pipe diameter, circular, unobstructed waterway and when closed shall seal drop tight to prevent reverse flow.

CONSTRUCTION

A. The ball valve shall have a one-piece body with bolted top cover so that all internal components can be serviced without removing the valve from the line. Multi-piece body valves are not acceptable. Unless otherwise specified, Pressure Class 150 valves shall be made from ASTM A126 Class B cast iron and Pressure Class 250 and 300 valves shall be made from ASTM A536 Grade 65-45-12 ductile iron. The valve body shall have a single bronze or stainless steel replaceable body seat on the pump side and shall incorporate integral pads to support the weight of the valve.

B. The valve body shall be provided with a seat access port with bolted cover to permit inspection, adjustment or replacement of the resilient rotor seat without valve disassembly or removal of adjacent piping.

C. The rotor (ball) shall be made from ASTM A536 Grade 65-45-12 ductile iron and have integrally cast upper and lower trunnions on the axis of rotation. The trunnions shall be fitted with bronze bearings that mate with bronze bushings in the body and cover and be sealed by removable O-ring cartridges.

D. The rotor shall be connected to the drive mechanism by a Type 303 stainless steel shaft which shall transmit rotational forces only and not be subjected to hydrodynamic side loads or be used as a sealing or bearing surface.

E. The rotor shall have a single, hydraulically actuated seat made from Ultra High Molecular Weight Polyethylene (UHMWPE) that is adjustable and replaceable through the seat access port using common hand tools. The resilient seat ring shall be assembled to a ductile iron seat retainer with a bronze or stainless steel retainer. The seat assembly shall move axially in response to system hydraulic forces. When in the closed position, downstream pressure shall press the seat assembly against the body seat to make a drop tight seal. Pump discharge pressure shall move the seat assembly away from the body seat to minimize wear while the valve is opening and closing. Adjustable tramming bolts shall control the resilient seat compression.

F. The valve shall be rotated open/closed by a specially designed link and lever mechanism that is securely mounted to the valve cover and keyed to the shaft. The mechanism shall convert the linear motion of the cylinder actuator to a characterized valve closure by imparting a decreasing rotational speed as the rotor approaches the closed position for ideal surge control. Visual indication of valve position shall be provided.

ACTUATION

A. The valve shall be operated by a metallic cylinder actuator conforming to AWWA C507 that is attached to the drive mechanism and does not swivel or pivot. Cylinder actuators shall be sized to reliably operate the valve under all conditions.

B. Water cylinder actuators shall have brass, bronze or stainless steel tubes with at least a 16 micro-inch inside surface finish. Cylinder heads and piston shall be made from bronze, stainless steel or other inherently corrosion resistant material. Cylinder rod shall be hard chrome plated stainless steel and equipped with a replaceable rod wiper and rod seal made from Buna-N or other suitable material.

C. Oil cylinder actuators shall have steel tubes with at least a 16 micro-inch inside surface finish and cast iron, ductile iron or steel heads and piston. Cylinder rod shall be hard chrome plated stainless steel and equipped with a rod wiper and replaceable rod sea made from Buna-N or other suitable material.

D. Pneumatic cylinder actuators shall be of the "air/oil" type such that operating forces are provided by the air cylinder but accurate operating speed control is provided by the opposed oil cylinder utilizing a self-contained hydraulic system.

CONTROLS

A. Controls shall consist of a 2-position, 4-way normal solenoid pilot with manual operator, independently adjustable opening and closing speed controls, 2-way emergency solenoid pilots with separate adjustable emergency closing speed control, pilot strainer or filter and pilot isolating valves.

B. Provide SPDT limit switches to indicate full open, full closed and an intermediate "pump motor off" signal.

C. When specified, an auxiliary manual operator shall be provided to close the valve in the event of an inoperative cylinder actuation system.

FUNCTION

A. The Rotary Pump Control Valve shall function to prevent surges associated with the starting and stopping of a pump.

B. The valve shall open at the rotational speed set on the opening speed control valve whenever the normal and emergency solenoids are energized.

C. The valve shall close at the rotational speed set on the normal closing speed control valve whenever the normal solenoid is de-energized but the emergency solenoid is energized. The "pump motor off" limit switch contacts shall open at an adjustable point near the fully closed position which simultaneously de-energizes the emergency solenoid and disengages the pump motor.

D. Should the normal and emergency solenoids simultaneously de-energize during the course of pumping due to a power outage, pump or motor failure, the valve shall rotate closed at the speed set on the emergency closing speed control valve.

MANUFACTURER

A. The Rotary Pump Control Valve shall be Figure R201 as manufactured by GA Industries, LLC, Cranberry Township. PA

Note: Consult GA Industries for specification information on electric motor actuated ball valves, optional construction, and accessories.

GA Industries offers a broad range of valves designed specifically for the waterworks market

AWWA C504
Rubber Seated Butterfly Valves
- Flanged and Mechanical Joint Ends
- Manual and Automatic Actuation

AWWA C507
Ball Valves
- Metal Seated
- Resilient Seated
- Hydraulic, Pneumatic, or Electric Motor Actuation

AWWA C508
Check Valves
- Cushioned Swing Check
- Rubber Flapper Check
- Globe and Wafer Silent Check
- Ball Check
- Foot Valves

AWWA C512
Air Valves for Water and Sewage
- Air Release
- Air and Vacuum
- Combination
- Vacuum Breaking

AWWA C517
Eccentric Plug Valves
- Flanged, Threaded, and Mechanical Joint Ends
- Manual and Automatic Actuation

AWWA C530
Control Valves
- Pump Control for Water and Sewage
- Surge Relief for Water and Sewage
- Level Control
- Pressure Regulating
- Solenoid Operated
- Anti-Cavitation

For more information about GA Industries' products, or to contact a sales representative, visit the GA website (**www.gaindustries.com**).

GA Industries, LLC • 9025 Marshall Road • Cranberry Township, PA 16066-3696 USA
Phone: 724-776-1020 • Fax: 724-776-1254 • E-Mail: **ga@gaindustries.com**

GA Industries is part of the Rexnord Water Management Group (**www.rexnord.com**)

VAG GA INDUSTRIES RODNEY HUNT® Fontaine®

GA-RPCV-1112

GA INDUSTRIES, INC

AWWA Ball Valve Approximate Cv versus Rotor Angle, Closed Loop Systems

Figure R201 Resilient Seated and R507 Metal Seated Valves

ROTOR ANGLE, Degrees From Open	VALVE SIZE										
	6	8	10	12	14	16	18	20	24	30	36
10	77	150	245	374	511	707	912	1147	1685	2693	4100
20	138	270	442	675	921	1275	1645	2068	3039	4855	7392
30	199	388	637	972	1326	1836	2368	2978	4376	6991	10645
40	281	549	900	1374	1874	2596	3347	4209	6185	9881	15045
50	404	789	1294	1976	2694	3732	4813	6052	8893	14208	21633
60	599	1171	1918	2930	3995	5535	7137	8975	13188	21071	32081
70	990	1934	3168	4839	6599	9141	11788	14823	21781	34800	52985
80	1990	3889	6373	9734	13273	18386	23710	29815	43811	69997	106575
90	3747	7322	11998	18325	24988	34614	44638	56131	82480	131779	200642

Note 1. Cv values indicate the number of gallons of water at standard conditions that can flow through the valve at a given rotor angle at a 1 PSI constant pressure drop in a closed loop system.

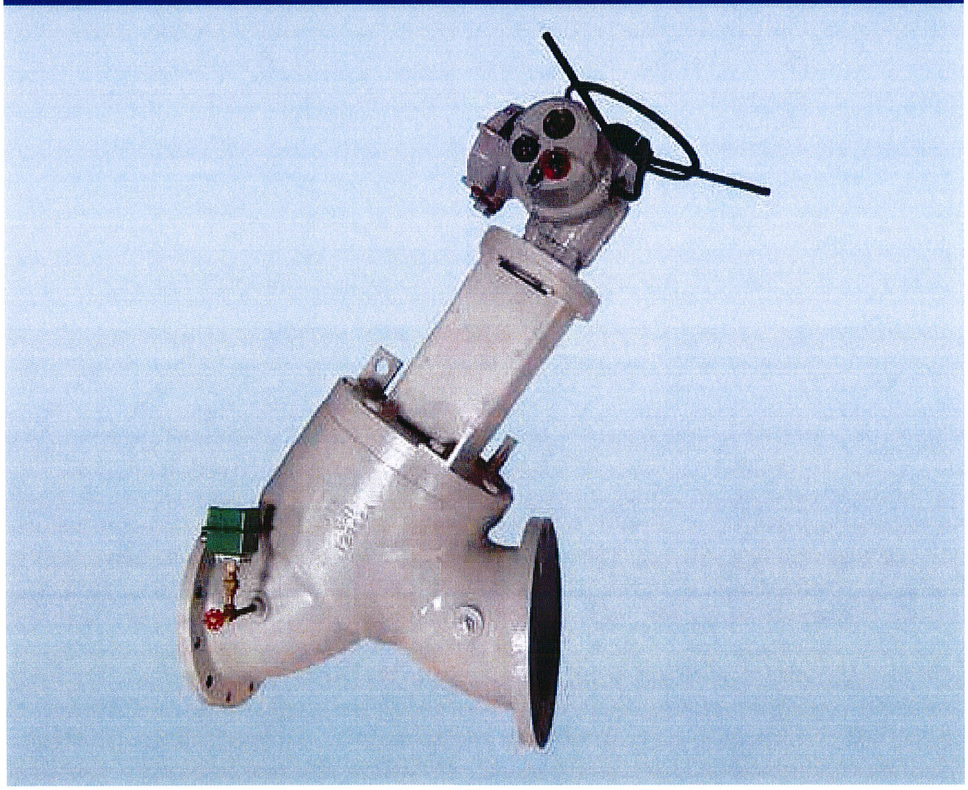
Note 2. Flow of water (specific gravity = 1.0) at other than 1 PSI pressure drop can be determined using the formula $Q = C_v (P_1 - P_2)^{1/2}$ where Q = flow (US gallons per minute) and $P_1 - P_2$ is the pressure drop across the valve in pounds per square inch (PSI).

5/27/99
cvvsplug

GA INDUSTRIES

CHECKtronic®

Pump Control Valve



VAG® Valve and Gate Group

GA INDUSTRIES

A Century of Experience

GA valves are known for long term reliability in the most demanding water and wastewater applications. Whether a simple check valve or a complex automatic control valve, each GA valve is built on over 100 years of design, manufacturing and application experience to ensure its dependability and superior performance.

Outstanding Technical Support

From the factory to the field, GA provides responsive and knowledgeable technical assistance and support. GA application engineers, and our team of trained and experienced sales representatives, work closely with designers to select the right valve from our broad product range to ensure that it meets the system requirements. GA Industries is committed to serving our customers in all phases of the project.

Superior Quality

All GA valves are designed in accordance with AWWA and other industry standards and are precision manufactured from the highest grade materials. Every valve is tested to ensure it meets our high standards and the latest industry requirements, so you can be sure it will operate as expected from the minute it is put in service.

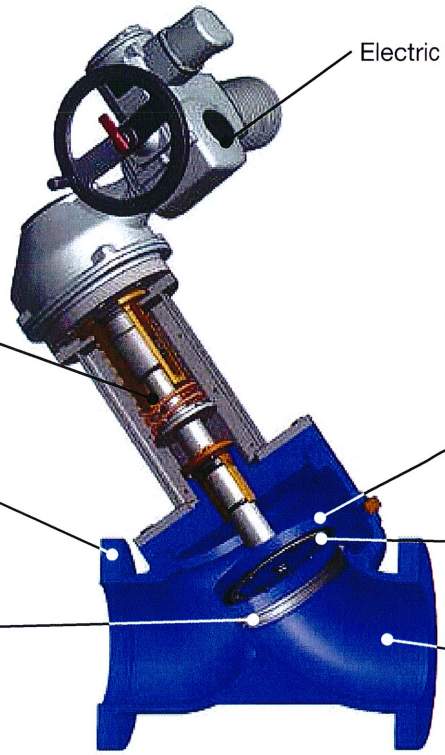
Comprehensive Product Range

We are continuously expanding and improving our product line to meet the ever-changing needs of the waterworks industry. From standard butterfly and plug valves to sophisticated, highly engineered pump control, check and surge control valves, GA Industries offers one of the broadest ranges of valves in the industry. Please see the back cover for a complete listing of our product offering.

CHECKtronic®

Pump Control Valve

The CHECKtronic® Pump Control Valve has evolved from GA's extensive experience in the design of automatic control valves to control surges associated with the starting and stopping of pumps. Its innovative design incorporates a fail-safe check feature into an electric motor operated valve, providing the ideal combination of surge control and positive closure for power failure or other emergencies. The electric actuator eliminates complicated hydraulic controls, minimizes installation costs, and reduces maintenance.



The innovative GA CHECKtronic® Pump Control Valve provides superior design, simple operation, and maximum performance in pump surge control.

Body Style

3" – 36" Cast Iron, ASTM A126 Class B, ANSI B16.1, Class 125 and 250 Flanged
3" – 36" Ductile Iron, ASTM A536, Grade 65-45-12, ANSI B16.1, Class 150 and 300 Flanged

Rugged and Corrosion Resistant

High strength epoxy coated cast iron or ductile iron body and stainless steel seat ensure long-term corrosion resistance, lengthening the life of the valve.

Flow Efficient Design

Streamlined wye and long radius elbow body designs reduce headloss by 60% compared to a typical globe or angle valve, reducing pumping costs.

Tight Sealing

Replaceable disc seat ring is made from abrasion resistant UHMWPE (Ultra-high Molecular Weight Polyethylene) for dependable, drop-tight seating in the most severe applications.

Electric Motor Actuation

Standard multi-turn electric motor actuator incorporates "pulse feature," providing adjustable open and close stroke times for ideal surge control. Virtually any brand of single or three-phase, water tight, explosion proof, or submersible actuator can be used.

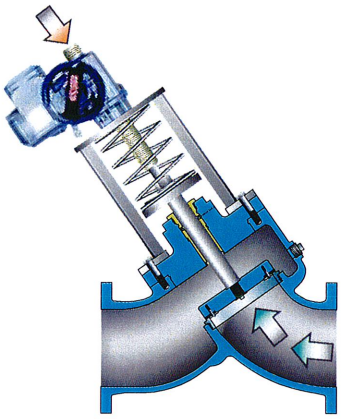
Fail-Safe Stop Check

Integral, spring-assisted stop check operates independently of the actuator and automatically closes in the event of a power outage or pump failure, preventing backflow.

Easy Installation and Maintenance

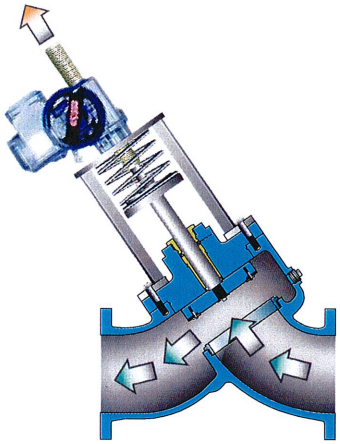
Installation is quick and simple, requiring only electrical power and simple electrical logic to sequence the operation of the CHECKtronic® Pump Control Valve to that of the pump motor. The valve's top entry design facilitates in-line maintenance, preventing a lengthy disruption in service.

How does the CHECKtronic® Pump Control Valve Work?



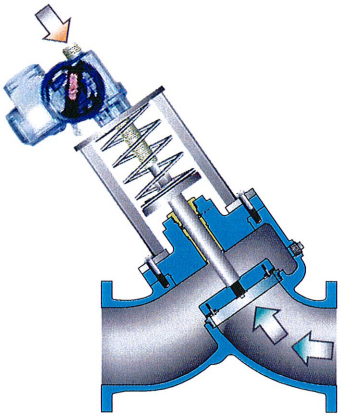
Pump Start

The pump motor starts, but the CHECKtronic® Pump Control Valve's electric motor actuator holds the valve closed. The actuator is signaled to open only after the pump is up to speed and pressure. Start-up surges are minimized with the actuator's adjustable "pulse feature," which controls how fast the valve opens and thus the rate at which the fluid column accelerates to design velocity.



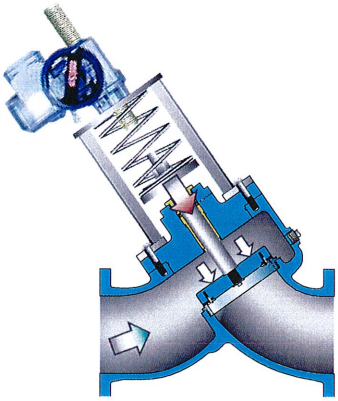
Pump Running

The valve opens fully at design flow conditions. Its streamlined body produces very low headloss and handles sewage or debris-laden water without clogging. Visual and electrical position indicators are provided.



Normal Pump Shutdown

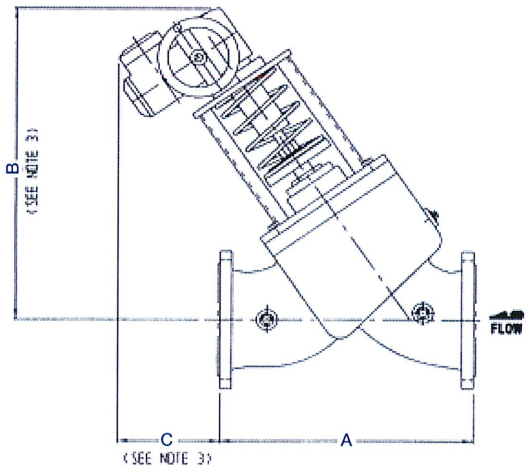
A pump stop command signals the CHECKtronic® Pump Control Valve to start closing as the pump continues to run. The electric motor actuator's adjustable "pulse feature" controls how fast the valve closes and how quickly the fluid's line velocity decelerates, thereby minimizing pressure surges and column separations. A valve-mounted limit switch disengages the pump motor only after the CHECKtronic® Pump Control Valve is fully shut.



Power Outage, Pump, or Motor Failure

A power outage or loss of pumping pressure immediately causes the CHECKtronic® Pump Control Valve's spring-assisted "stop-check" to separate from the electric actuator and quickly close to prevent backflow.

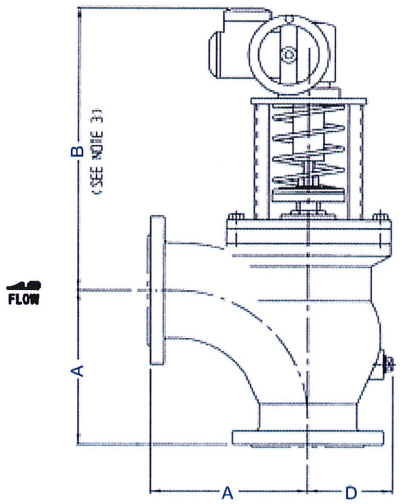
Wye Body



Dimensions (inches)

SIZE	A	B	C	Valve Body Width	Approx. Wgt. (lbs)
3"	12	29	15½	6¾	275
4"	13	30½	14½	8	300
6"	18	33½	13	11½	525
8"	24½	37	10½	15	675
10"	26	40½	13	18	870
12"	31	45	12½	19⅝	1,400
14"	33	46	11½	23½	2,400
16"	36	52½	13½	25	2,750
18"	40	60	15½	28	3,150
20"	40	61	15½	28	3,450
24"	48	64	17	35½	6,800
30"	64	87	35½	45	12,500
36"	78	100	29	54	20,500

Elbow Body



Dimensions (inches)

	A	B	D	Valve Body Width	Approx. Wgt. (lbs)
3"	7¾	32	5	6¾	275
4"	9	33	6	10	300
6"	11½	34	7	12	525
8"	14	35	9	13½	675
10"	16½	36	11	17⅝	870
12"	19	37½	13	20⅞	1,400
14"	21½	41	16	23¾	2,400
16"	24	50	17	27½	2,750
18"	26½	52	21	29½	3,150
20"	29	54	23	34	3,450
24"	34	58	24	39¾	6,800

NOTE:
1. Standard flanges per ANSI B16.1. BS, DIN, ISO and other flanges are available.
2. "A" dimension on valves with raised face flanges does not include the length of the raised face.
3. Dimension B and C may vary per operator selection. For accurate dimension, consult factory.
4. Actuator may extend beyond valve body width and can be rotated in 90° increments.
5. Dimensions shown are for estimating purposes and are not guaranteed. Certified drawings are available when requested with order.

Standard Materials

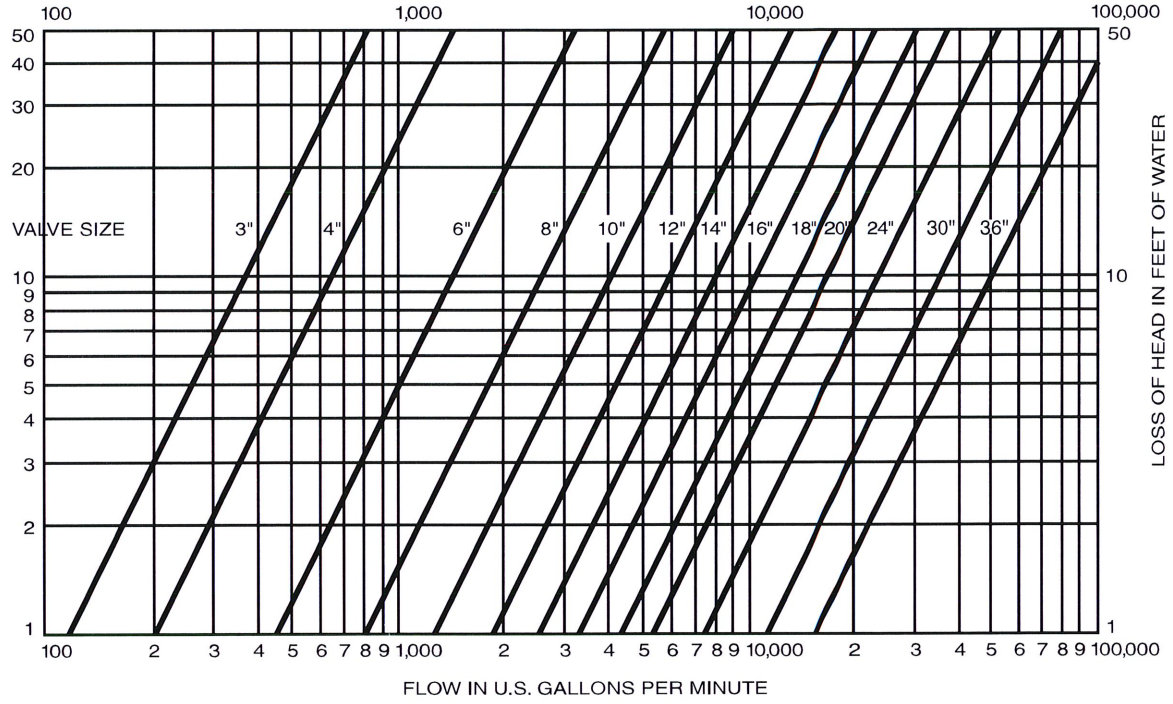
Body, Cover	Cast Iron (Standard) ASTM A126 Class B
	Ductile Iron (Optional) ASTM A536
	Cast Steel (Optional) ASTM A216 Gr. WCB
	Cast Stainless Steel (Optional) ASTM A351
Disc	Ductile Iron (Standard) ASTM A536
	Cast Stainless Steel (Optional) Type 18-8
	Cast Steel ASTM A216 Gr. WCB
Body Seat, Seat Follower	Stainless Steel Type 316
Stem	Stainless Steel Type 303
Disc Seat Ring	Synthetic Polymer, Ultra High Molecular Weight Polyethylene (UHMWPE)
O-Rings & Gaskets	Rubber/Composition Buna-N/Fiber
Gland, Bushing	Brass C36000
Internal Wetted Fasteners	Stainless Steel Type 18-8
Actuator Bracket & Adaptor	Steel ASTM A36
Spring	Steel ASTM A229
External Fasteners	Steel ASTM A307
Threaded Stem	Stainless Steel Type 17-4 PH

Note: Other materials of construction can be provided. Consult factory for availability.

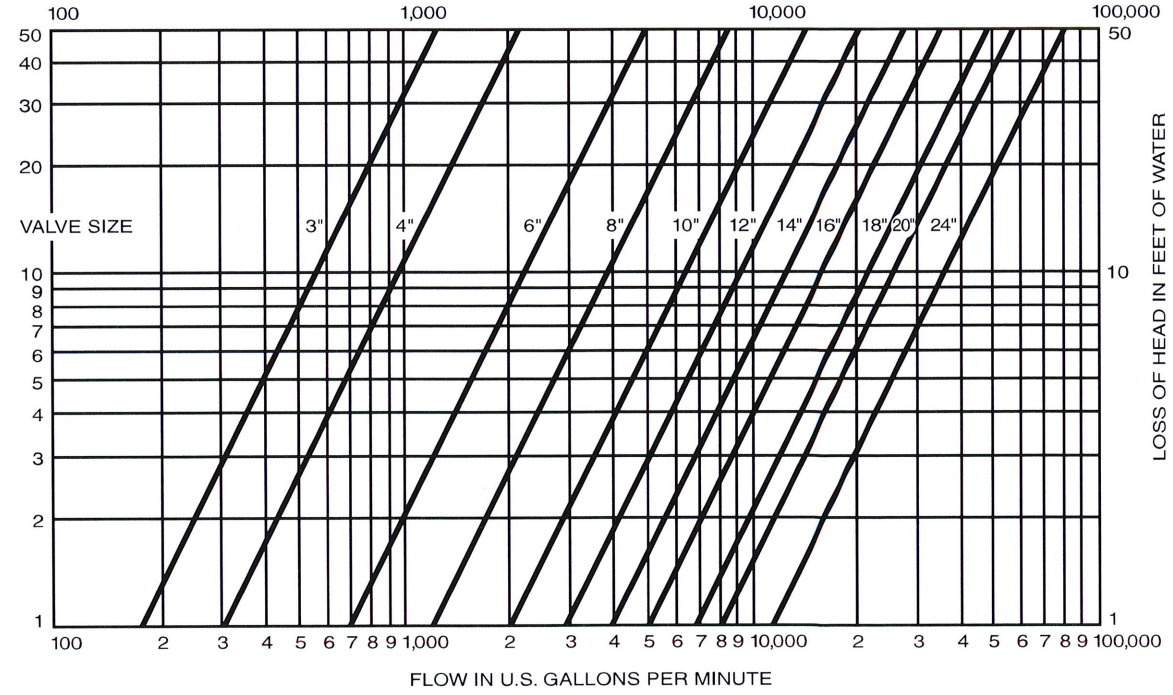
Reduce Headloss and Pumping Costs

The CHECKtronic® Pump Control Valve's full-ported, streamlined long radius elbow pattern and wye body style have 60% less headloss than traditional angle and globe body valves.

Headloss vs. Flow for Wye Body CHECKtronic®



Headloss vs. Flow for Long Radius Elbow Body CHECKtronic®



Specification

CHECKtronic® Pump Control Valve

DESIGN

A. The pump control valve shall consist of a main valve and electric motor actuator, completely factory assembled, tested and ready for installation and field wiring.

B. The valve shall have a field adjustable opening and closing stroke time for surge control during normal pump operation.

C. The valve shall have an integral, spring-assisted stop-check that closes independent of the actuator to prevent flow reversal subsequent to power outage or pump, pump motor or actuator failure.

CONSTRUCTION

A. The valve body shall be of the [in-line wye] [long radius elbow] body style and be of cast iron conforming to ASTM A126 Class B with integral flanges faced and drilled to ANSI B16.1 Class [125][250]. The valve shall be inherently self-cleaning and have a net flow area through it no less than area of its nominal pipe size. The body shall have a replaceable Type 316 stainless steel seat. There shall be a clean out/inspection port near the valve seat.

B. The valve disc shall be ductile iron or steel with a renewable, resilient seat of ultra-high molecular weight polyethylene (UHMWPE) retained by a stainless steel follower ring and screws.

C. The valve stem shall be stainless steel and guided in a long bronze bushing retained in the valve cover. A pressure-actuated seal shall seal the valve stem where it passes through the body.

D. The actuator stem shall be high strength Type 17-4PH stainless steel with heavy duty ACME threads.

E. The valve shall be supplied with a valve mounted SPDT limit switch that is actuated by the valve disc.

ACTUATOR

A. The valve shall be operated by a multi-turn, non-modulating [___ VAC/__Phase/NEMA__] electric motor actuator meeting AWWA C540 with integral controls.

B. The actuator controls shall include reversing starter, control transformer, local-off-remote selector switch, indicating lights, open/stop/close pushbuttons, torque switches and limit switches.

C. A manual override with handwheel and visual position indication shall be provided. The manual override shall auto matically disengage when the actuator is electrically operated.

D. The electric motor actuator shall provide an independent valve opening and closing stroke time to suit field conditions and be capable of providing two-speed operation with an adjustable transition point from slow to fast speed.

MANUFACTURER

A. The electric motor actuated pump control valve shall be the Series 1600M CHECKtronic® Pump Control Valve as manufactured by GA Industries, LLC, Cranberry Township, PA USA

Note: Specifier to select [bracketed items]

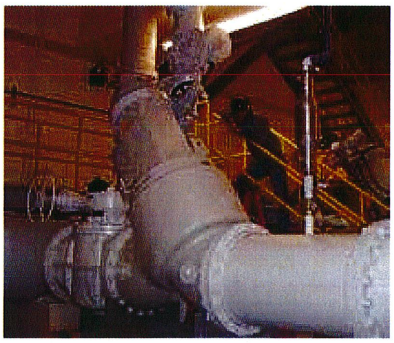
Pressure Ratings

Cast Iron Body, Class 125 Flanges	200 PSI (3" to 12" Size)
	150 PSI (14" to 36" Size)
Cast Iron Body, Class 250 Flanges	400 PSI (3" to 12" Size)
	300 PSI (14" to 36" Size)
Ductile Iron Body, Class 150 Flanges	250 PSI (3" to 36" Size)
Ductile Iron Body, Class 300 Flanges	500 PSI (3" to 36" Size)

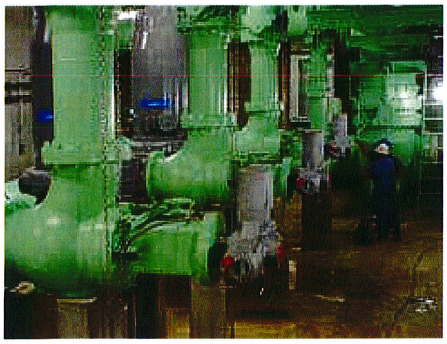
Note:
1. Standard flanges conform to ANSI standards. BS, DIN, ISO and other flanges are available, consult factory for availability and pressure ratings.
2. Higher pressure ratings available with steel or stainless steel body.
3. Valve maximum working pressure (MWP) may be less than pressure rating due to actuator.

Projects

Olentangy Water Treatment Plant, Ohio, USA
6 – 14" CHECKtronic® Pump Control Valves



Brooks Road Sewage Pump Station, Georgia, USA
2 – 24" Checktronic® Pump Control Valves



DELCO Raw Water Pump Station, Ohio, USA
3 – 14" Checktronic® Pump Control Valves

GA Industries offers a broad range of valves designed specifically for the waterworks market

AWWA C504
Rubber Seated Butterfly Valves
- Flanged and Mechanical Joint Ends
- Manual and Automatic Actuation

AWWA C507
Ball Valves
- Metal Seated
- Resilient Seated
- Hydraulic, Pneumatic, or Electric Motor Actuation

AWWA C508
Check Valves
- Cushioned Swing Check
- Rubber Flapper Check
- Globe and Wafer Silent Check
- Ball Check
- Foot Valves

AWWA C512
Air Valves for Water and Sewage
- Air Release
- Air and Vacuum
- Combination
- Vacuum Breaking

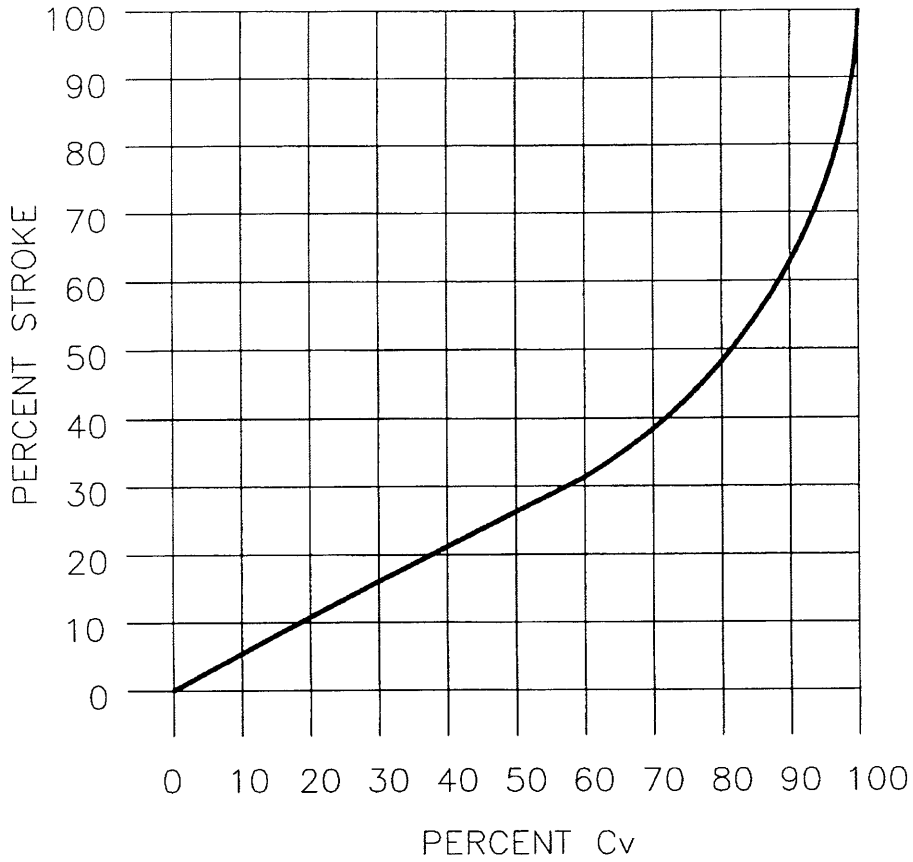
AWWA C517
Eccentric Plug Valves
- Flanged, Threaded, and Mechanical Joint Ends
- Manual and Automatic Actuation

AWWA C530
Control Valves
- Pump Control for Water and Sewage
- Surge Relief for Water and Sewage
- Level Control
- Pressure Regulating
- Solenoid Operated
- Anti-Cavitation

For more information about GA Industries' products, or to contact a sales representative, visit the GA website (**www.gaindustries.com**).

GA Industries, LLC • 9025 Marshall Road • Cranberry Township, PA 16066-3696 USA
PHONE: 724-776-1020 • FAX: 724-776-1254 • E-Mail: **ga@gaindustries.com**

VAG® Valve and Gate Group



30" Currently only available in Wye body

SIZE	2 1/2"	3"	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"	30"	36"
Cv – ELBOW	175	260	480	1040	1930	3100	4350	5900	7600	10000	12000	17000	26900	38740
Cv – WYE	120	175	315	700	1230	1975	2900	3900	5000	6800	8100	11400	16755	24180

J:\GA-VALVE\GA-SHOW\H-1110-B.DWG

GA INDUSTRIES, LLC

VALVE CHARACTERISTIC CURVE
LONG RADIUS ELBOW AND WYE BODY VALVES
SIZES 2 1/2" - 36", % STROKE vs % Cv

SERIAL NO. *		**DRAWN BY** FP	
FIG. NUMBER *		**APPR. BY** FP	
DATE 03-07-2001		**SCALE** NTS	
PROPERTY OF GA INDUSTRIES, LLC			
REFERENCES H-1027	**FILE** H-3	**DRAWING NO.** H-1110	**REV.** B

*

Appendix F

Proposed Pump Control Valve Results

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Scenario 1 – Simultaneous All Pump Failure 24-inch GA Ball Valve 30-sec Emergency Closure

Scenario 1 – Simultaneous All Pump Failure 30-inch GA Ball Valve 30-sec Emergency Closure

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EXHIBIT 1
Scenario 1 - Simultaneous Failure of All Pumps

All pumps fail after running for 5 seconds

Adams 30-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	131.3	8.50	Directly Downstream of Pump 6 Control Valve (CK6-O)	-5.9	8.50	Directly Upstream of Pump 7 Control Valve (CK7-I)	-30.65 MGD (Pump 8)	6.27
30 Second Emergency Closure	115.8	1.34	Yard Piping to North Surge Tank (ST-1)	5.7	26.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.76 MGD (Pump 8)	6.27
60 Second Emergency Closure	115.8	1.39	Yard Piping to North Surge Tank (ST-1)	6.3	47.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.76 MGD (Pump 8)	6.27

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	2.3	2.25	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.79 MGD (Pump 8)	6.27
30 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	6.2	35.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.76 MGD (Pump 8)	6.27
60 Second Emergency Closure(1)	115.9	1.39	Yard Piping to North Surge Tank (ST-1)	6.6	65.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-29.5 MGD (Pump 8)	6.15

(1) Surge Tanks empty with 60 second valve closure

Golden Anderson 30-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	-1.2	10.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.84 MGD (Pump 8)	6.27
30 Second Emergency Closure	115.9	1.39	Yard Piping to North Surge Tank (ST-1)	6.1	35.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.85 MGD (Pump 8)	6.27
60 Second Emergency Closure(1)	115.9	1.37	Yard Piping to North Surge Tank (ST-1)	6.5	65.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-29.5 MGD (Pump 8)	6.15

(1) Surge Tanks empty with 60 second valve closure

Golden Anderson 30-inch Checktronic Wye Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
0.5 Second Emergency Closure	178.4	5.55	Directly Downstream of Pump 4 Control Valve (CK4-O)	6.6(1)	179.8	Directly Upstream of Pump 2 Control Valve (CK2-I)	-6.0 MGD (Pump 8)	5.45
1 Second Emergency Closure	183.9	6.00	Directly Downstream of Pump 7 Control Valve (CK7-O)	-12.9	6.50	Directly Upstream of Pump 3 Control Valve (CK3-I)	-19.63 MGD (Pump 8)	5.74
3 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	2.5(1)	8.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-28.58 MGD (Pump 8)	6.14
5 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	4.6(1)	10.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-29.5 MGD (Pump 8)	6.15

(1) Minimum pressures occur on multiple Control Valve inlets

EXHIBIT 2

Scenario 1 - Simultaneous Failure of All Pumps without Surge Tar

All pumps fail after running for 5 seconds

Adams 24-inch AZI Disc Valve (5 Second Closure)

	Location Description	Max Pressure (psi)	Time (sec)	Min Pressure (psi)	Time (sec)
DH-2	Discharge Header at Pump 2	105.9	0.01	-14.05	8.56
DH-8	Discharge Header at Pump 8	105.9	0.00	-14.4	8.54
VL2-I	Flow Meter	105.92	0.00	-5.4	8.71
VL3-I	Flow Meter	105.9	0.00	-5.4	9.08
PL-END	Fence Line of Plant	107.6	0.00	7.3	9.50
HAWC-4	84-inch line at Beltway 8	106.8	0.00	22.3	10.41
ST-1	Max System Pressure - Yard Piping to Surge Tank 1	115.6	0.00	-11.5	8.92
CK8-O(1)	Min System Pressure - Downstream of Pump 8 Control Valve	107.1	0.00	-14.4	8.55

(1) Minimum pressure occures in multiple locations along pump discharge lines

Adams 24-inch AZI Disc Valve (30 Second Closure)

	Location Description	Max Pressure (psi)	Time (sec)	Min Pressure (psi)	Time (sec)
DH-2	Discharge Header at Pump 2	105.9	0.01	6.0	10.38
DH-8	Discharge Header at Pump 8	105.9	0.00	5.8	7.7
VL2-I	Flow Meter	105.9	0.00	5.8	10.36
VL3-I	Flow Meter	105.9	0.00	5.8	10.38
PL-END	Fence Line of Plant	107.6	0.00	12.3	15.52
HAWC-4	84-inch line at Beltway 8	106.8	0.00	12.4	18.15
HAWC-1	Max System Pressure - 84" Water Line	109.5	0.00	14.6	17.79
BFV8-O	Min System Pressure - Downstream of Pump 8 Butterfly Valve	109.3	0.00	5.81	7.71

Adams 24-inch AZI Disc Valve (60 Second Closure)

	Location Description	Max Pressure (psi)	Time (sec)	Min Pressure (psi)	Time (sec)
DH-2	Discharge Header at Pump 2	105.9	0.01	6.0	10.38
DH-8	Discharge Header at Pump 8	105.9	0.00	5.8(1)	7.72
VL2-I	Flow Meter	105.9	0.00	5.8	10.4
VL3-I	Flow Meter	105.9	0.00	5.8	10.38
PL-END	Fence Line of Plant	107.6	0.00	12.3	18.3
HAWC-4	84-inch line at Beltway 8	106.8	0.00	12.4	19.2
HAWC-1	Max System Pressure - 84" Water Line	109.4	0.00	14.5	18.8

(1) Minimum System Pressure

EXHIBIT 3

Scenario 1 - Simultaneous Failure of All Pumps without Surge Tanks and EWPP Backpres

All pumps fail after running for 5 seconds

Adams 24-inch AZI Disc Valve (30 Second Closure)

	Location Description	Max Pressure (psi)	Time (sec)	Min Pressure (psi)	Time (sec)
DH-2	Discharge Header at Pump 2	105.9	0.00	5.8	18.79
DH-8	Discharge Header at Pump 8	106.0	0.00	5.7(1)	18.59
VL2-I	Flow Meter	105.9	0.00	6.2	10.36
VL3-I	Flow Meter	106.0	0.00	6.3	10.38
PL-END	Fence Line of Plant	107.6	0.43	11.5	21.18
HAWC-4	84-inch line at Beltway 8	106.8	0.00	11.6	24.26
ST-1	Max System Pressure - Yard Piping to Surge Tank 1	115.6	0.02	15.4	18.61

(1) Minimum System Pressure

Adams 24-inch AZI Disc Valve (60 Second Closure)

	Location Description	Max Pressure (psi)	Time (sec)	Min Pressure (psi)	Time (sec)
DH-2	Discharge Header at Pump 2	105.9	0.00	5.7(1)	35.46
DH-8	Discharge Header at Pump 8	106.0	0.00	5.7(1)	31.68
VL2-I	Flow Meter	106.0	0.00	6.3	10.36
VL3-I	Flow Meter	106.0	0.00	6.3	10.38
PL-END	Fence Line of Plant	107.6	0.43	11.3	36.19
HAWC-4	84-inch line at Beltway 8	106.9	0.00	11.4	37.85
ST-1	Max System Pressure - Yard Piping to Surge Tank 1	115.6	0.02	15.3	18.81

(1) Minimum System Pressure

EXHIBIT 4

Scenario 1 - Simultaneous Failure of All Pumps with Lake Houston Cost Share 36-inch Water Line

All pumps fail after running for 5 seconds

Adams 24-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	0.2	177.71	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.26 MGD (Pump 8)	6.17
30 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	6.1	26.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.57 MGD (Pump 8)	6.27
60 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	6.4	47.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	-30.58 MGD (Pump 8)	6.27

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	116.2	0.16	Yard Piping to North Surge Tank (ST-1)	2.2	10.00	Directly Downstream of Pump 3 Control Valve (CK3-O)	-30.94 MGD (Pump 8)	6.23
30 Second Emergency Closure	116.2	0.16	Yard Piping to North Surge Tank (ST-1)	6.3	35.00	Directly Downstream of Pump 2 Control Valve (CK2-O)	-31.00 MGD (Pump 8)	6.27
60 Second Emergency Closure(1)	116.2	0.16	Yard Piping to North Surge Tank (ST-1)	6.5	65.00	Directly Upstream of Pump 3 Control Valve (CK3-I)	-29.69 MGD (Pump 8)	6.15

(1) Surge Tanks empty in this scenario

EXHIBIT 5
Scenario 2 - Normal Shutdown

Adams 30-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	136.0	4547.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.6	4780.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	42.9 MGD (Pump 2)	3764.57
180 Second Closure	135.5	4631.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.6	4899.58	Directly Upstream of Pump 2 Control Valve (CK2-I)	42.9 MGD (Pump 2)	3856.85

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	135.6	4565.00	Directly Upstream of Pump 2 Control Valve	6.58	4799.80	Directly Upstream of Pump 2 Control Valve	43.08 MGD (Pump 2)	3782.57
180 Second Closure	135.6	4685.00	Directly Upstream of Pump 2 Control Valve	6.58	4899.66	Directly Upstream of Pump 2 Control Valve	43.08 MGD (Pump 2)	3913.17

Golden Anderson 30-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	135.8	4565.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.58	4799.80	Directly Upstream of Pump 2 Control Valve (CK2-I)	43.10 MGD (Pump 2)	3782.6
180 Second Closure	135.5	4685.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.58	4899.58	Directly Upstream of Pump 2 Control Valve (CK2-I)	43.10 MGD (Pump 2)	3912.91

Golden Anderson 30-inch Checktronic Wye Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	135.5	4565.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.58	4799.80	Directly Upstream of Pump 2 Control Valve (CK2-I)	42.28 MGD (Pump 2)	3793.97
180 Second Closure	135.4	4685.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.58	4899.58	Directly Upstream of Pump 2 Control Valve (CK2-I)	42.28 MGD (Pump 2)	3924.51

60 Second Closure
Pump 2 control valve closes at 4565 seconds

180 Second Closure
Pump 2 control valve closes at 4685 seconds

EXHIBIT 6
Scenario 2 - Normal Pump Shutdown with Summerwood 36-inch Water Line

Adams 24-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	135.7	4547.00	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.6(1)	4800.0	Directly Upstream of Pump 2 Control Valve (CK2-I)	42.63 MGD (Pump 2)	3765.31
180 Second Closure	135.4	4631.0	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.6(1)	4899.6	Directly Upstream of Pump 2 Control Valve (CK2-I)	42.63 MGD (Pump 2)	3849.54

(1) Minimum pressure occurs at each respective pump control valve when it closes

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	135.6	4565.0	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.6(1)	4800.0	Directly Upstream of Pump 2 Control Valve (CK2-I)	43.25 MGD (Pump 2)	3783.0
180 Second Closure	135.4	4685.0	Directly Upstream of Pump 2 Control Valve (CK2-I)	6.6(1)	4899.6	Directly Downstream of Pump 2 Control Valve (CK2-O)	43.25 MGD (Pump 2)	3903.3

(1) Minimum pressure occurs at each respective pump control valve when it closes

EXHIBIT 7
Scenario 3 - Normal Startup

Adams 30-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Opening	116.9	408.80	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	45.92 MGD (Pump 8)	36.18
180 Second Opening	116.9	1008.81	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	43.50 MGD (Pump 8)	141.10

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	116.7	408.81	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	44.69 MGD (Pump 8)	58.7
180 Second Closure	116.6	808.73	Directly Upstream of Pump 3 Control Valve (CK3-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	43.35 MGD (Pump 8)	177.01

Golden Anderson 30-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	116.5	408.66	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	44.8 MGD (Pump 8)	46.84
180 Second Closure	115.8	8.23	Directly Upstream of Pump 8 Control Valve (CK8-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	43.36 MGD (Pump 8)	175.51

Golden Anderson 30-inch Checktronic Wye Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Closure	117.0	409.28	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	43.55 MGD (Pump 8)	75.05
180 Second Closure	117.0	1009.28	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.00	Suction Side of Pump 8 (Well-8)	42.59 MGD (Pump 8)	195.61

EXHIBIT 8
Scenario 3 - Normal Pump Start Up with Summerwood 36-inch Water Line

Adams 24-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Opening	117.0	409.2	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.0	Suction Side of Pump 8 (Well-8)	42.80 MGD (Pump 8)	83.4
180 Second Opening	117.0	1009.2	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.0	Suction Side of Pump 8 (Well-8)	42.80 MGD (Pump 8)	141.2

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Opening	117.0	409.3	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.0	Suction Side of Pump 8 (Well-8)	43.51 MGD (Pump 8)	85.5
180 Second Opening	117.0	1009.2	Directly Upstream of Pump 2 Control Valve (CK2-I)	18.3	0.0	Suction Side of Pump 8 (Well-8)	43.52 MGD (Pump 8)	177.1

EXHIBIT 9
Scenario 4 - Single Pump Failure

Pump 8 fails after running for 5 seconds

Adams 30-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	118.2	8.50	Directly Downstream of Pump 8 Control Valve (CK8-O)	-5.3	8.50	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.0 MGD (Pump 8)	5.96
30 Second Emergency Closure	115.8	0.16	Yard Piping to North Surge Tank (ST-1)	4.8	26.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.1 MGD (Pump 8)	6.11
60 Second Emergency Closure	115.8	0.16	Yard Piping to North Surge Tank (ST-1)	5.7	47.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.2 MGD (Pump 8)	6.11

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	1.6	10.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.2 MGD (Pump 8)	6.11
30 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	5.8	35.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.3 MGD (Pump 8)	6.11
60 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	6.2	65.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.3 MGD (Pump 8)	6.11

Golden Anderson 30-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	-1.6	10.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.3 MGD (Pump 8)	6.11
30 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	5.3	35.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.3 MGD (Pump 8)	6.11
60 Second Emergency Closure	115.9	1.38	Yard Piping to North Surge Tank (ST-1)	5.6	65.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-35.3 MGD (Pump 8)	6.11

Golden Anderson 30-inch Checktronic Wye Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
0.5 Second Emergency Closure	144.8	5.50	Directly Downstream of Pump 8 Control Valve (CK8-O)	6.6	6.58	Directly Upstream of Pump 8 Control Valve (CK8-I)	-18.3 MGD (Pump 8)	5.38
1 Second Emergency Closure	126.4	6.00	Directly Downstream of Pump 8 Control Valve (CK8-O)	-7.6	5.99	Directly Upstream of Pump 8 Control Valve (CK8-I)	-26.7 MGD (Pump 8)	5.62
3 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	2.4	8.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-33.1 MGD (Pump 8)	5.82
5 Second Emergency Closure	115.5	0.56	Yard Piping to North Surge Tank (ST-1)	4.2	10.00	Directly Upstream of Pump 8 Control Valve (CK8-I)	-33.9 MGD (Pump 8)	5.85

EXHIBIT 10

Scenario 4 - Single Pump Failure with Other Pumps Running with Summerwood 36-inch Water Line

Adams 24-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Backflow	Time (sec)
5 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	0.1	8.5	Directly Upstream of Pump 8 Control Valve (CK8-I)	-34.60 MGD (Pump 8)	5.9
30 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	5.6	26.0	Directly Upstream of Pump 8 Control Valve (CK8-I)	-34.86 MGD (Pump 8)	6.1
60 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	6.1	47.0	Directly Upstream of Pump 8 Control Valve (CK8-I)	-34.88 MGD (Pump 8)	6.1

Golden Anderson 24-inch Resilient Ball Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
5 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	0.1	8.5	Directly Upstream of Pump 8 Control Valve (CK8-I)	-34.60 MGD (Pump 8)	5.9
30 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	5.6	26.0	Directly Upstream of Pump 8 Control Valve (CK8-I)	-34.86 MGD (Pump 8)	6.1
60 Second Emergency Closure	115.3	0.16	Yard Piping to North Surge Tank (ST-1)	6.1	47.0	Directly Upstream of Pump 8 Control Valve (CK8-I)	-34.88 MGD (Pump 8)	6.1

EXHIBIT 11

Scenario 5 - Emergency Diesel Pump (Pump 5) Shutdown with Other Pumps Running

Adams 24-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)
60 Second Closure	135.6	47.00	Directly Upstream of Pump 5 Control Valve (CK5-I)	6.6	300.0	Directly Upstream of Pump 5 Control Valve (CK5-I)
180 Second Closure	135.4	131.00	Directly Upstream of Pump 5 Control Valve (CK5-I)	6.6	599.0	Directly Upstream of Pump 5 Control Valve (CK5-I)

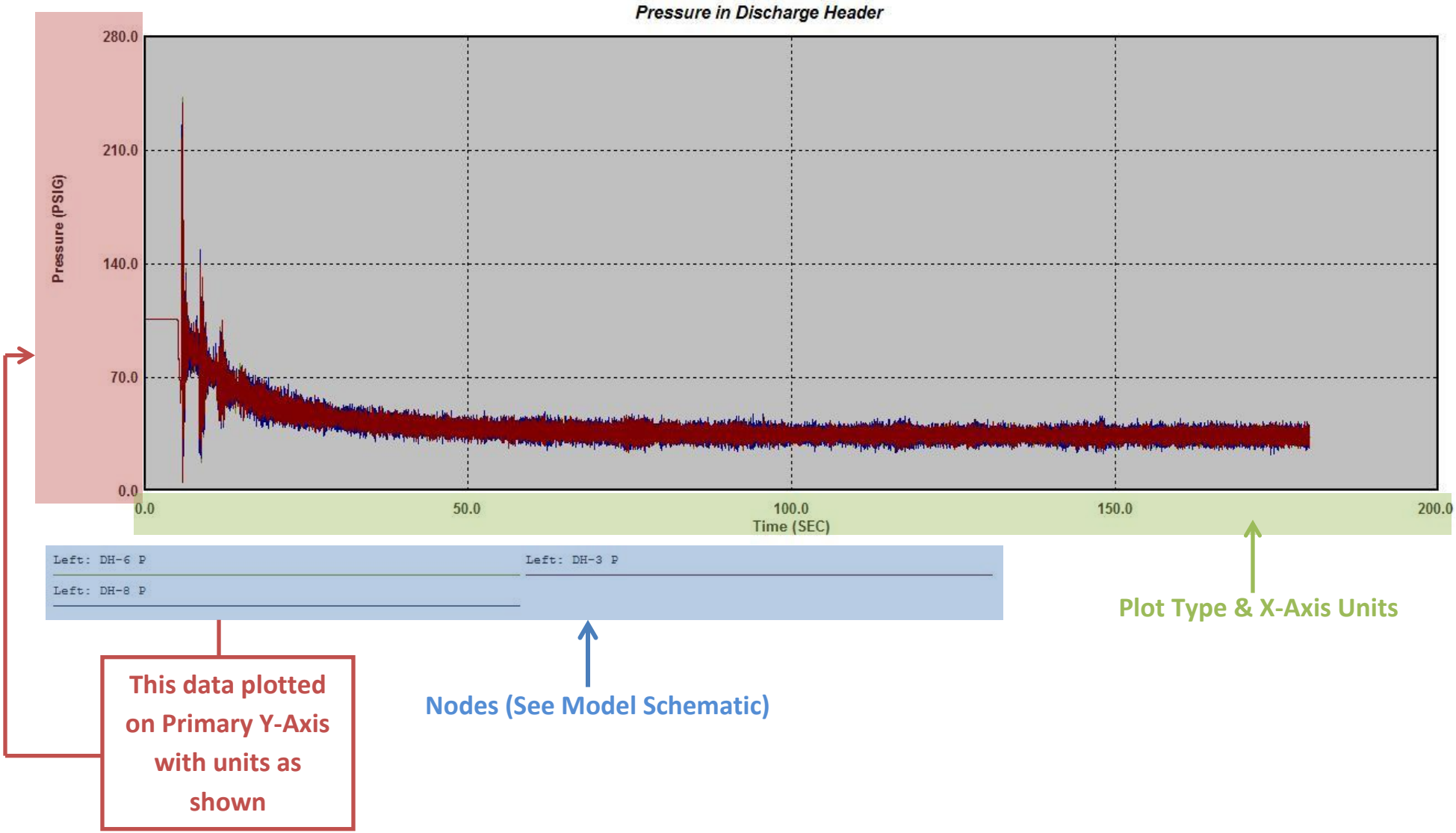
EXHIBIT 12
Scenario 6 - Emergency Diesel Pump Start Up with No Other Pumps Running

Adams 24-inch AZI Disc Valve

	Max Pressure (psi)	Time (sec)	Description (Node)	Min Pressure (psi)	Time (sec)	Description (Node)	Max Flow	Time (sec)
60 Second Opening	136.1	6.01	Directly Upstream of Pump 5 Control Valve (CK5-I)	18.3	0.0	Suction Side of Pump 8 (Well-8)	44.36 MGD (Pump 8)	36.52
180 Second Opening	136.1	6.01	Directly Upstream of Pump 5 Control Valve (CK5-I)	18.3	0.0	Suction Side of Pump 8 (Well-8)	42.52 MGD (Pump 8)	133.13

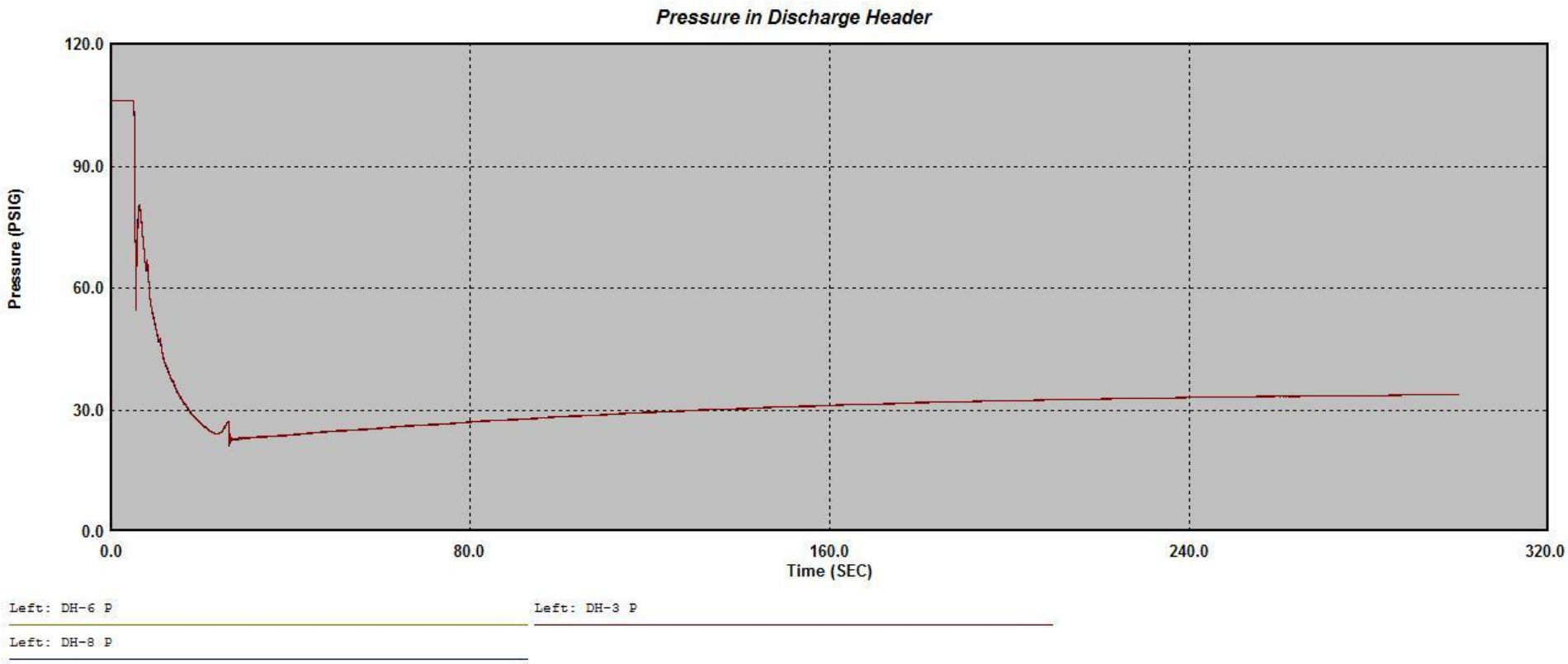
How To Read a Time Plot from LIQT

A TIME Plot in LIQT displays variables as a function of simulation time for a given node.

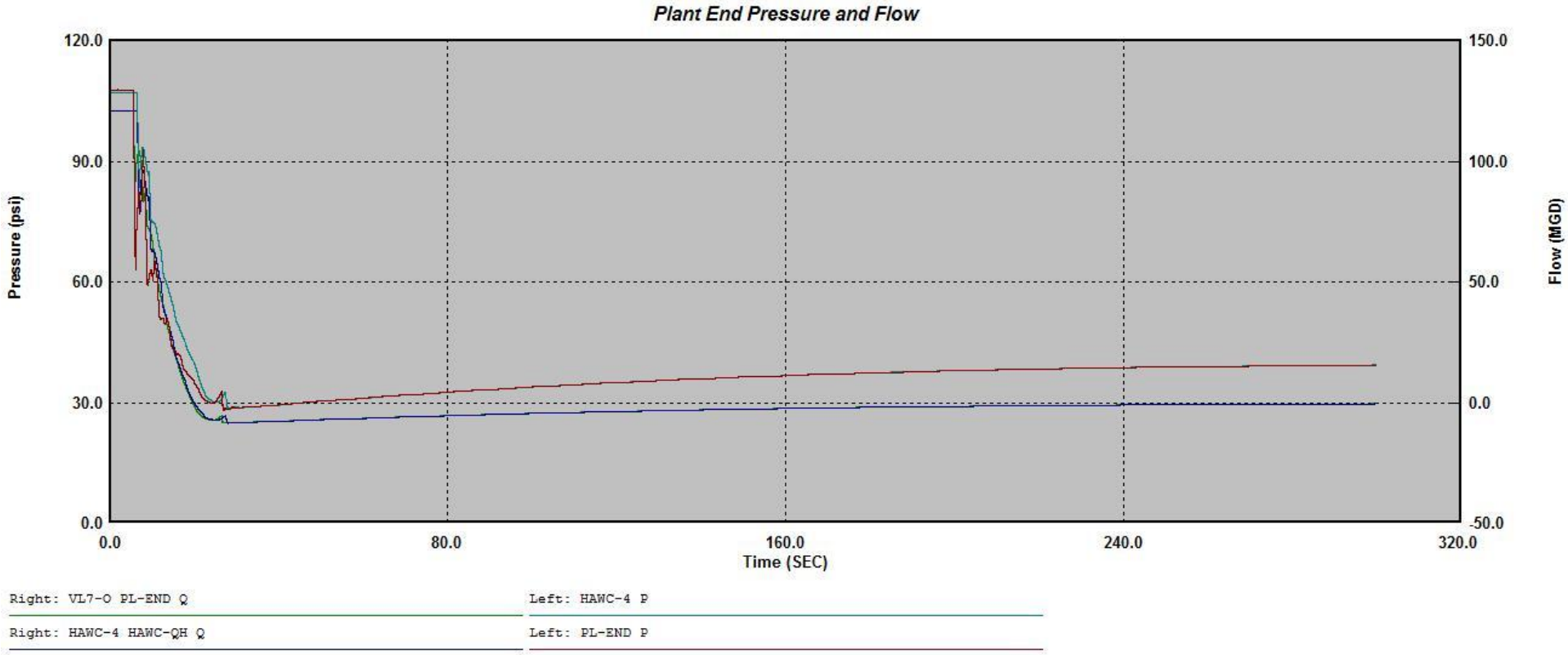


Scenario 1 – Simultaneous All Pump Failure Adams 30-inch Disc Valve 30-sec Emergency Closure

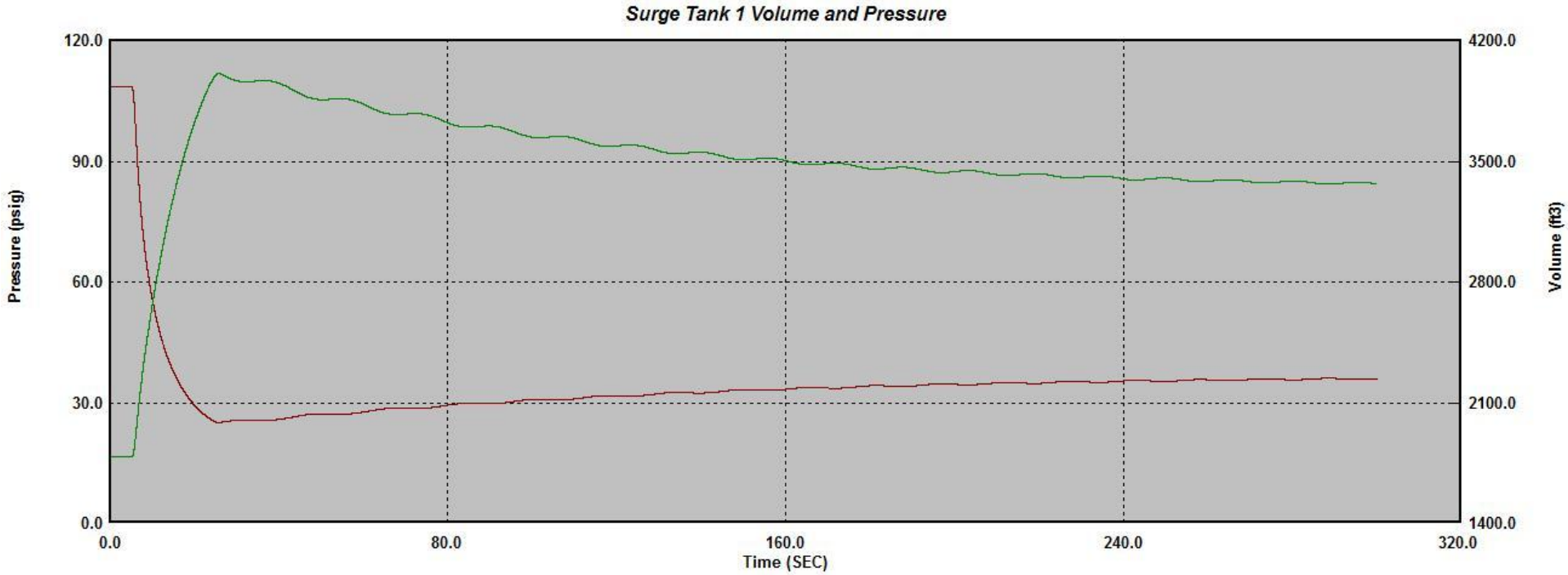
Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
Adams 30-inch Disc Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
Adams 30-inch Disc Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
Adams 30-inch Disc Valve
30-sec Emergency Closure

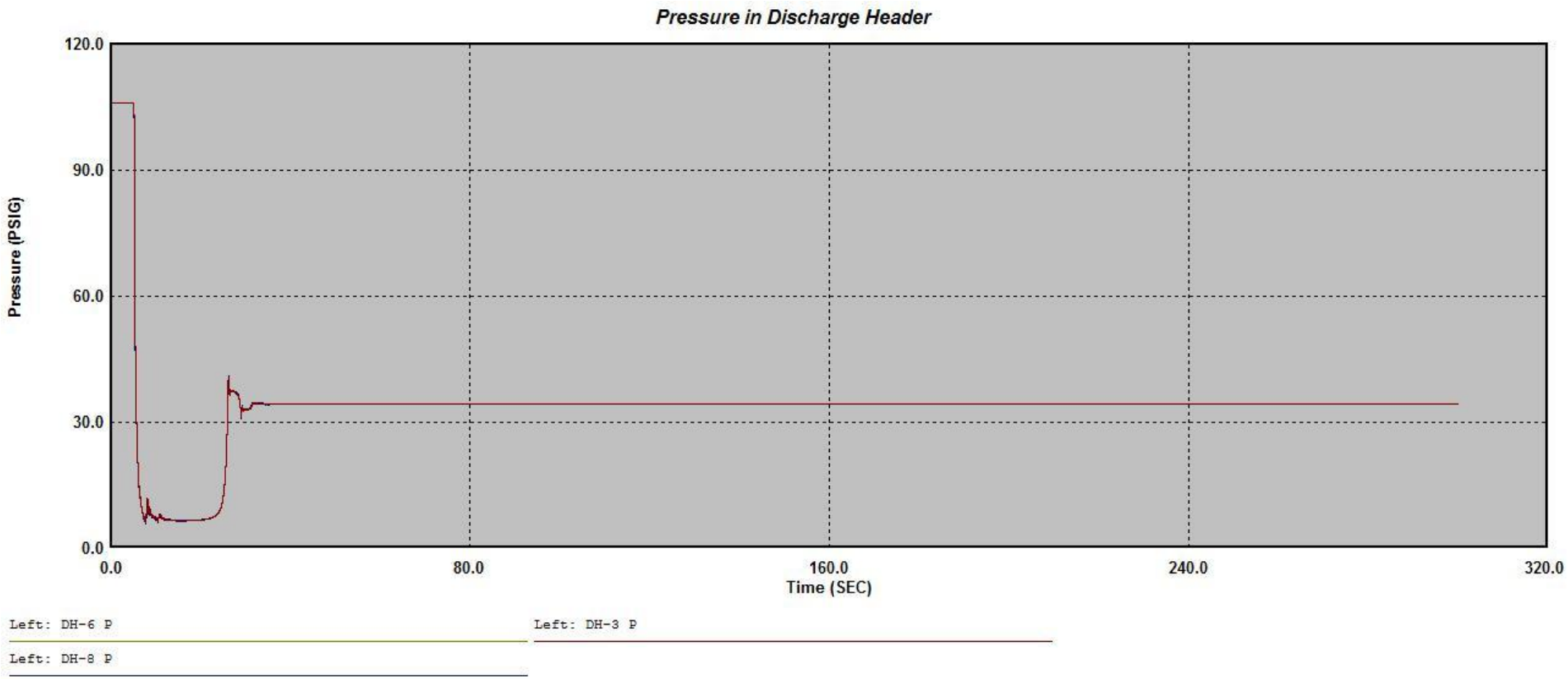


Left: AC1-I AC1-O AIRP

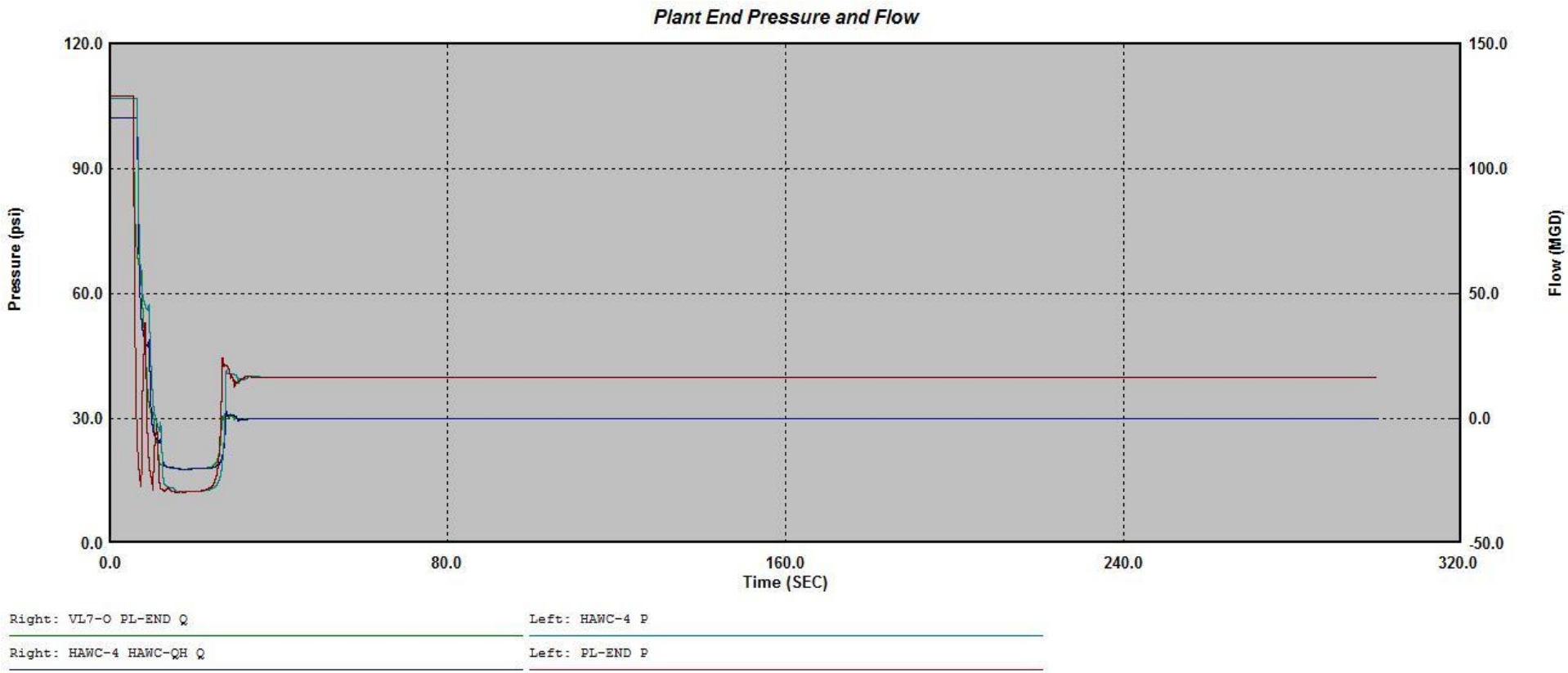
Right: AC1-I AC1-O VOL

Scenario 1 – Simultaneous All Pump Failure without Surge Tanks Adams 24-inch Disc Valve 30-sec Emergency Closure

Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure without Surge Tanks
Adams 24-inch Disc Valve
30-sec Emergency Closure

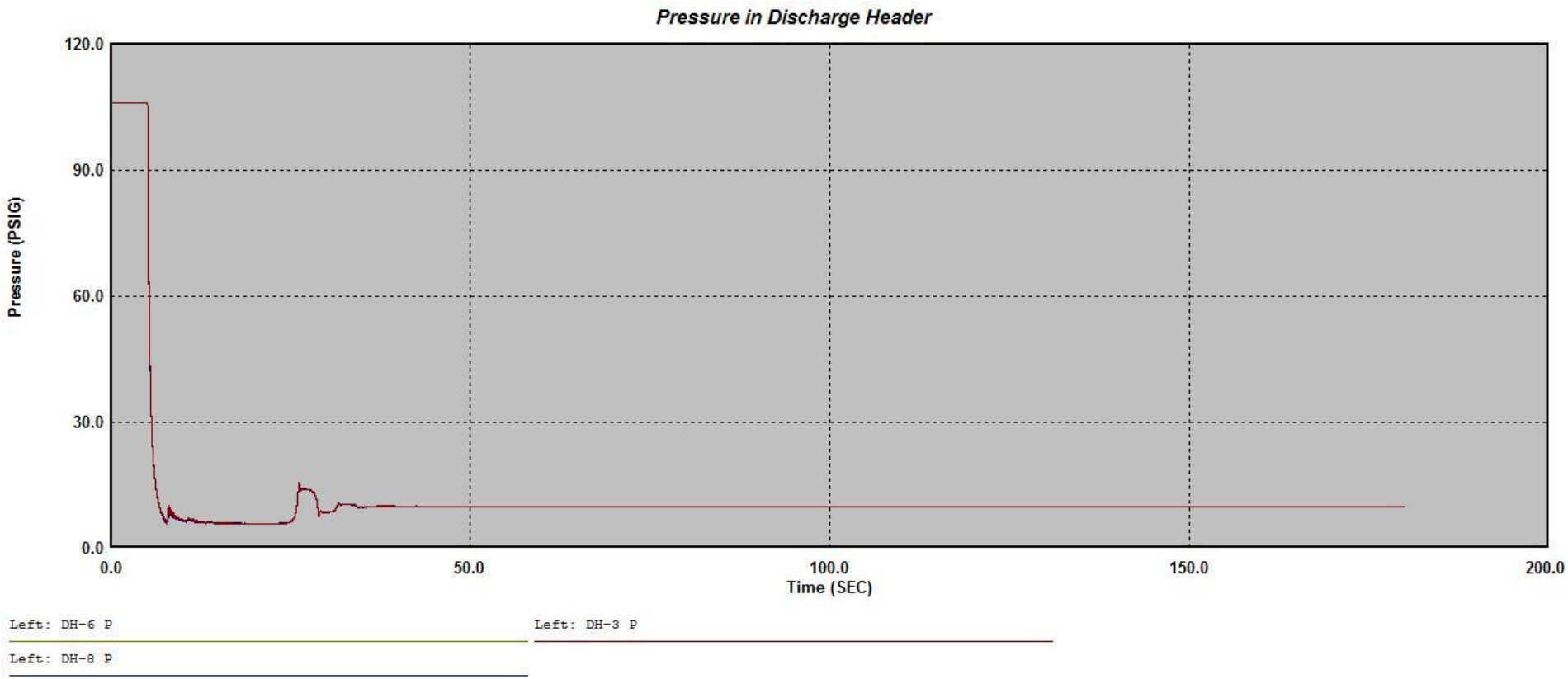


Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure without Surge Tanks
Adams 24-inch Disc Valve
30-sec Emergency Closure

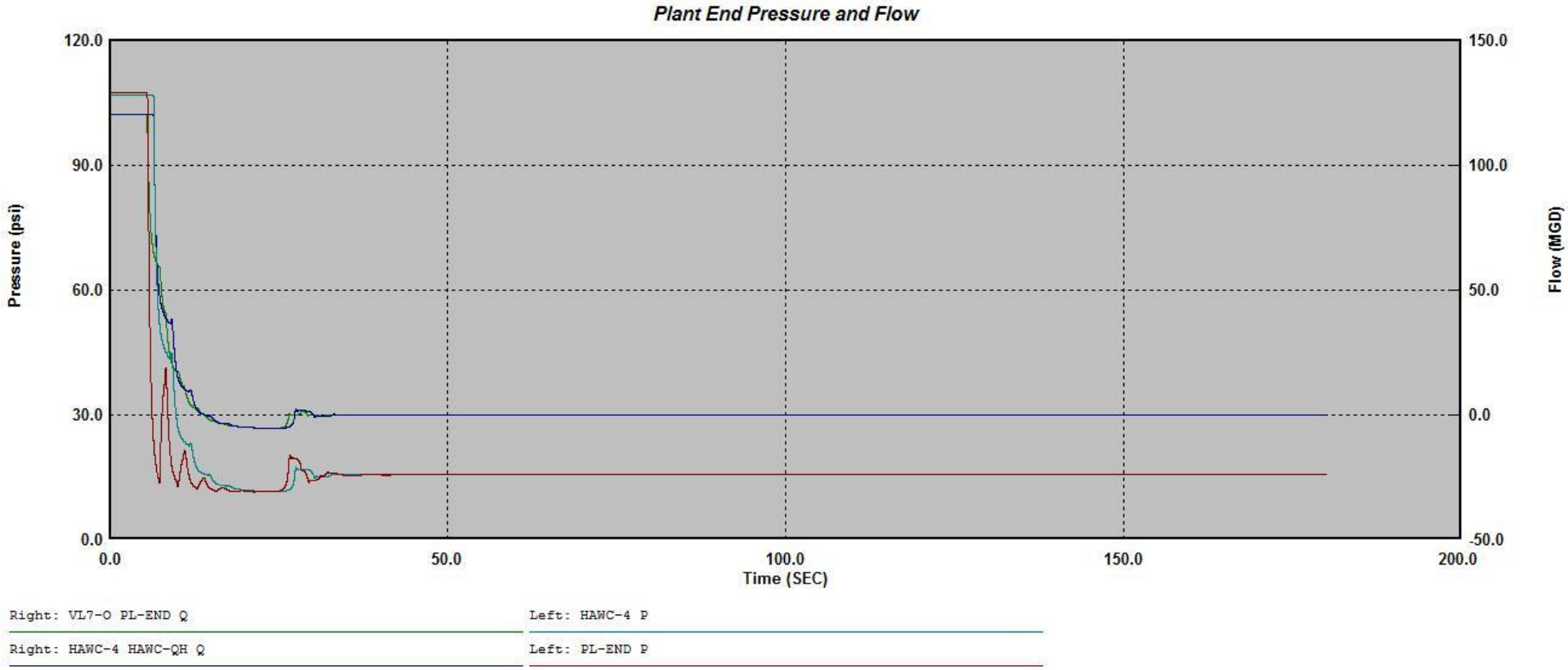


Scenario 1 – Simultaneous All Pump Failure without Surge Tanks and EWPP Backpressure Adams 24-inch Disc Valve 30-sec Emergency Closure

Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure without Surge Tanks and EWPP Backpressure
Adams 24-inch Disc Valve
30-sec Emergency Closure

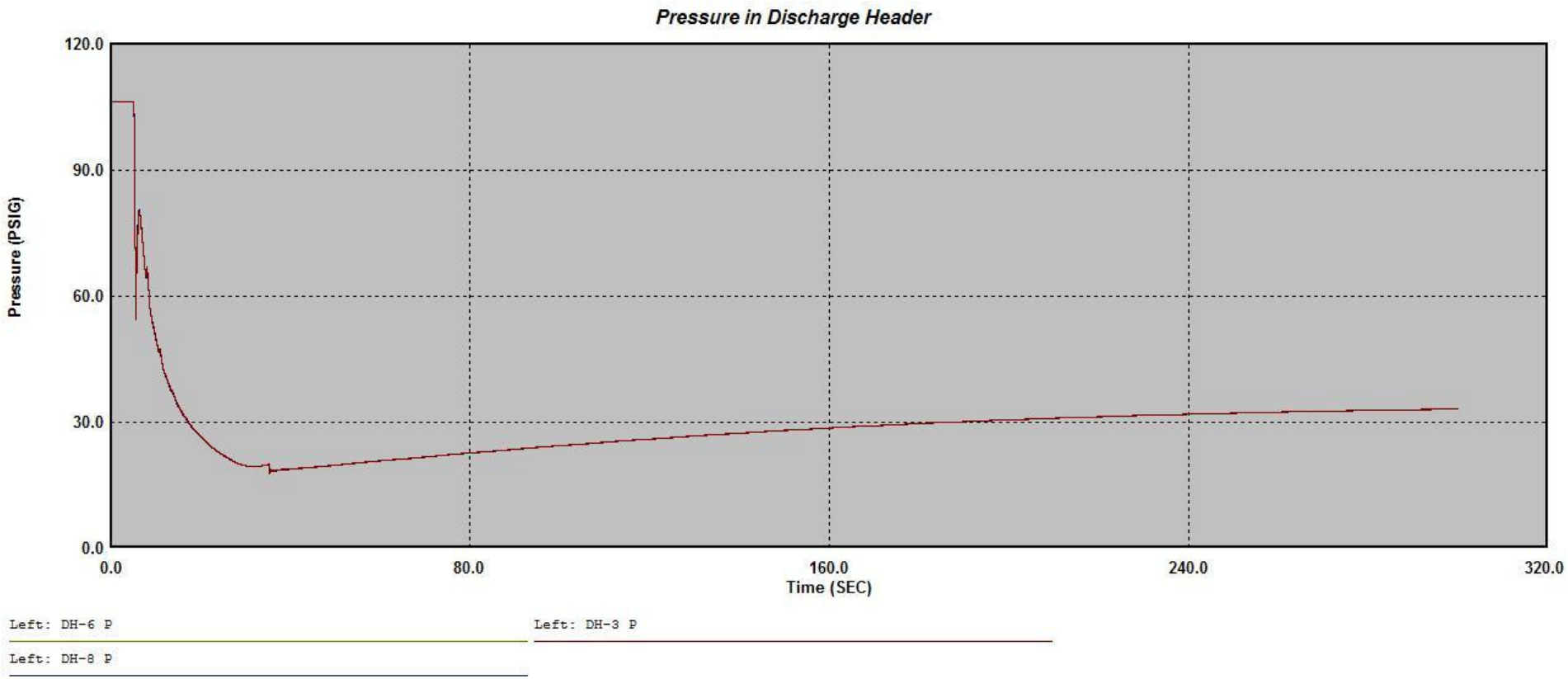


Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure without Surge Tanks and EWPP Backpressure
Adams 24-inch Disc Valve
30-sec Emergency Closure

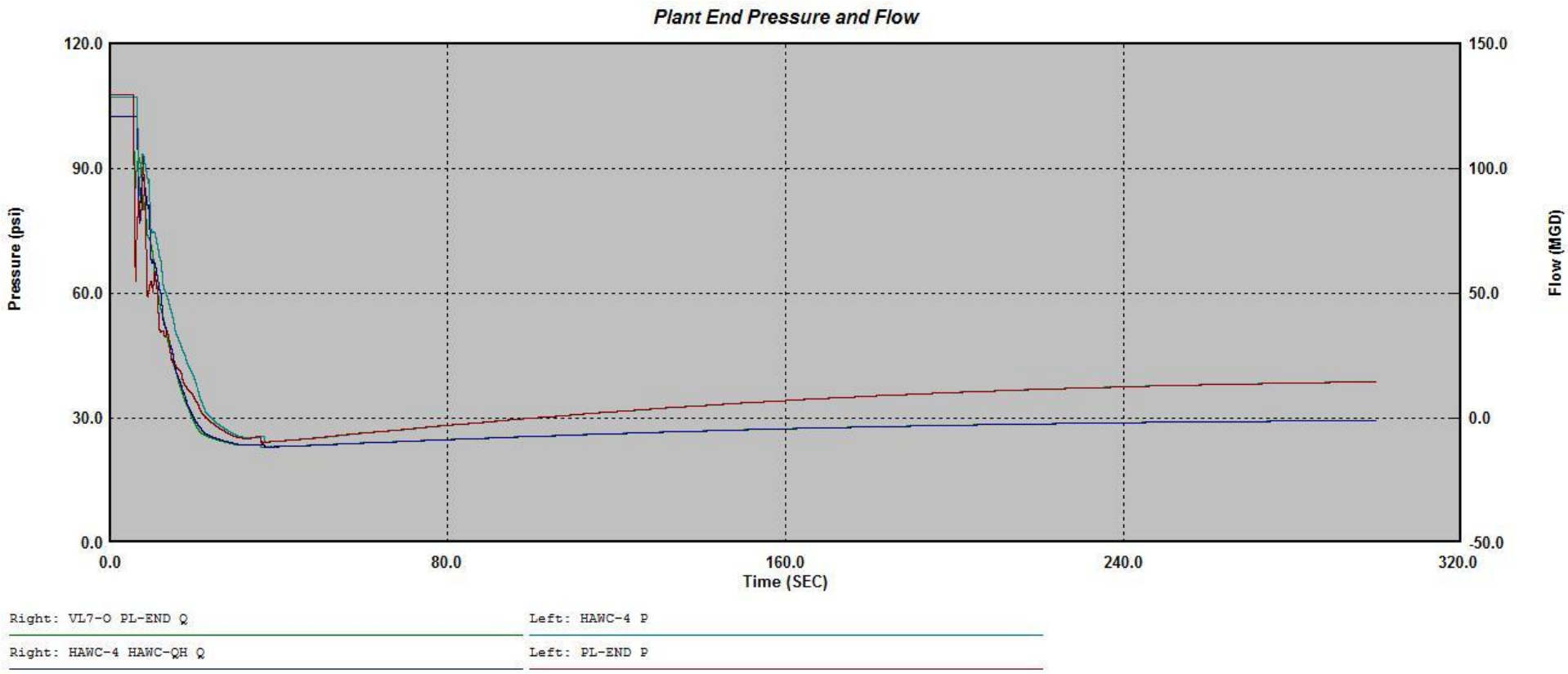


Scenario 1 – Simultaneous All Pump Failure 24-inch GA Ball Valve 30-sec Emergency Closure

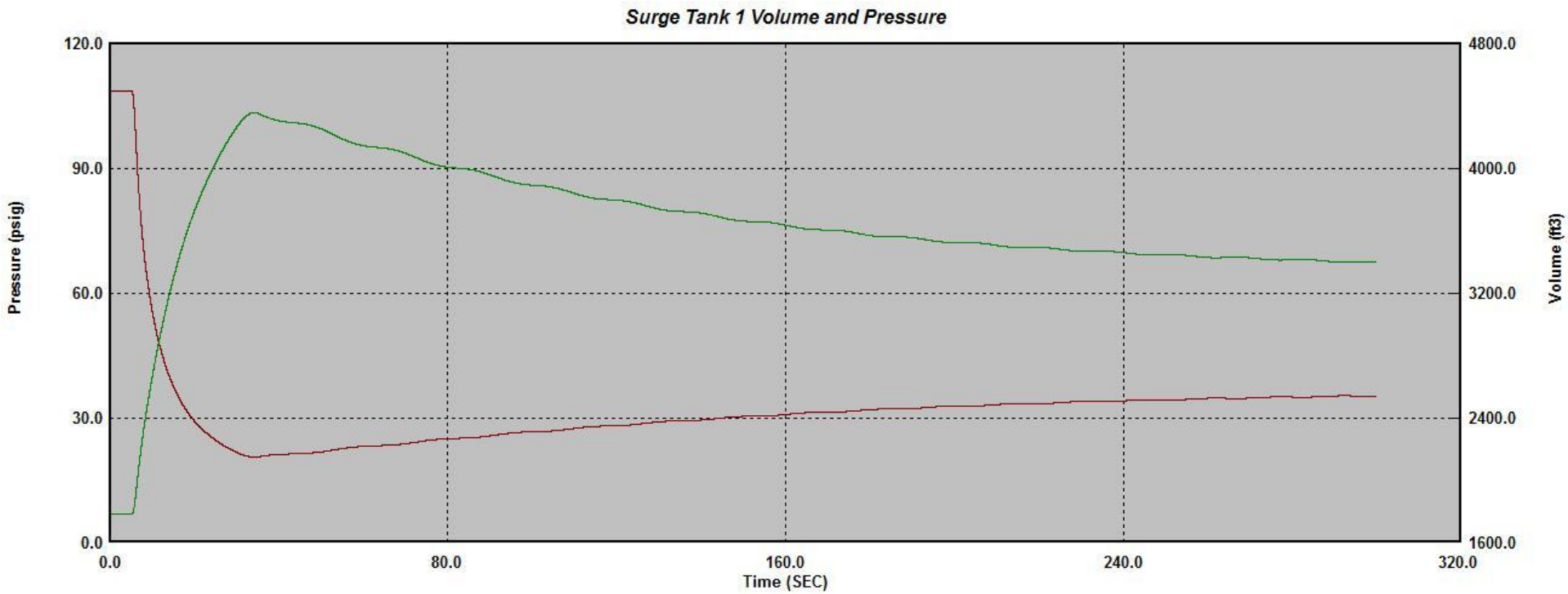
Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
24-inch GA Ball Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
24-inch GA Ball Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
24-inch GA Ball Valve
30-sec Emergency Closure

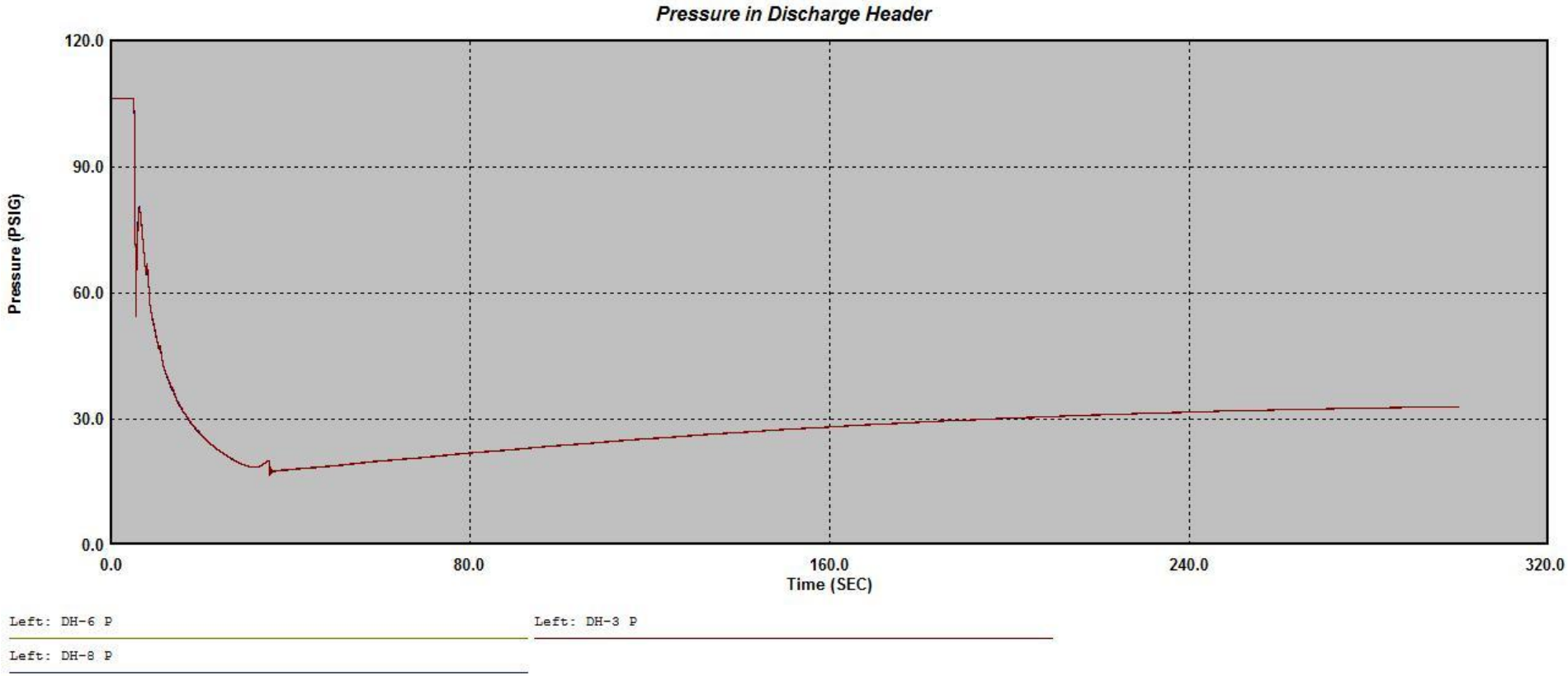


Left: AC1-I AC1-O AIRP

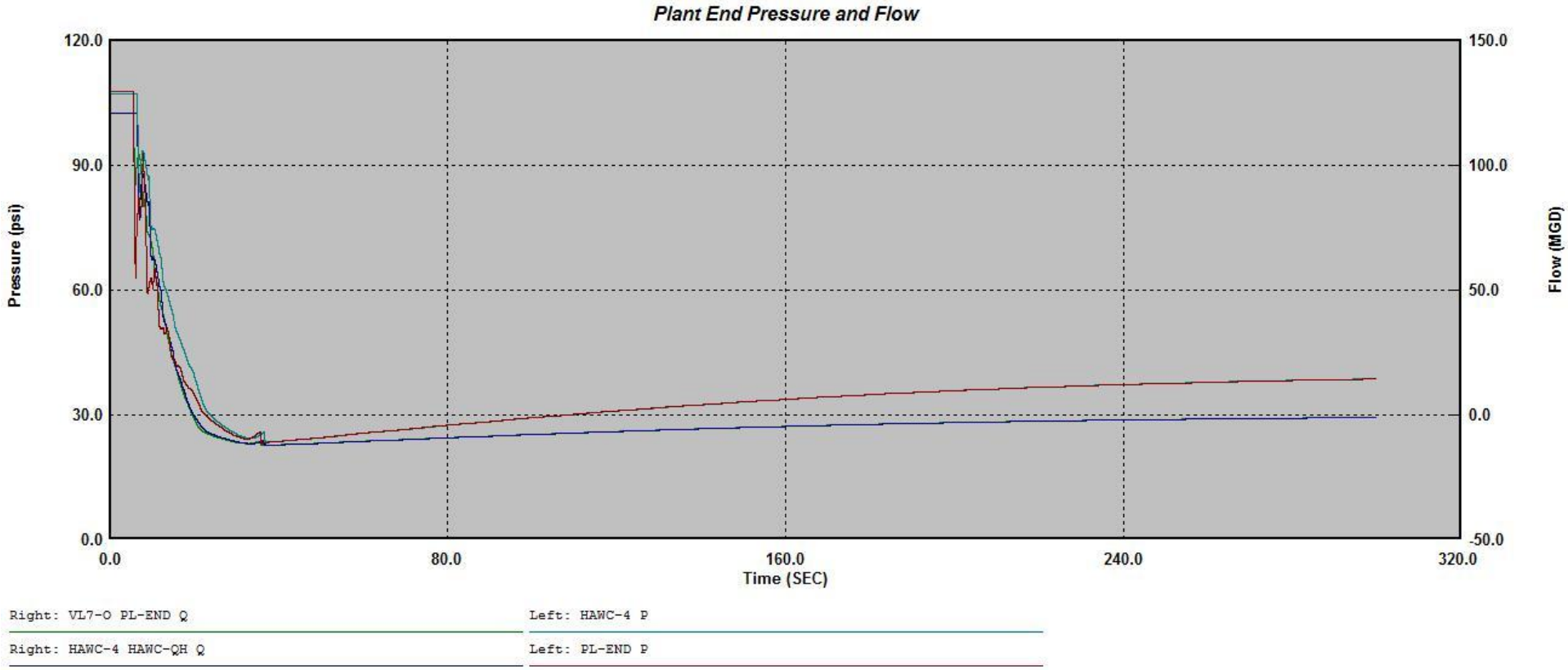
Right: AC1-I AC1-O VOL

Scenario 1 – Simultaneous All Pump Failure 30-inch GA Ball Valve 30-sec Emergency Closure

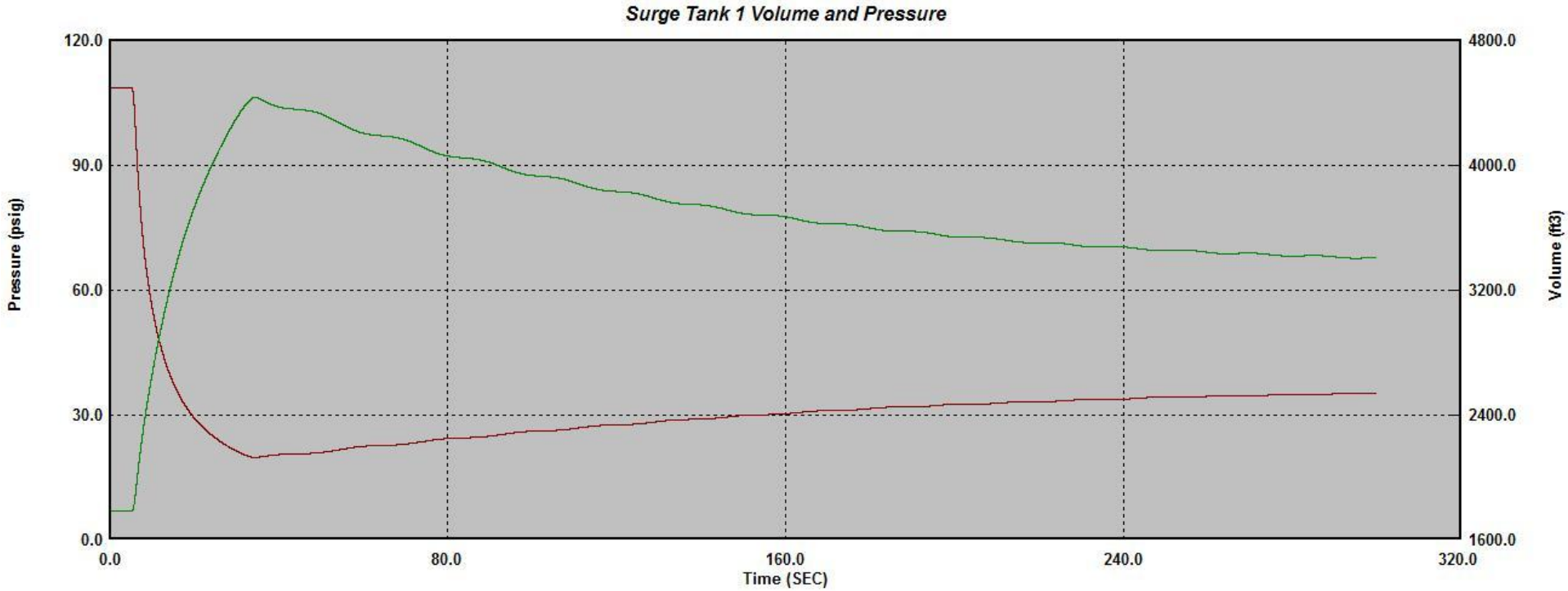
Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Ball Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Ball Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Ball Valve
30-sec Emergency Closure

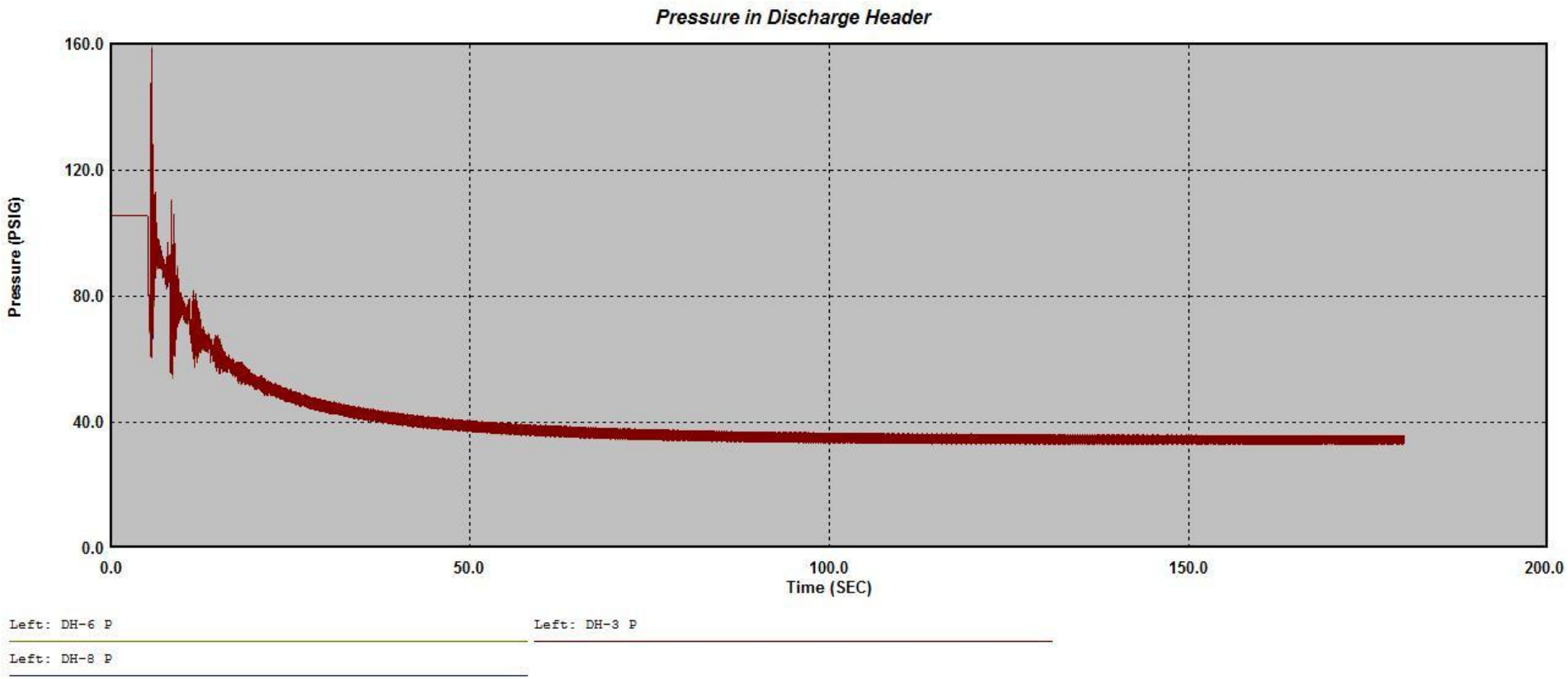


Left: AC1-I AC1-O AIRP

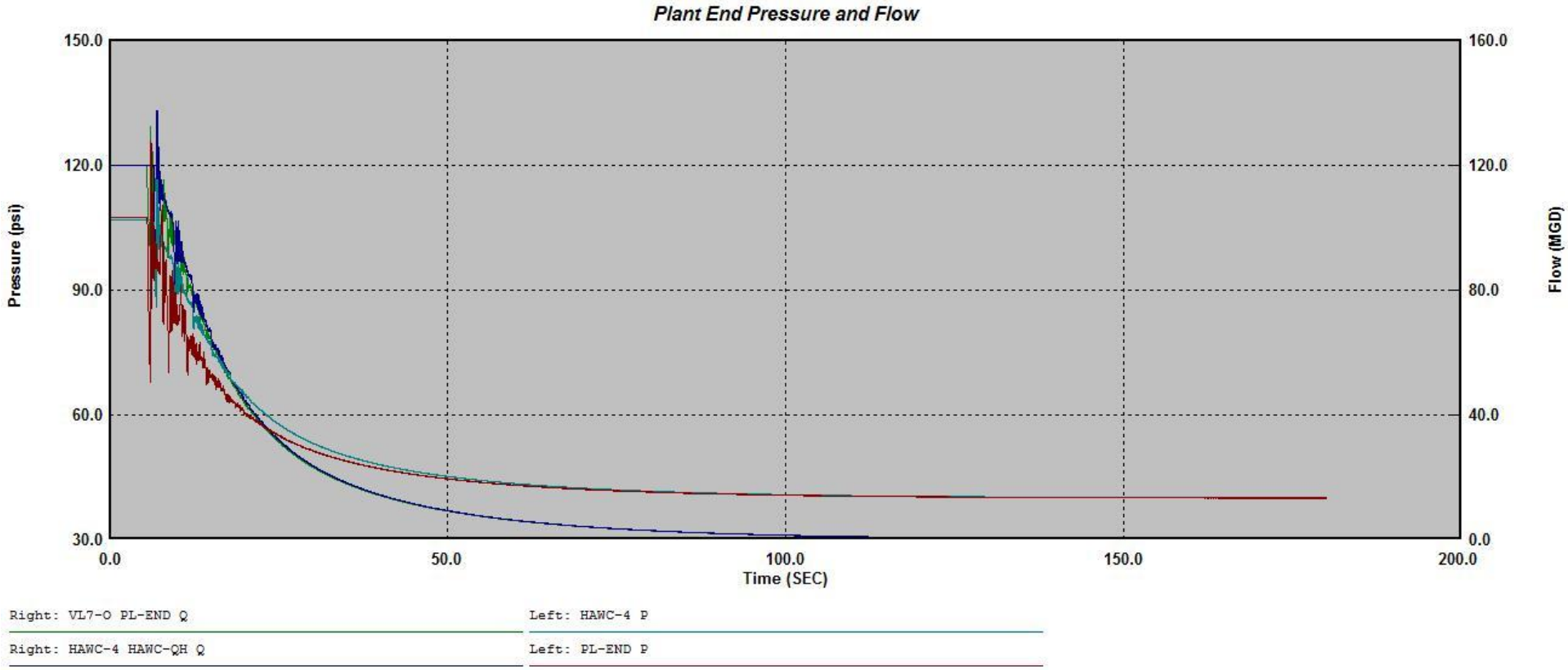
Right: AC1-I AC1-O VOL

Scenario 1 – Simultaneous All Pump Failure 30-inch GA Wye Valve 0.5-sec Emergency Closure

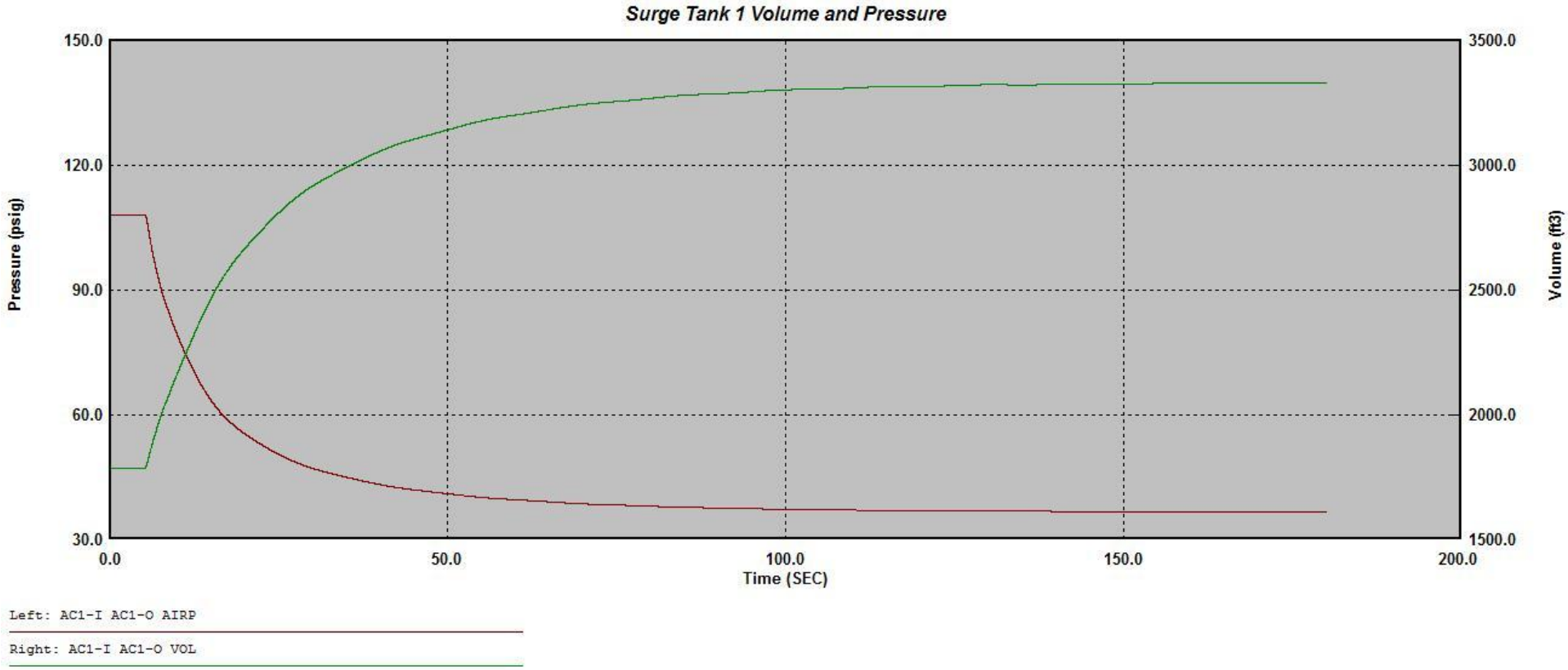
Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Wye Valve
0.5-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Wye Valve
0.5-sec Emergency Closure

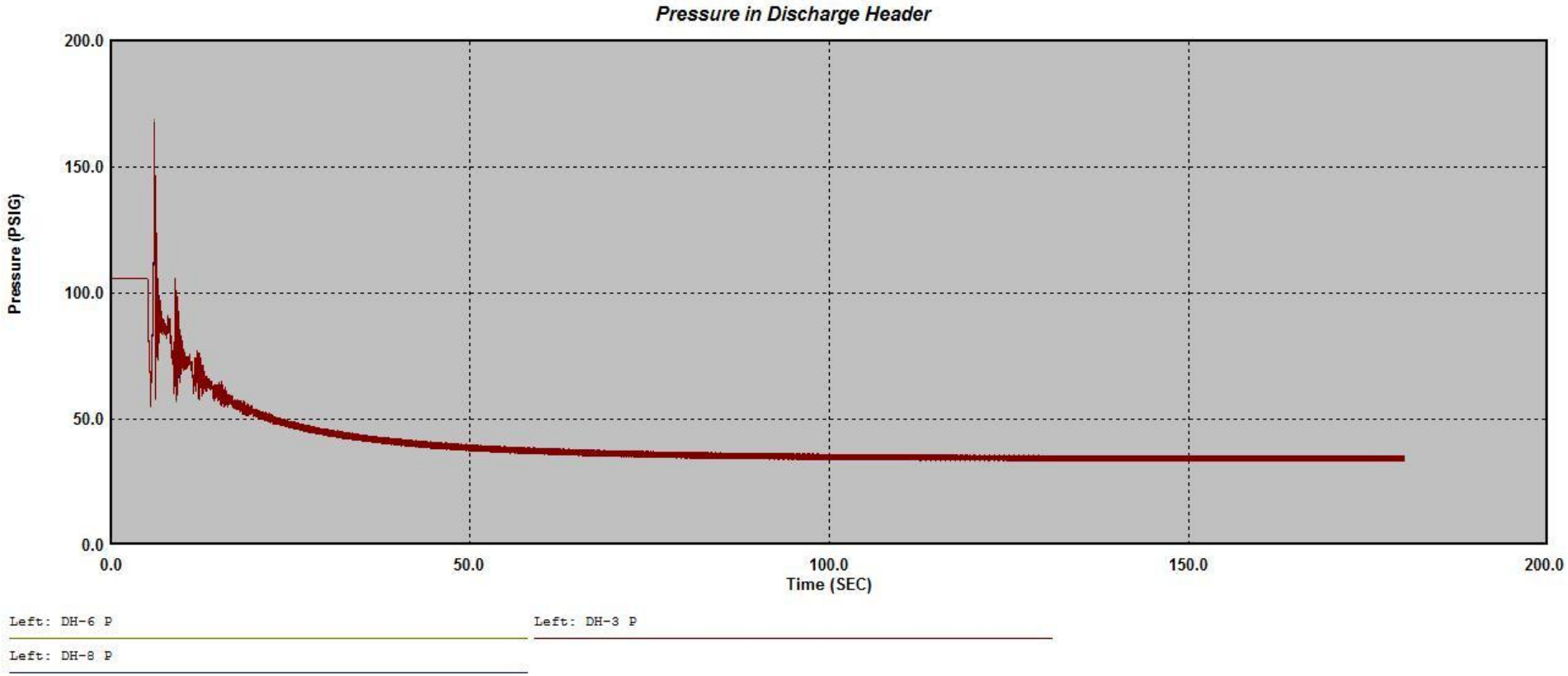


Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Wye Valve
0.5-sec Emergency Closure

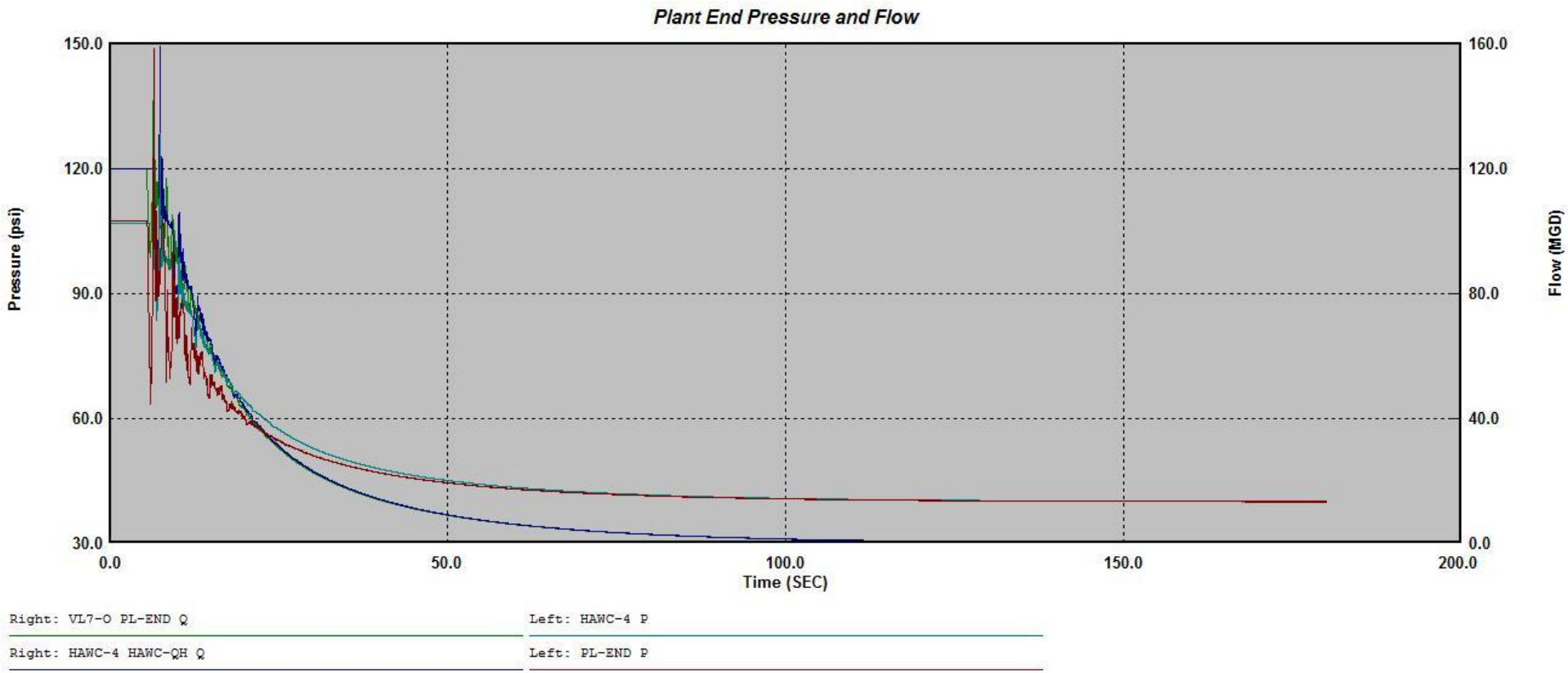


Scenario 1 – Simultaneous All Pump Failure 30-inch GA Wye Valve 1-sec Emergency Closure

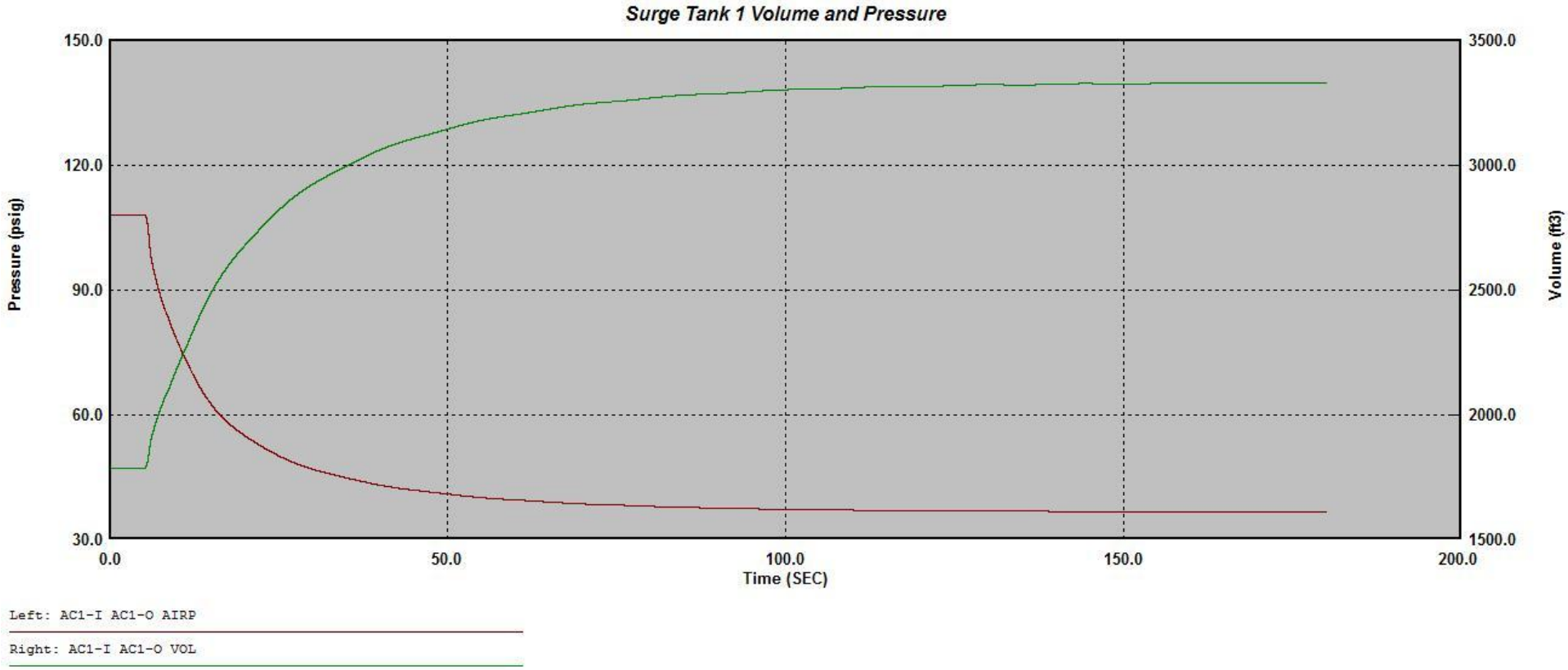
Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Wye Valve
1-sec Emergency Closure



Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Wye Valve
1-sec Emergency Closure

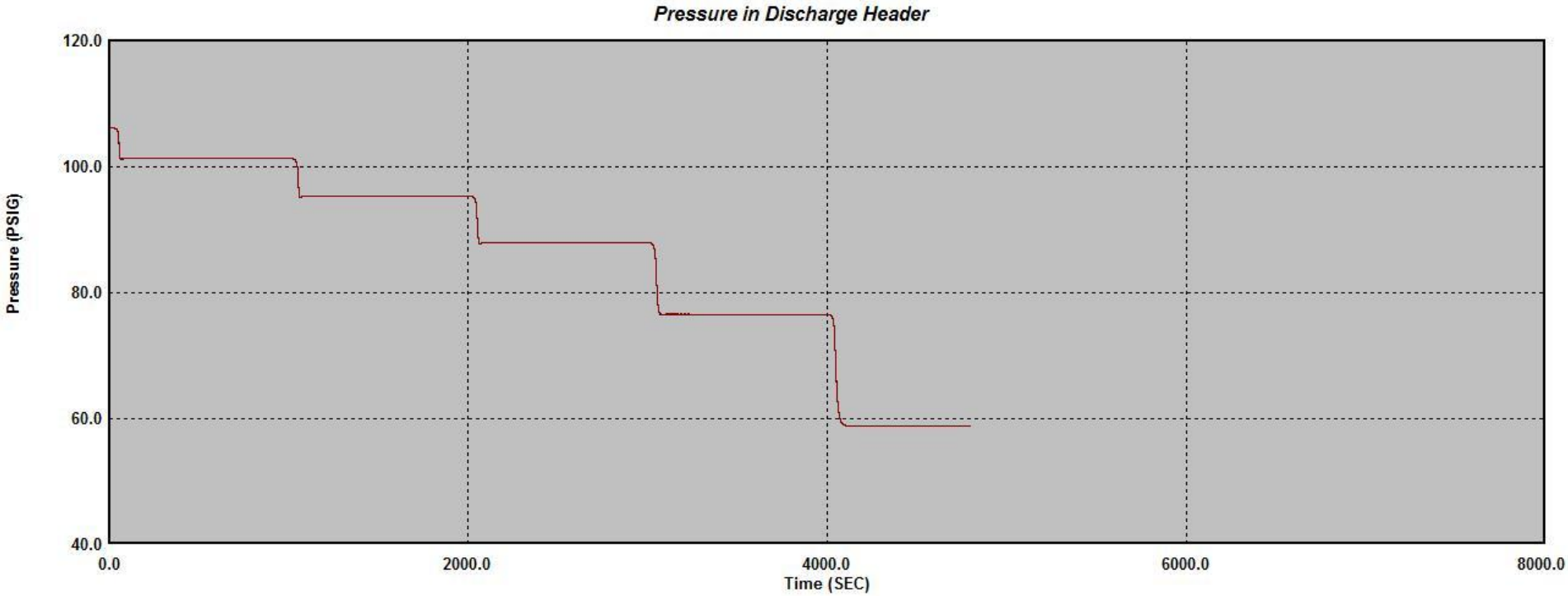


Proposed Pump Control Valves
Scenario 1 – Simultaneous All Pump Failure
30-inch GA Wye Valve
1-sec Emergency Closure



Scenario 2 – Normal Pump Shut Down Adams 30-inch Disc Valve 60-sec Closure

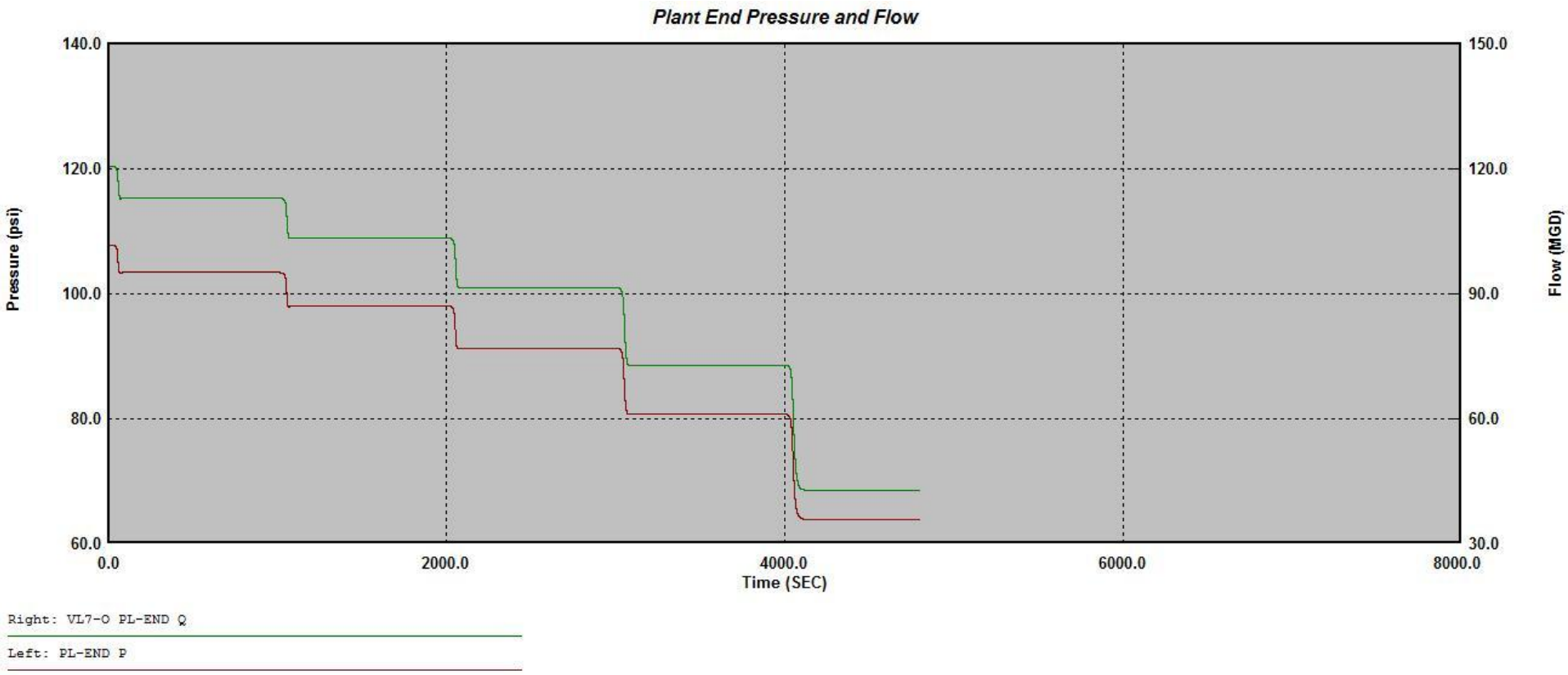
Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
Adams 30-inch Disc Valve
60-sec Closure



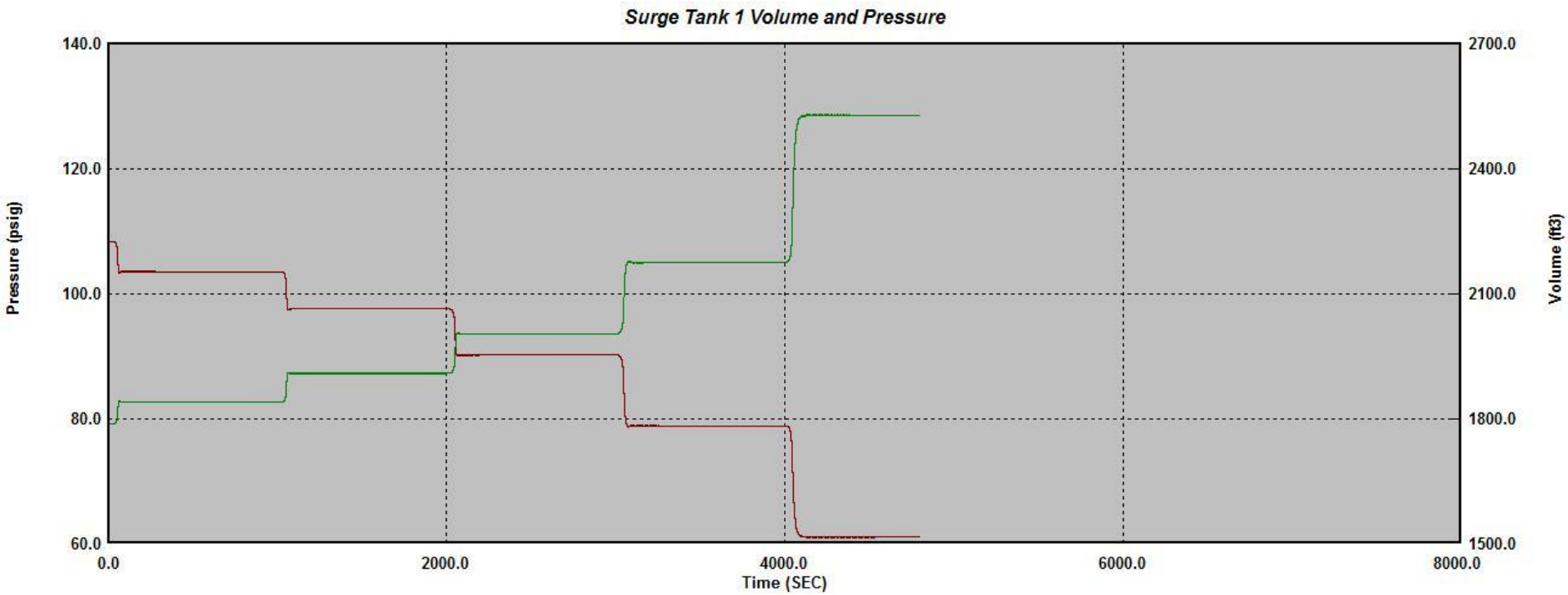
Left: DH-8 P

Left: DH-3 P

Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
Adams 30-inch Disc Valve
60-sec Closure



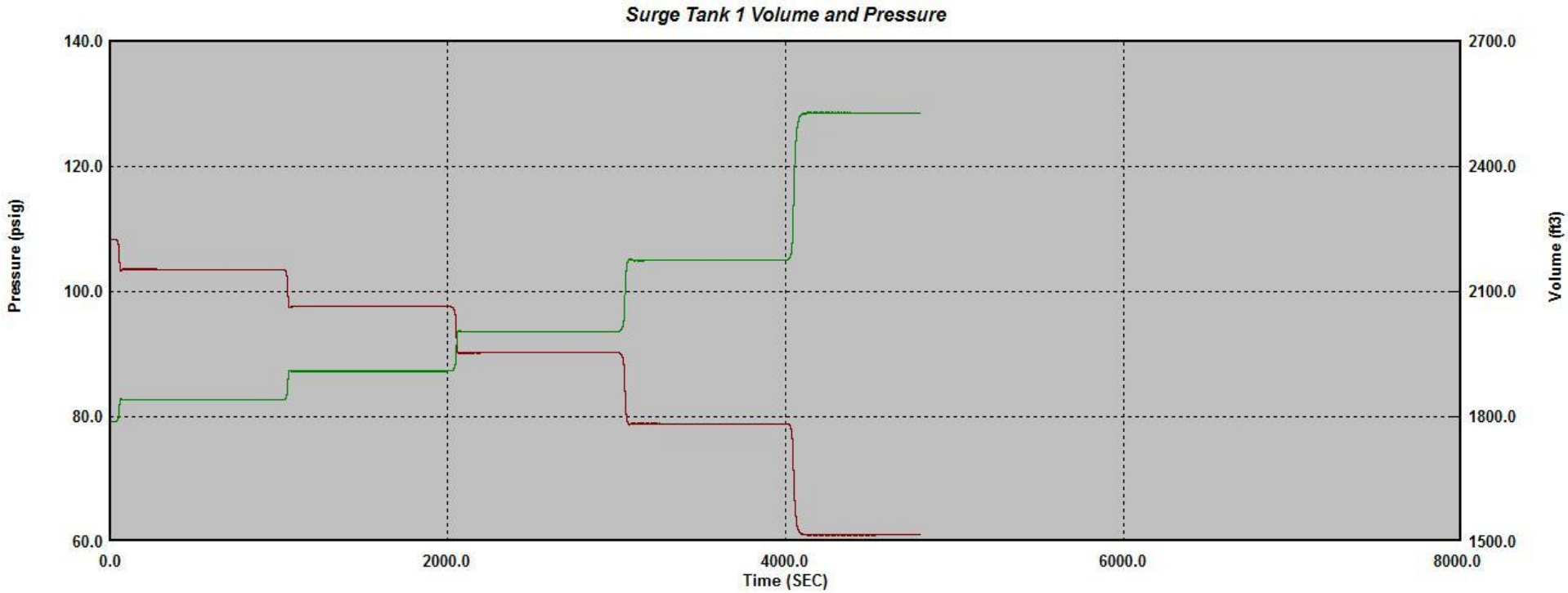
Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
Adams 30-inch Disc Valve
60-sec Closure



Left: AC1-I AC1-O AIRP

Right: AC1-I AC1-O VOL

Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
Adams 30-inch Disc Valve
60-sec Closure

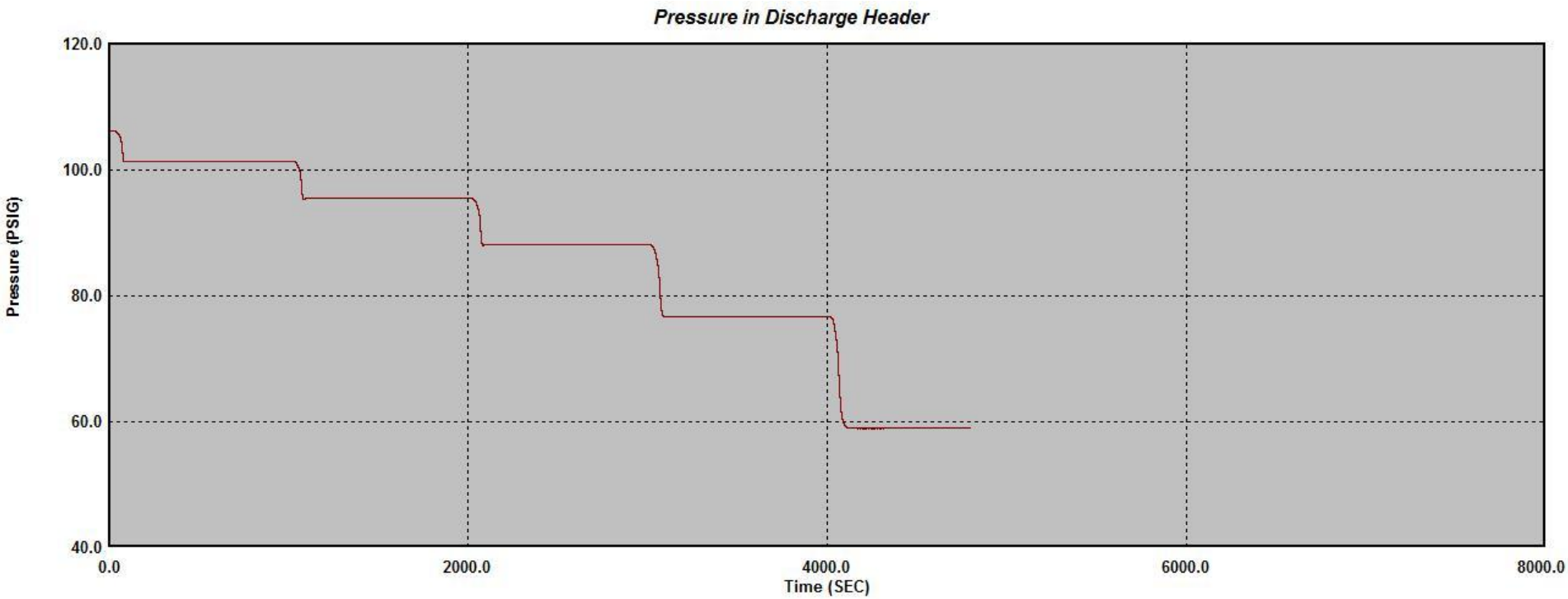


Left: AC1-I AC1-O AIRP

Right: AC1-I AC1-O VOL

Scenario 2 – Normal Pump Shut Down GA 24-inch Ball Valve 60-sec Closure

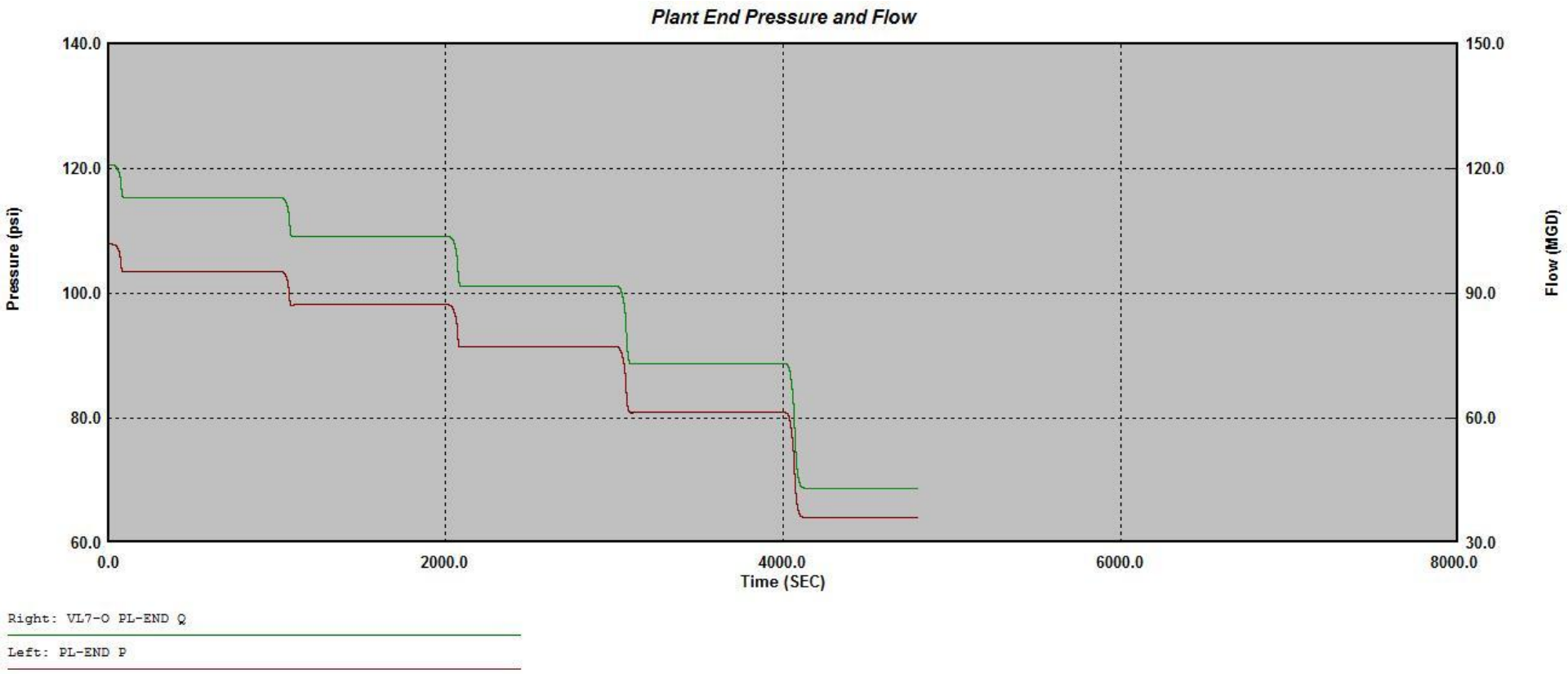
Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 24-inch Ball Valve
60-sec Closure



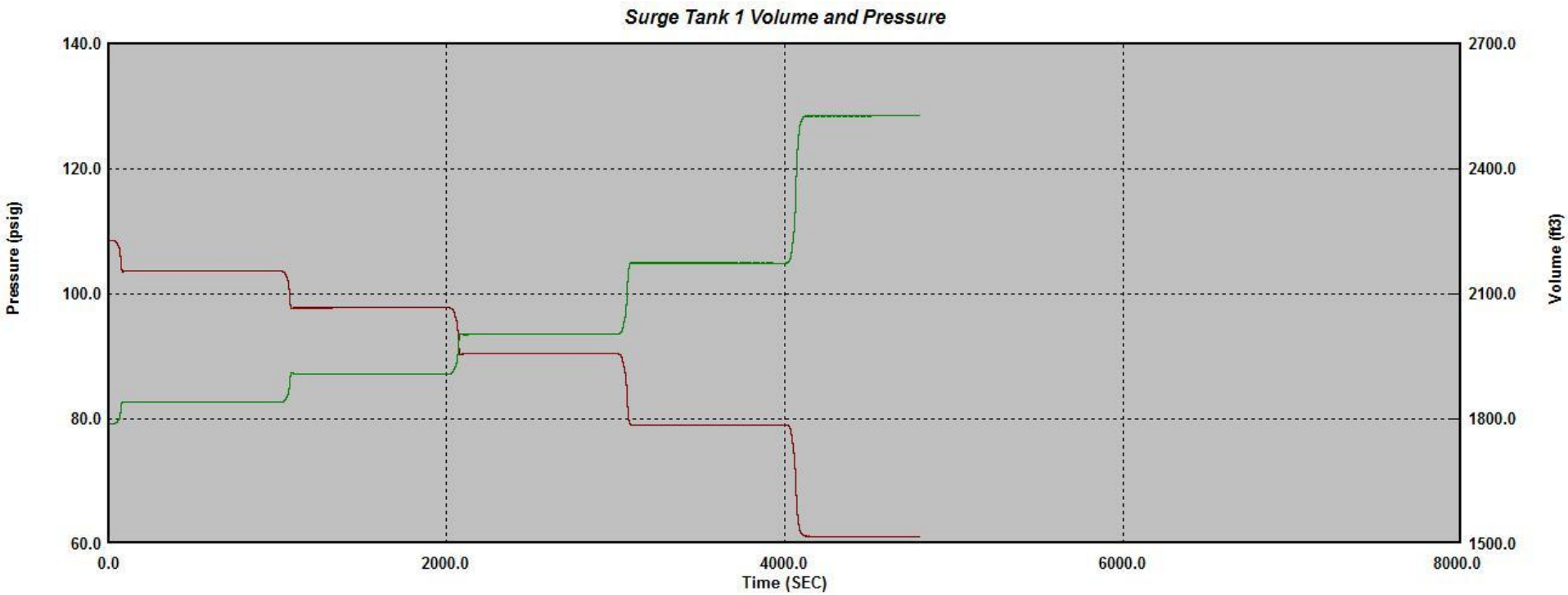
Left: DH-8 P

Left: DH-3 P

Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 24-inch Ball Valve
60-sec Closure



Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 24-inch Ball Valve
60-sec Closure

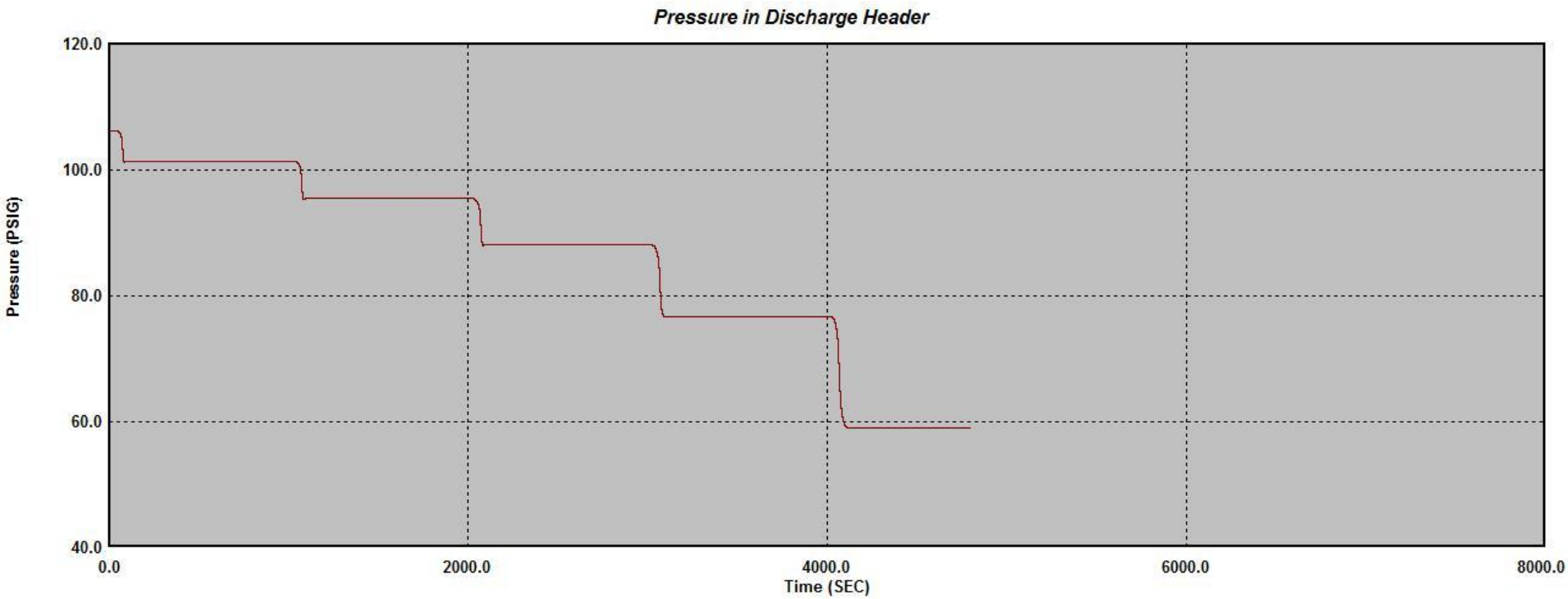


Left: AC1-I AC1-O AIRP

Right: AC1-I AC1-O VOL

Scenario 2 – Normal Pump Shut Down GA 30-inch Ball Valve 60-sec Closure

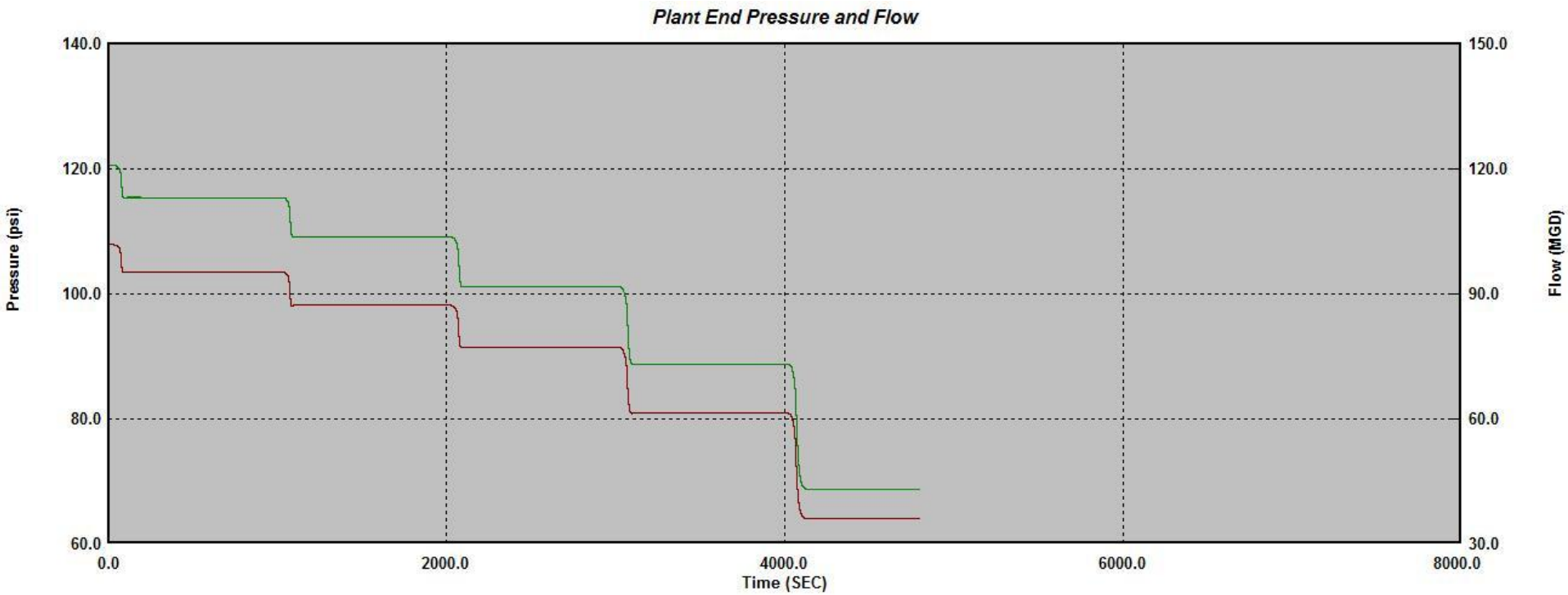
Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 30-inch Ball Valve
60-sec Closure



Left: DH-8 P

Left: DH-3 P

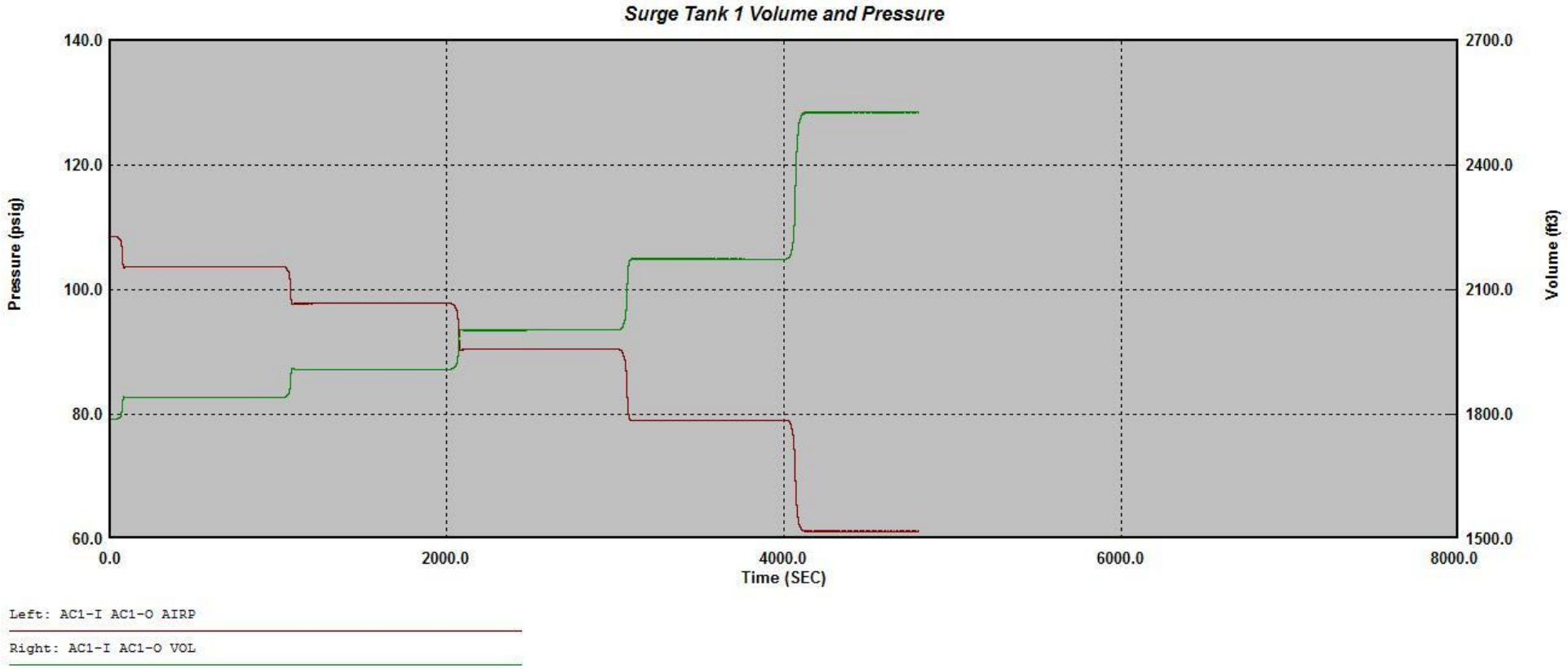
Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 30-inch Ball Valve
60-sec Closure



Right: VL7-O PL-END Q

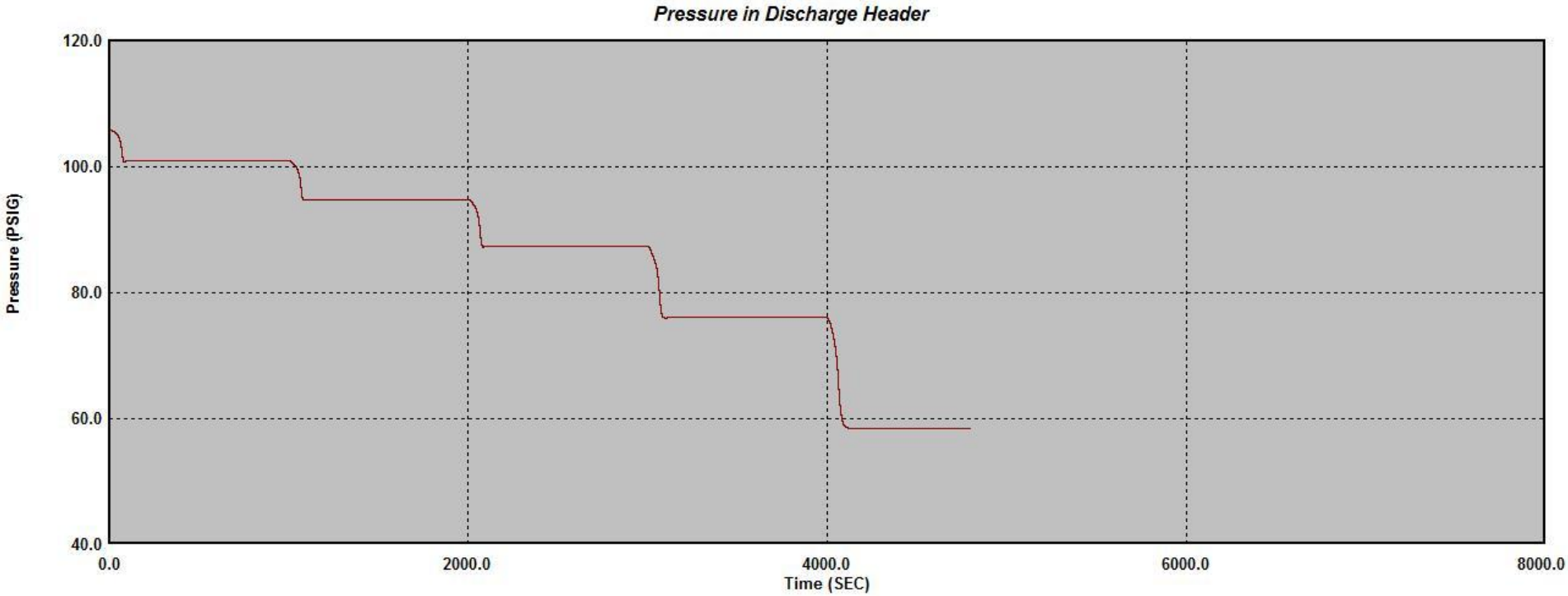
Left: PL-END P

Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 30-inch Ball Valve
60-sec Closure



Scenario 2 – Normal Pump Shut Down GA 30-inch Wye Valve 60-sec Closure

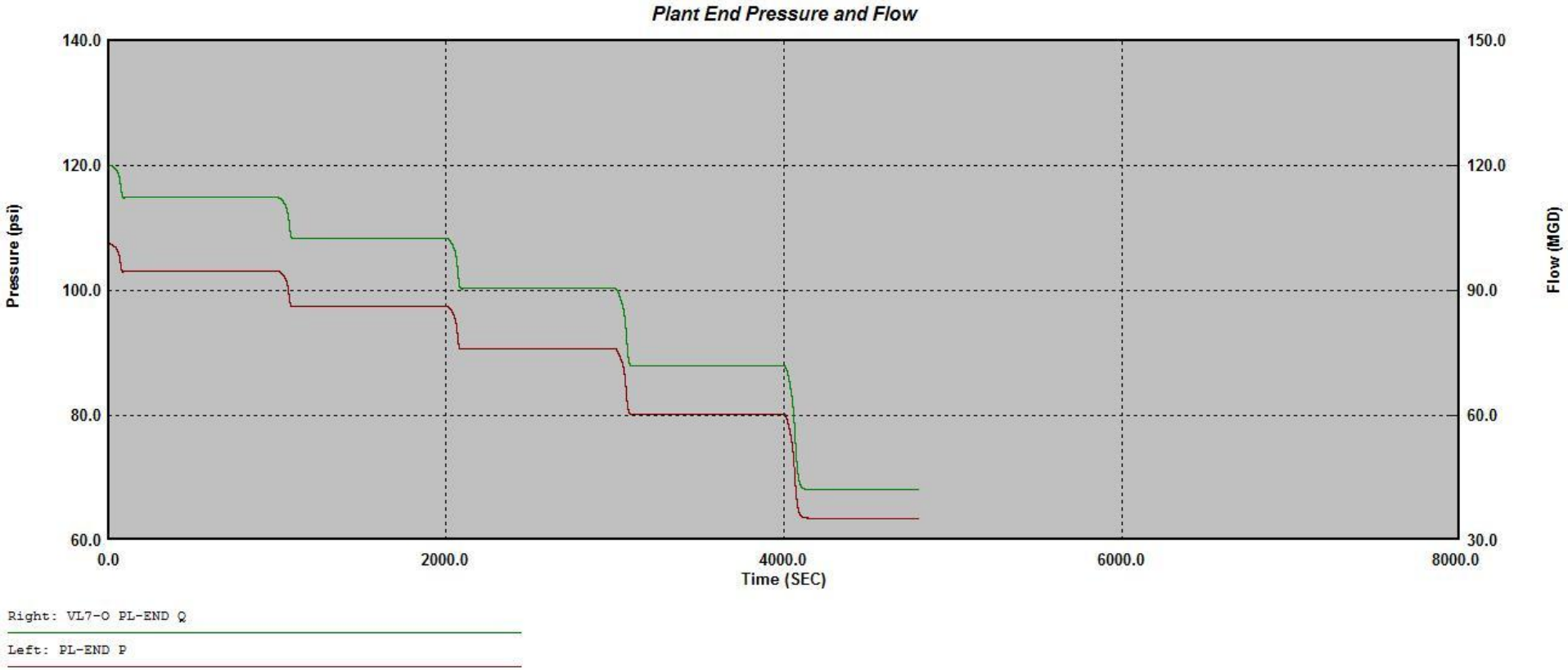
Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 30-inch Wye Valve
60-sec Closure



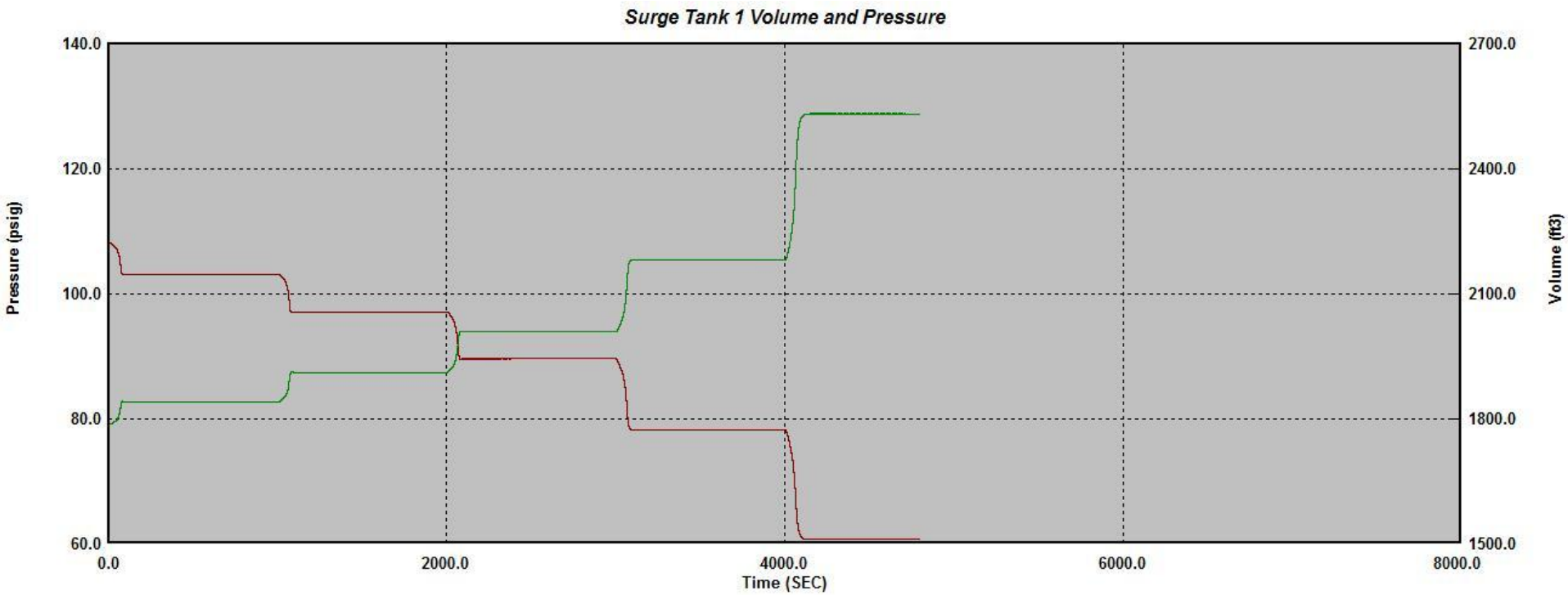
Left: DH-8 P

Left: DH-3 P

Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 30-inch Wye Valve
60-sec Closure



Proposed Pump Control Valves
Scenario 2 – Normal Pump Shut Down
GA 30-inch Wye Valve
60-sec Closure

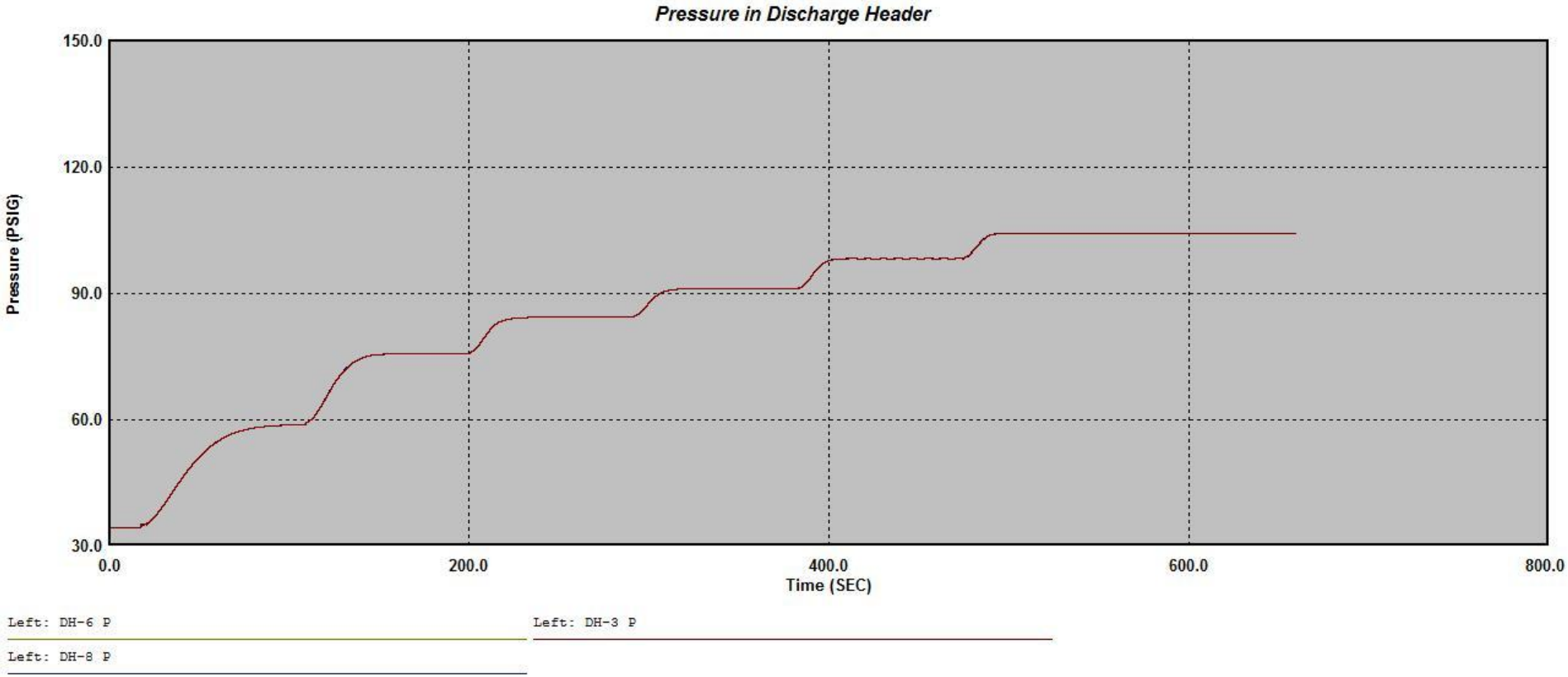


Left: AC1-I AC1-O AIRP

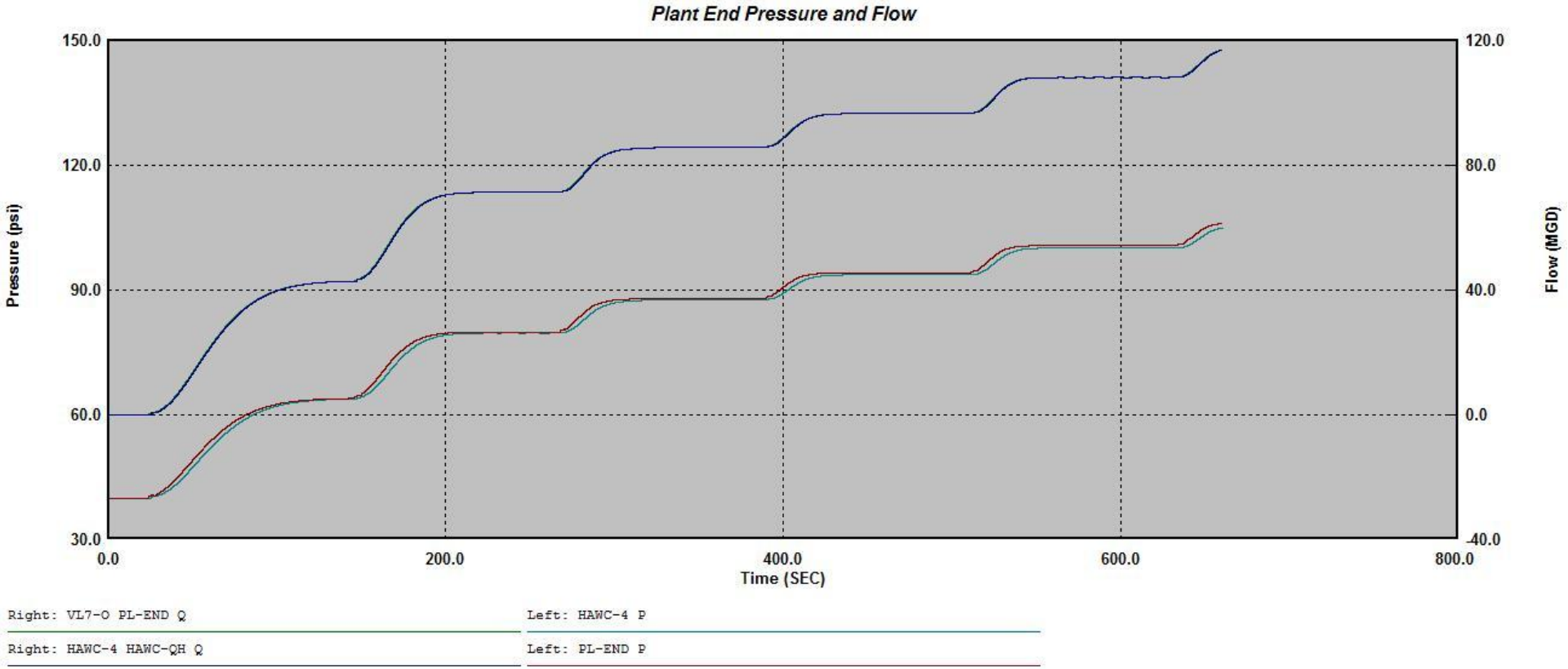
Right: AC1-I AC1-O VOL

Scenario 3 – Normal Pump Start Up Adams 30-inch Disc Valve 60-sec Opening

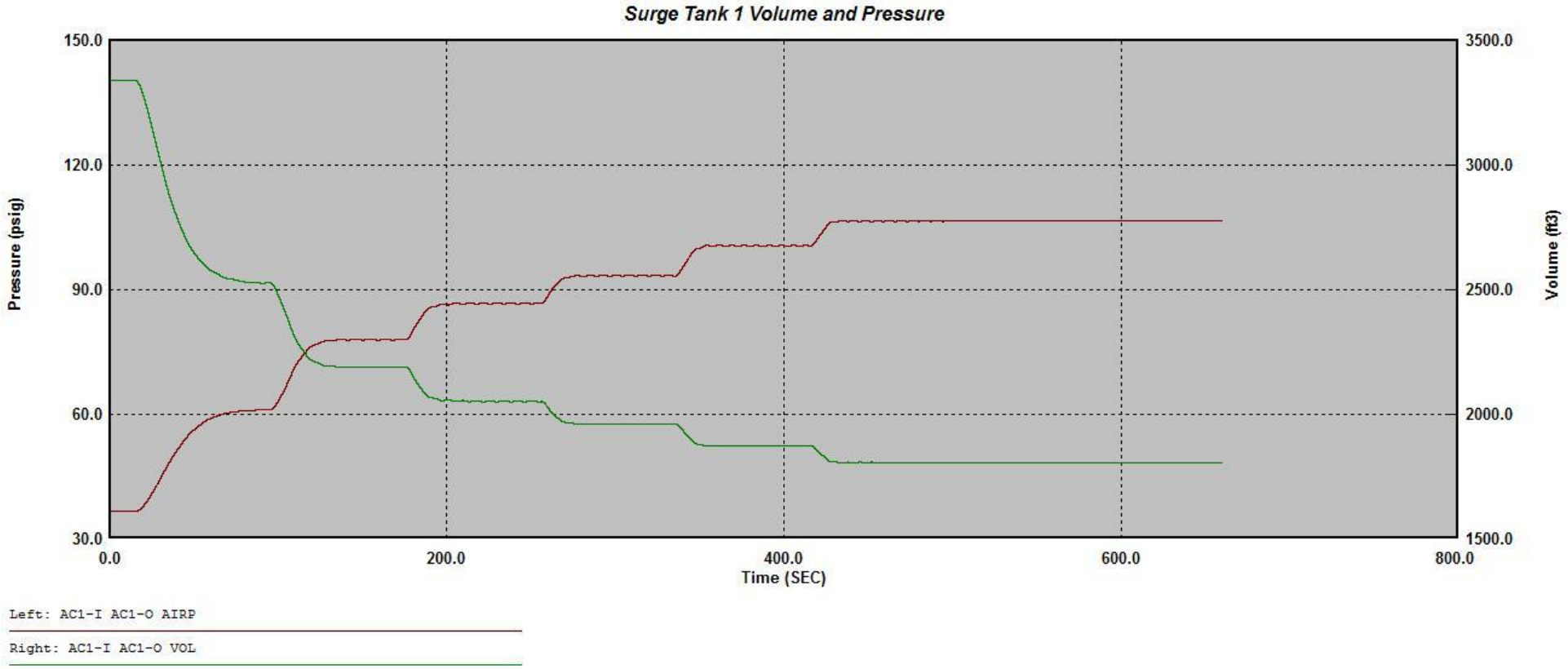
Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
Adams 30-inch Disc Valve
60-sec Opening



Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
Adams 30-inch Disc Valve
60-sec Opening

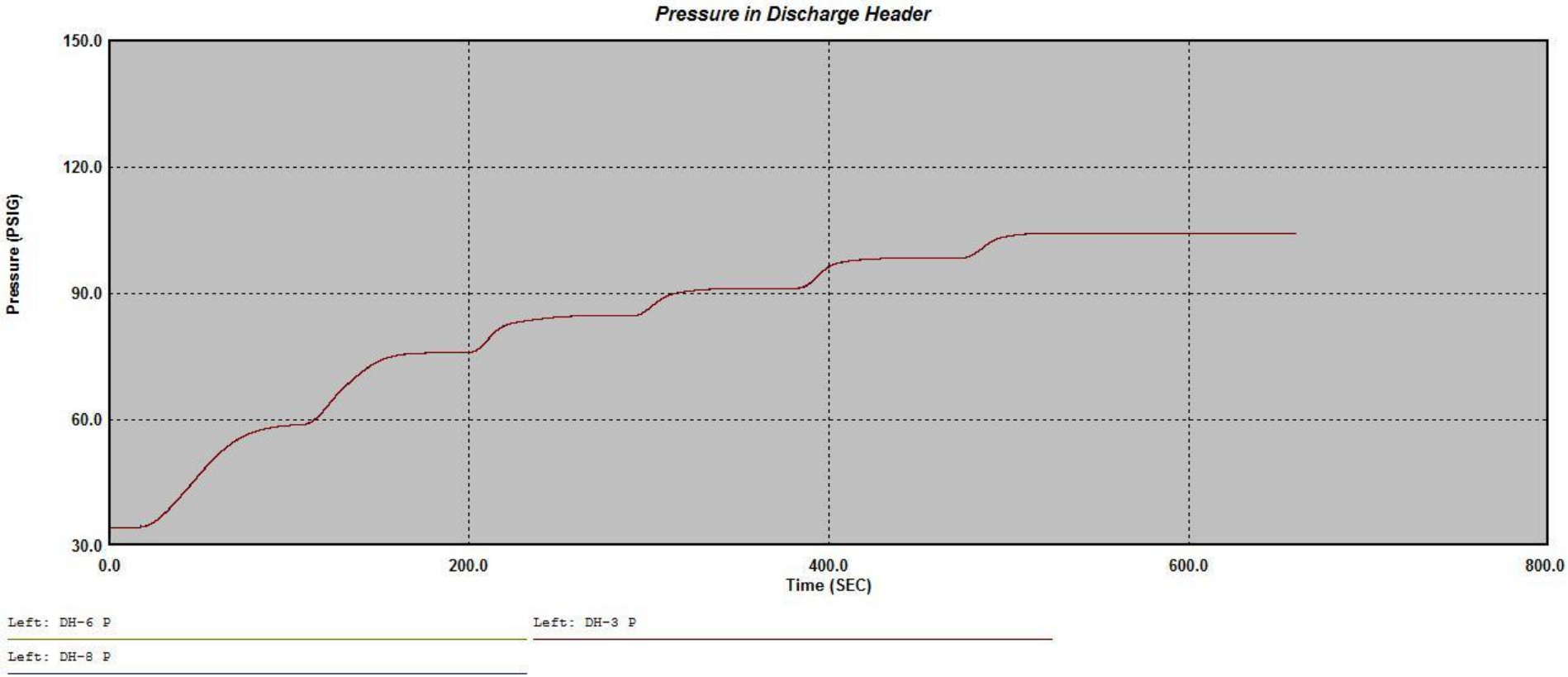


Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
Adams 30-inch Disc Valve
60-sec Opening

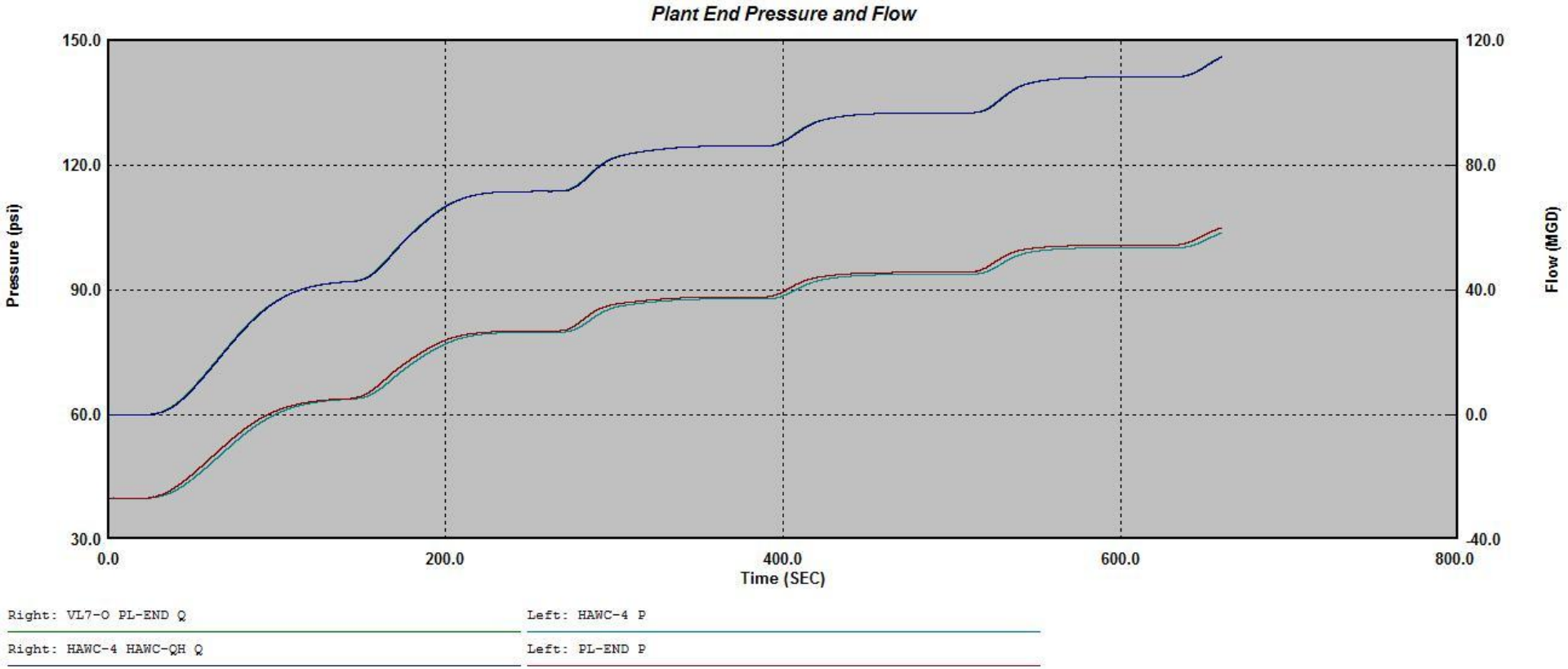


Scenario 3 – Normal Pump Start Up GA 24-inch Ball Valve 60-sec Opening

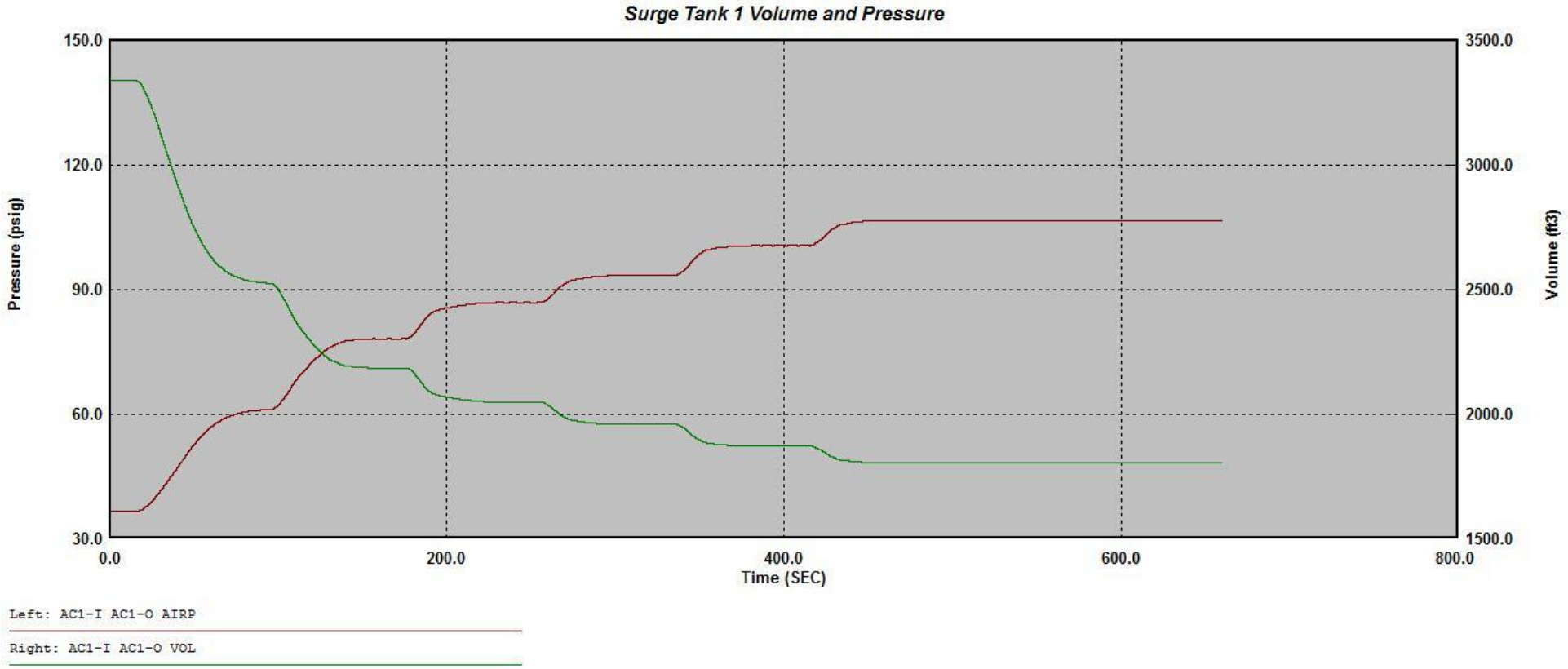
Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 24-inch Ball Valve
60-sec Opening



Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 24-inch Ball Valve
60-sec Opening

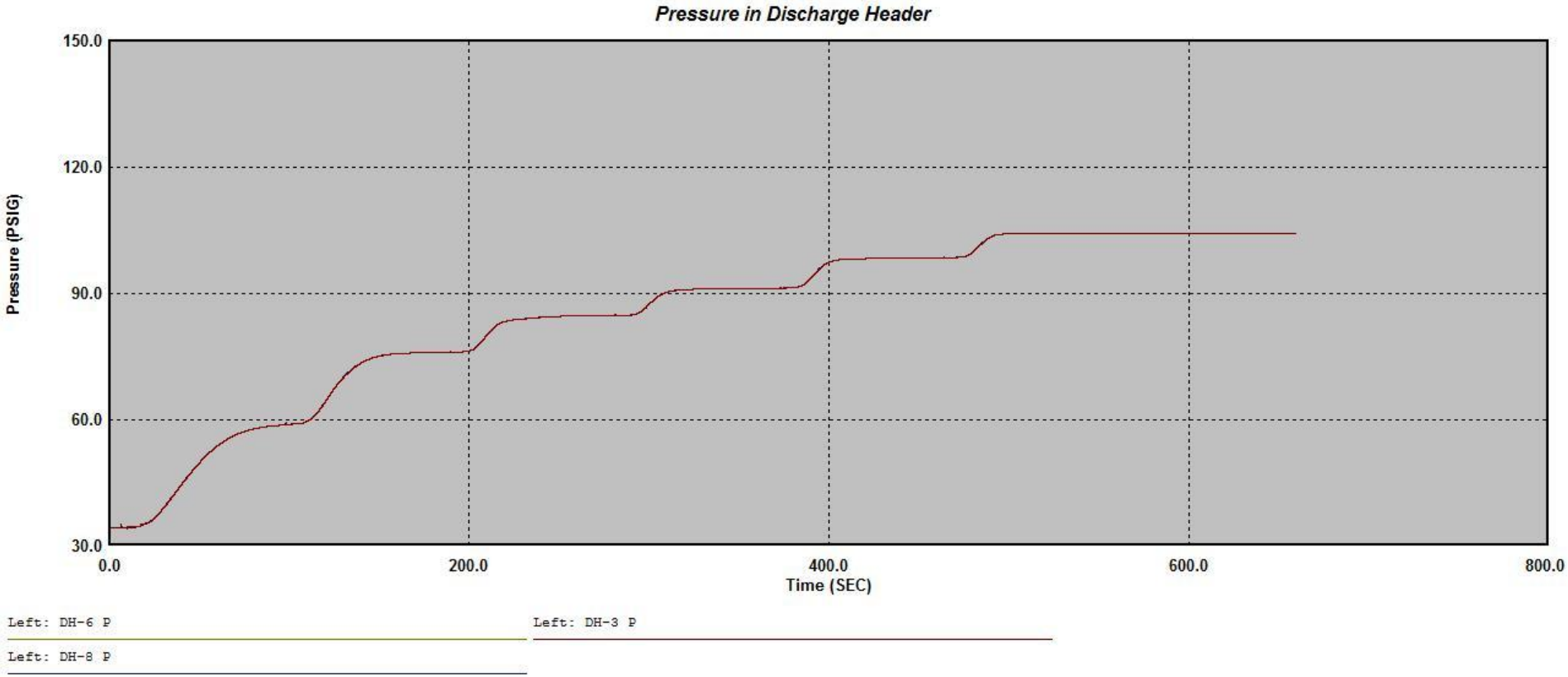


Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 24-inch Ball Valve
60-sec Opening

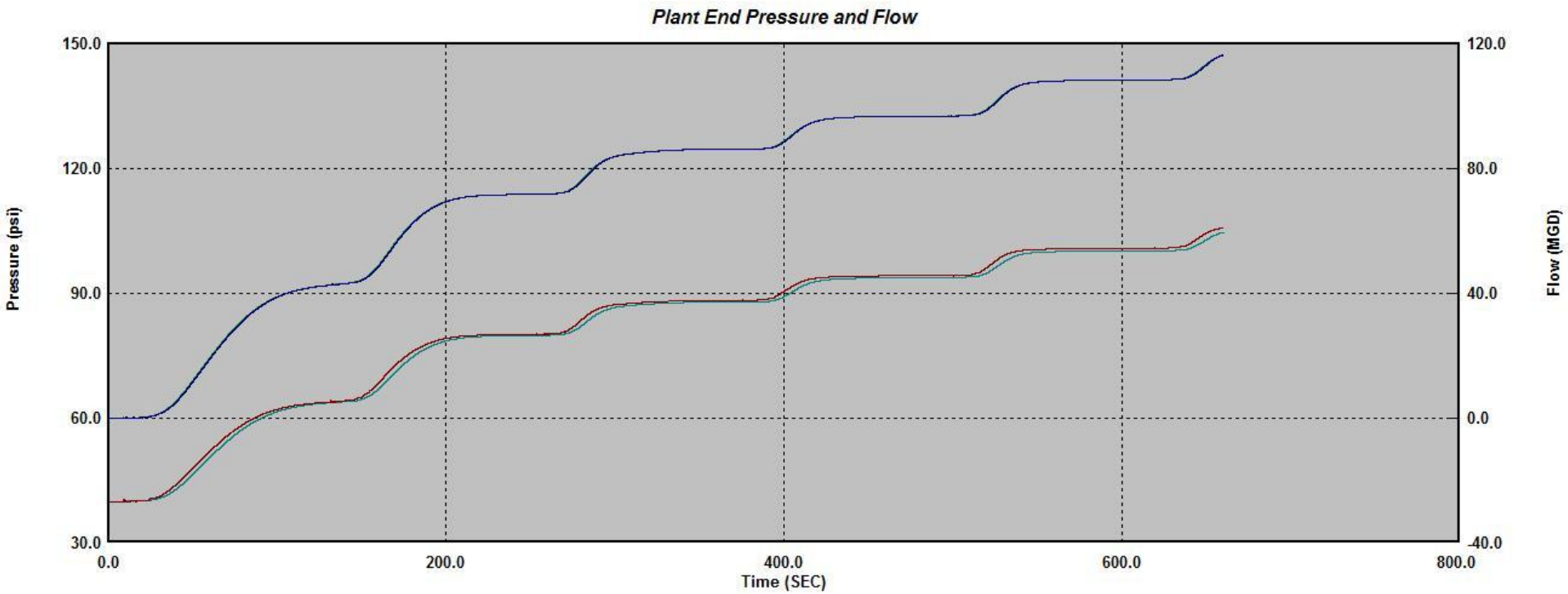


Scenario 3 – Normal Pump Start Up GA 30-inch Ball Valve 60-sec Opening

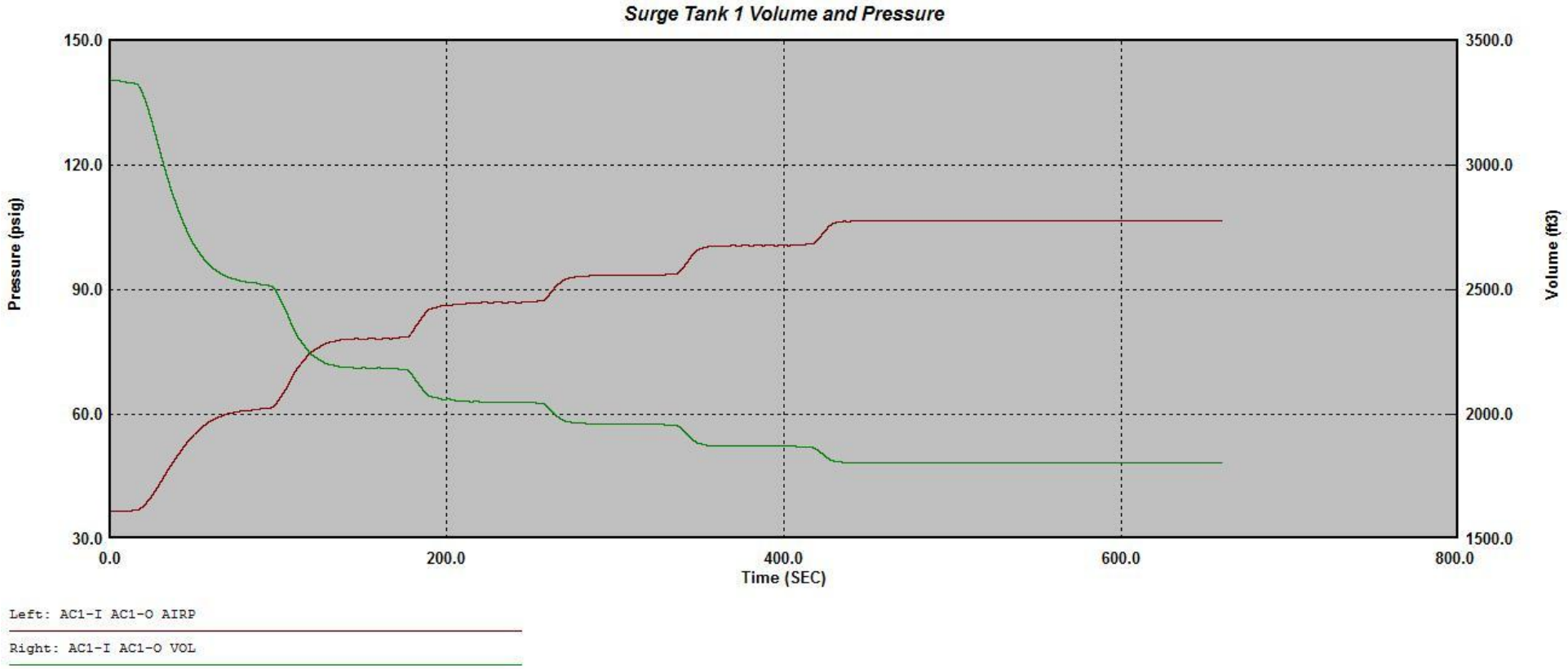
Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 30-inch Ball Valve
60-sec Opening



Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 30-inch Ball Valve
60-sec Opening

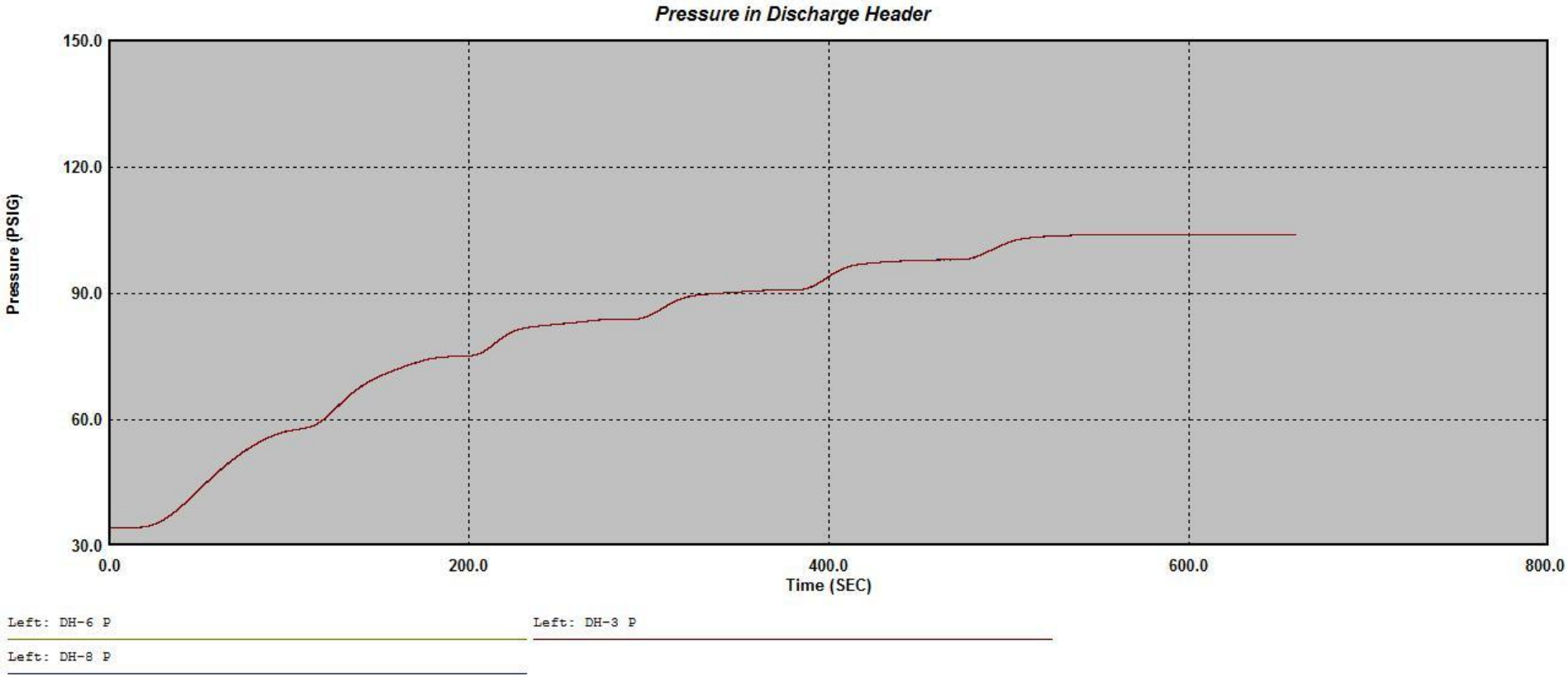


Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 30-inch Ball Valve
60-sec Opening

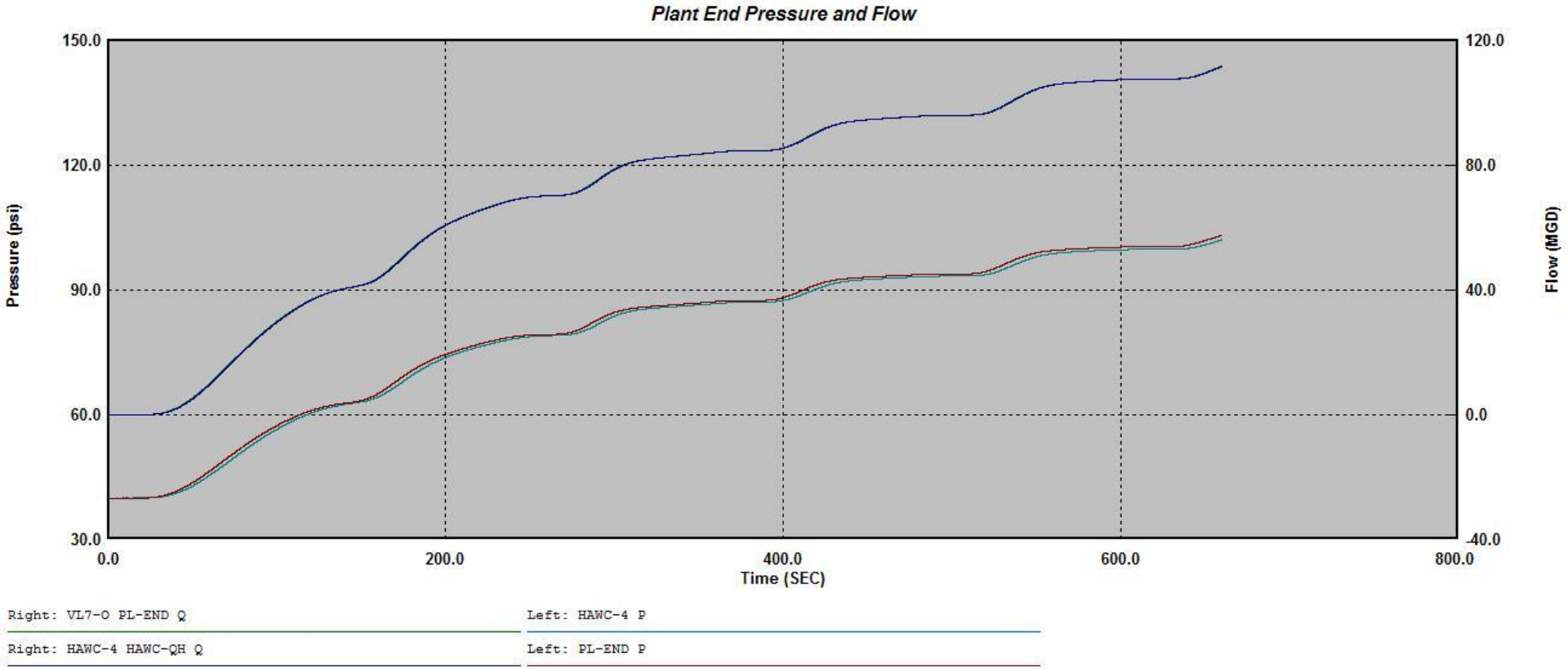


Scenario 3 – Normal Pump Start Up GA 30-inch Wye Valve 60-sec Opening

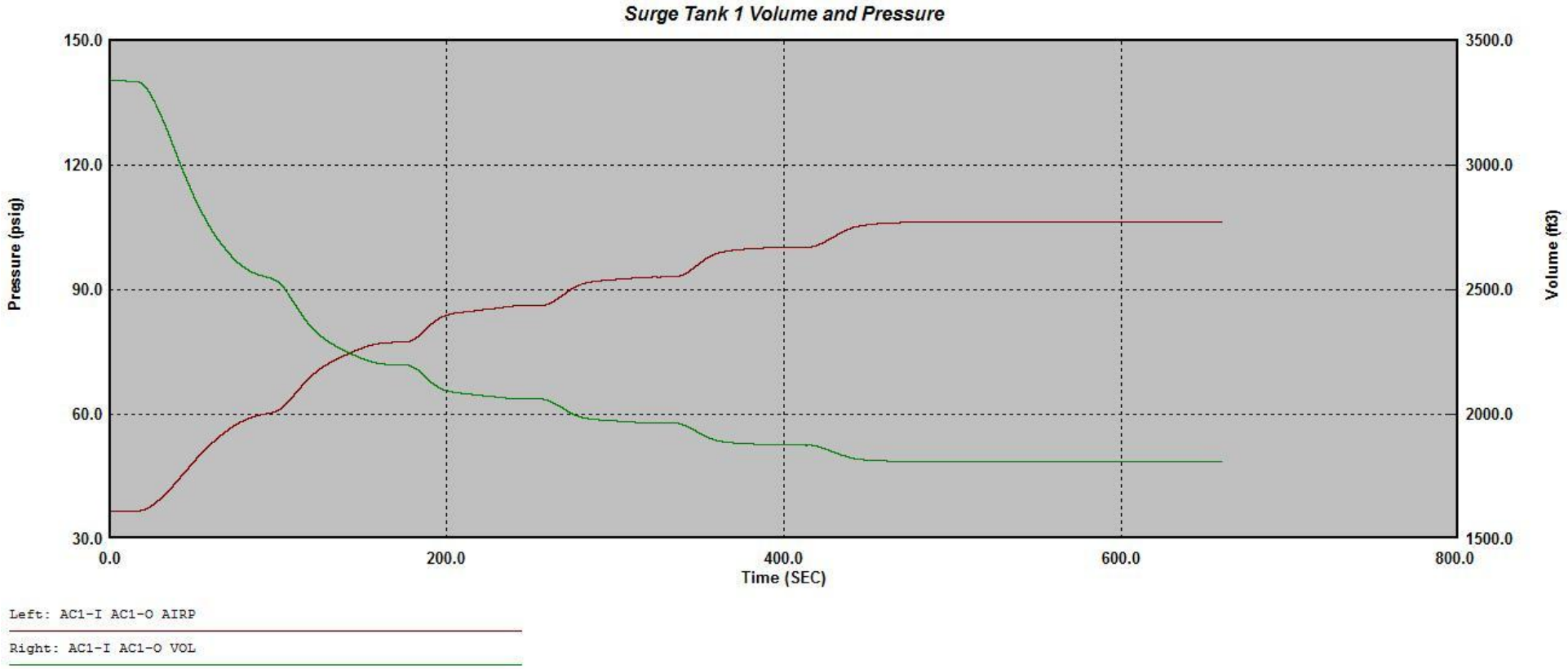
Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 30-inch Wye Valve
60-sec Opening



Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 30-inch Wye Valve
60-sec Opening

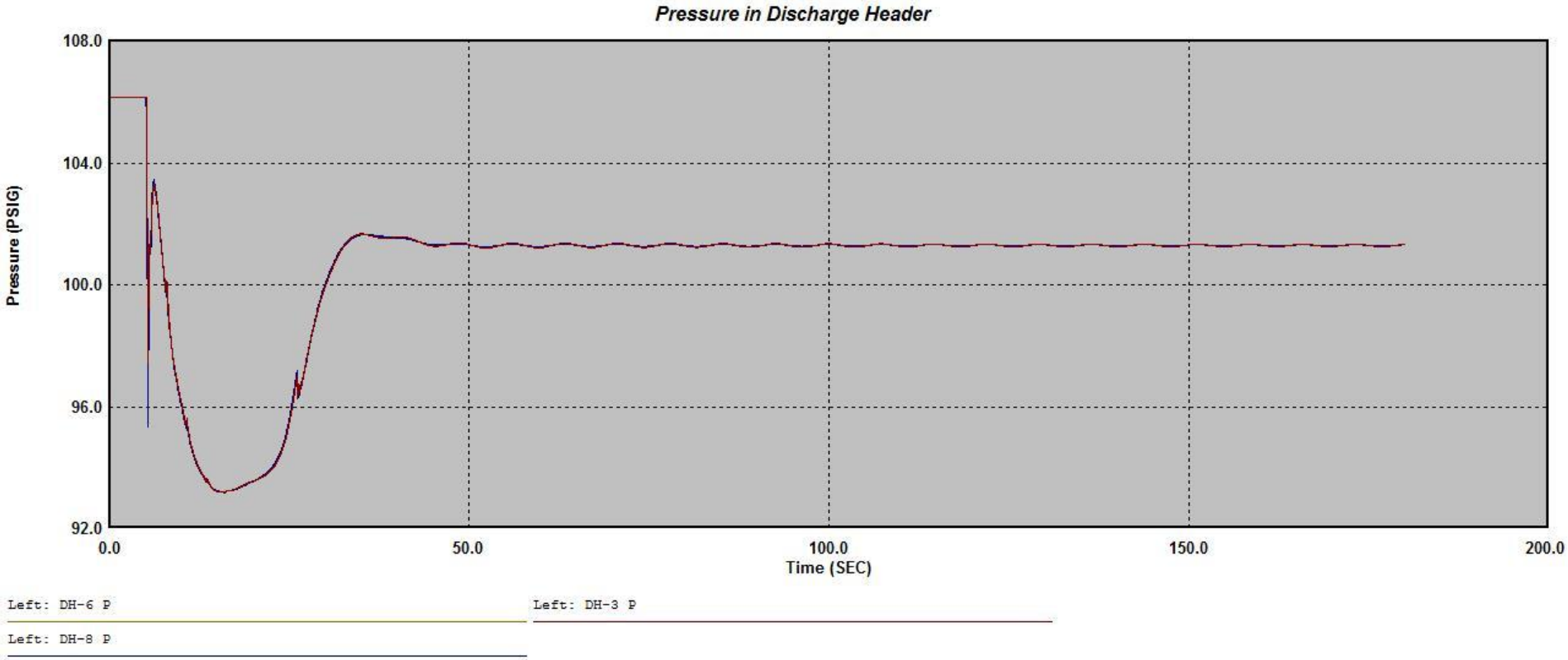


Proposed Pump Control Valves
Scenario 3 – Normal Pump Start Up
GA 30-inch Wye Valve
60-sec Opening

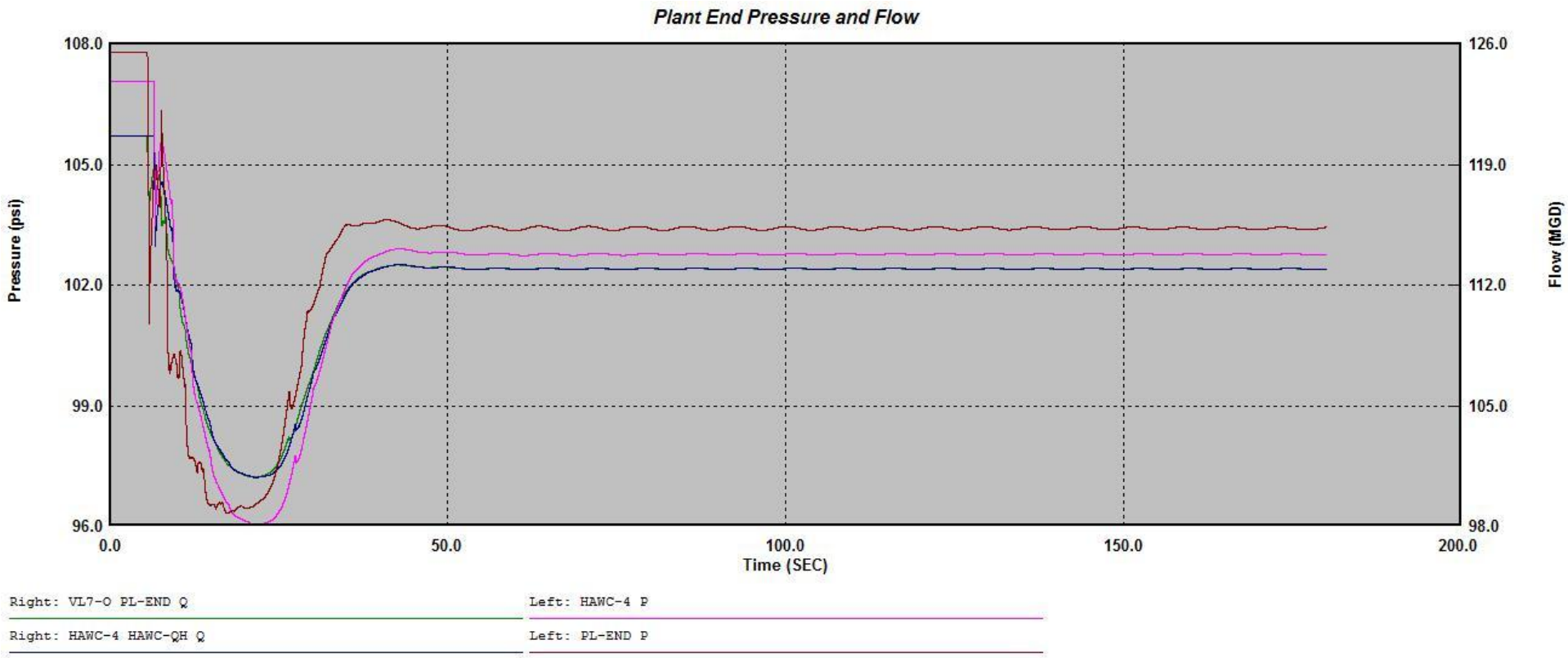


Scenario 4 – Single Pump Failure with Five Pumps Running
Adams 30-inch Disc Valve 30-sec Emergency Closure

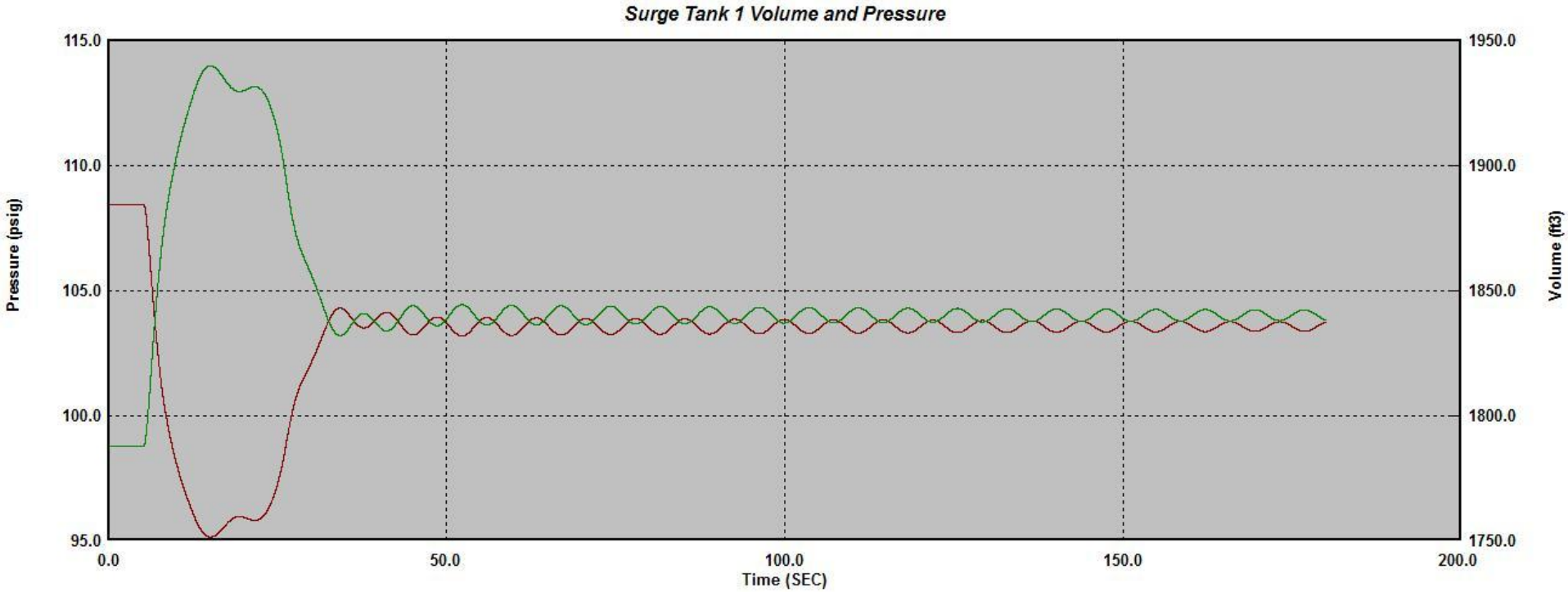
Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
Adams 30-inch Disc Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
Adams 30-inch Disc Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
Adams 30-inch Disc Valve
30-sec Emergency Closure

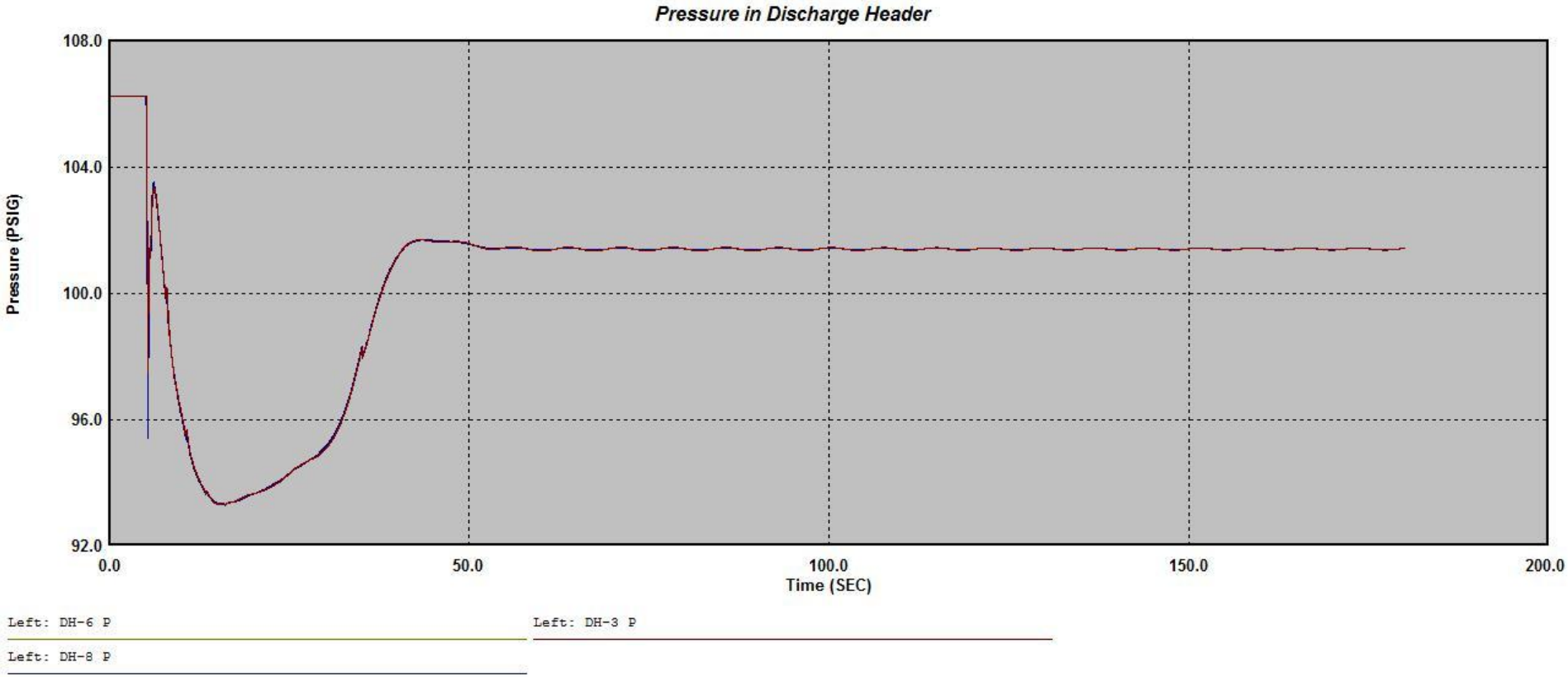


Left: AC1-I AC1-O AIRP

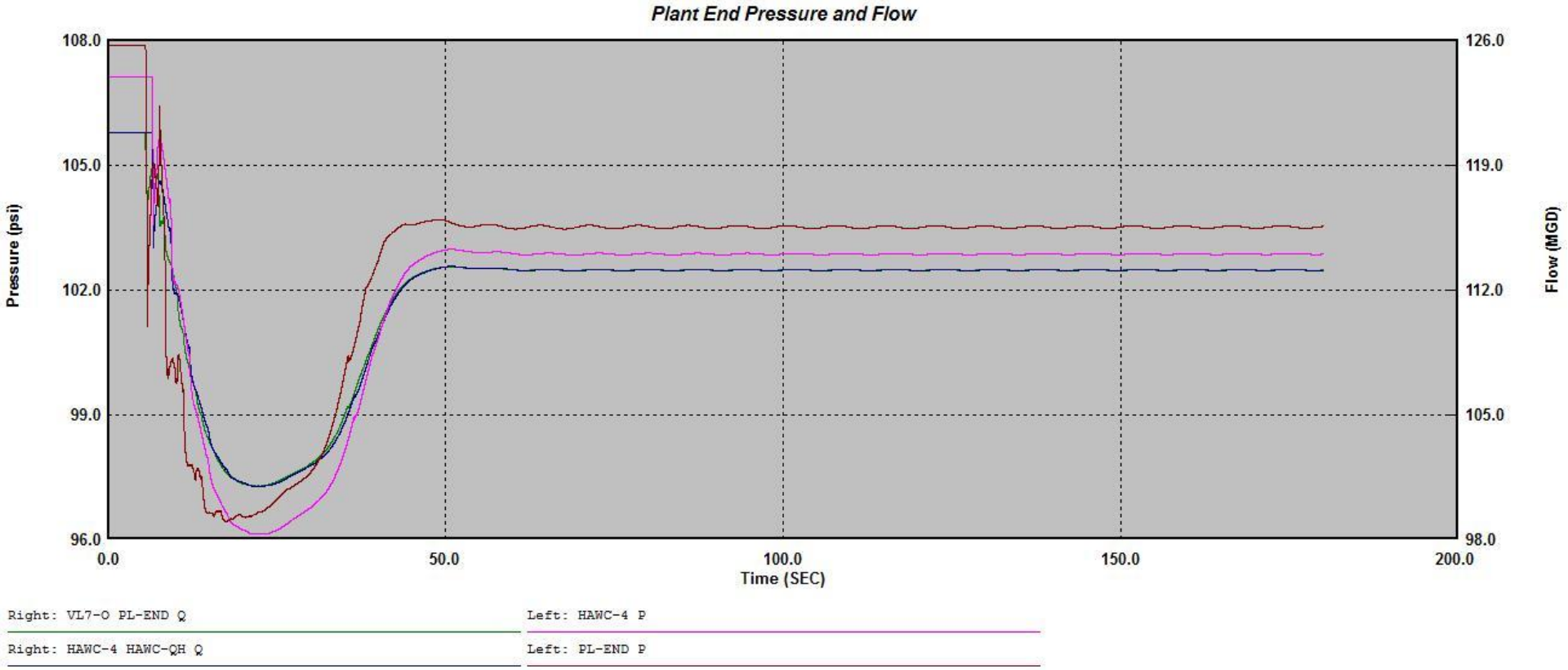
Right: AC1-I AC1-O VOL

Scenario 4 – Single Pump Failure with Five Pumps Running
GA 24-inch Ball Valve 30-sec Emergency Closure

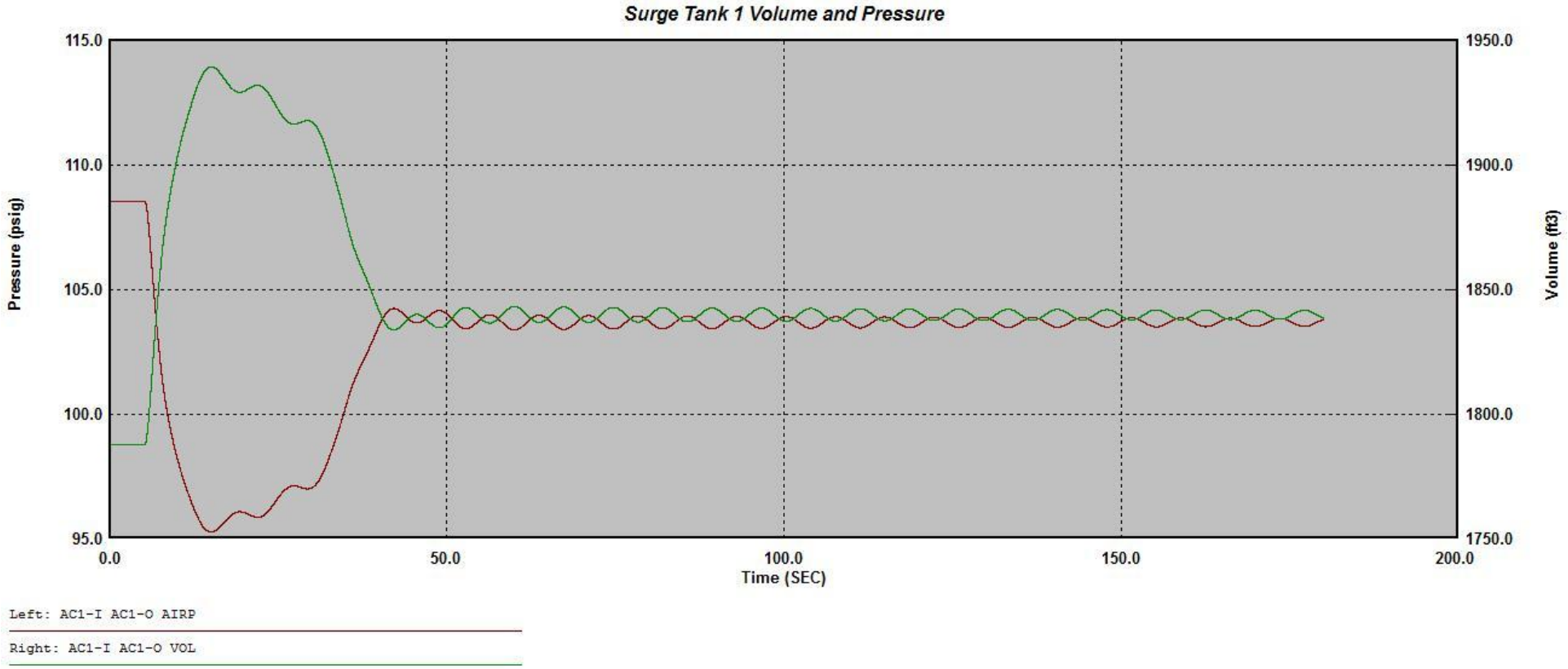
Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 24-inch Ball Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 24-inch Ball Valve
30-sec Emergency Closure

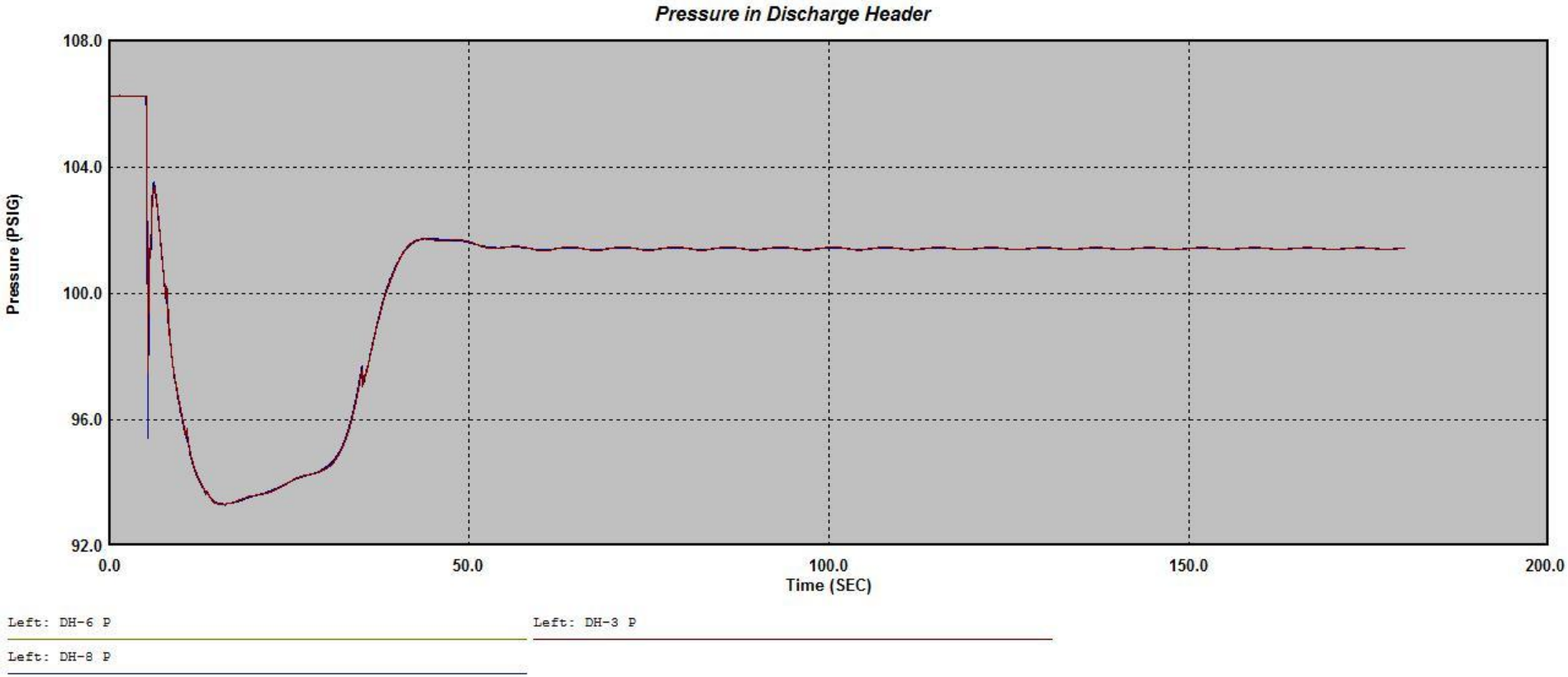


Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 24-inch Ball Valve
30-sec Emergency Closure

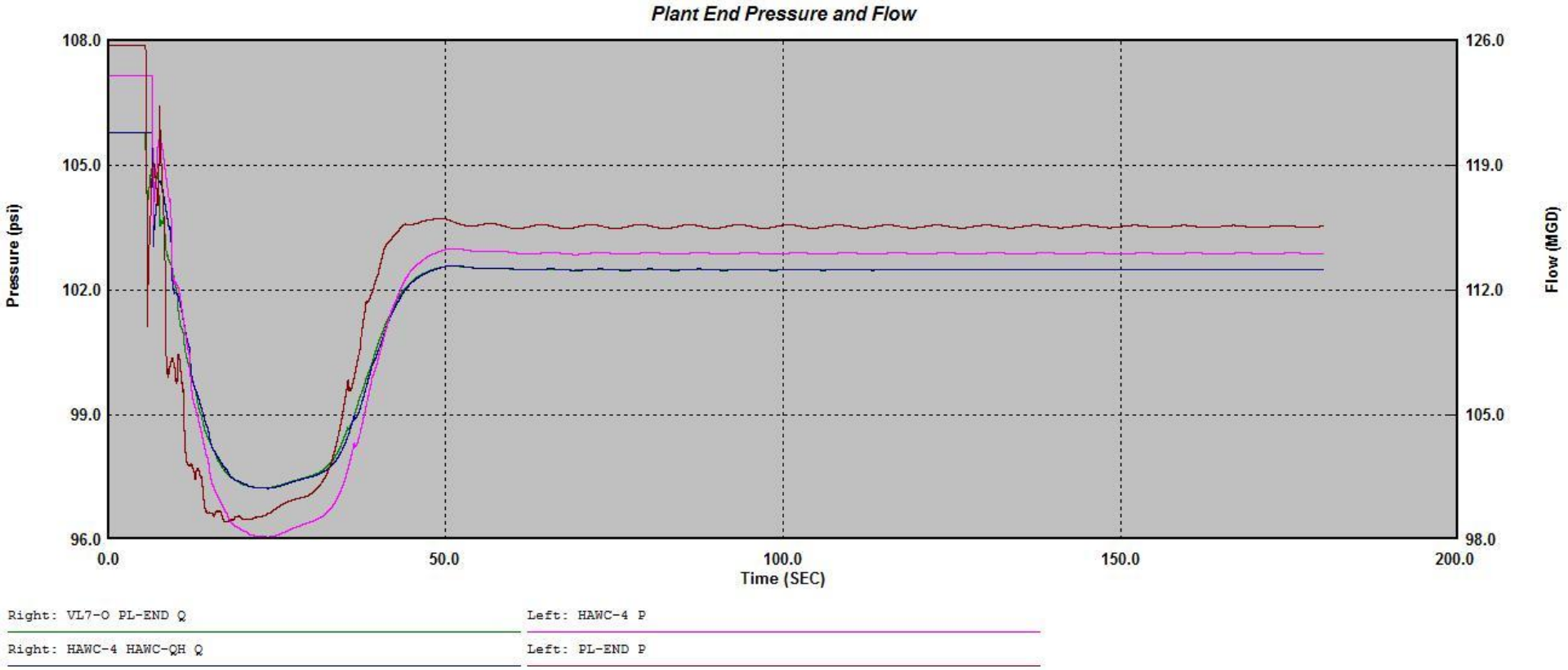


Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Valve 30-sec Emergency Closure

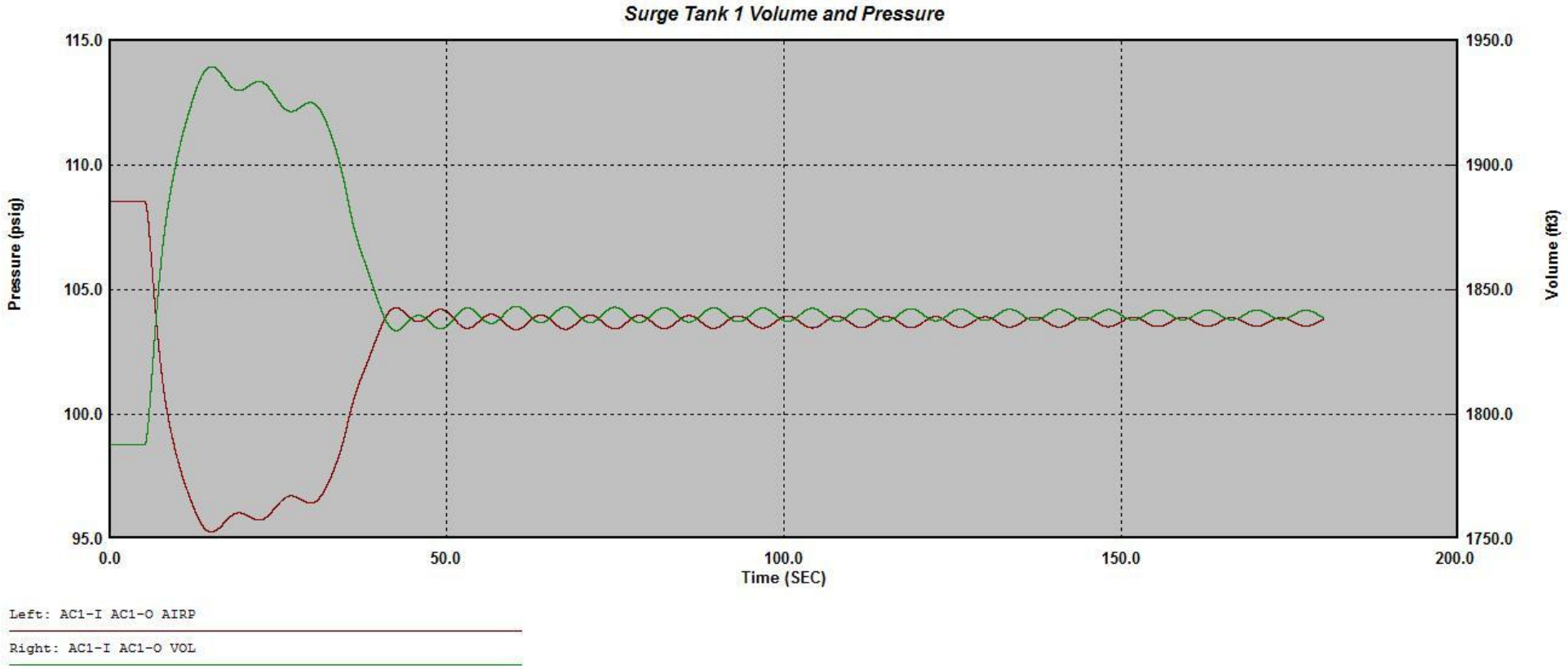
Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Valve
30-sec Emergency Closure



Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Valve
30-sec Emergency Closure

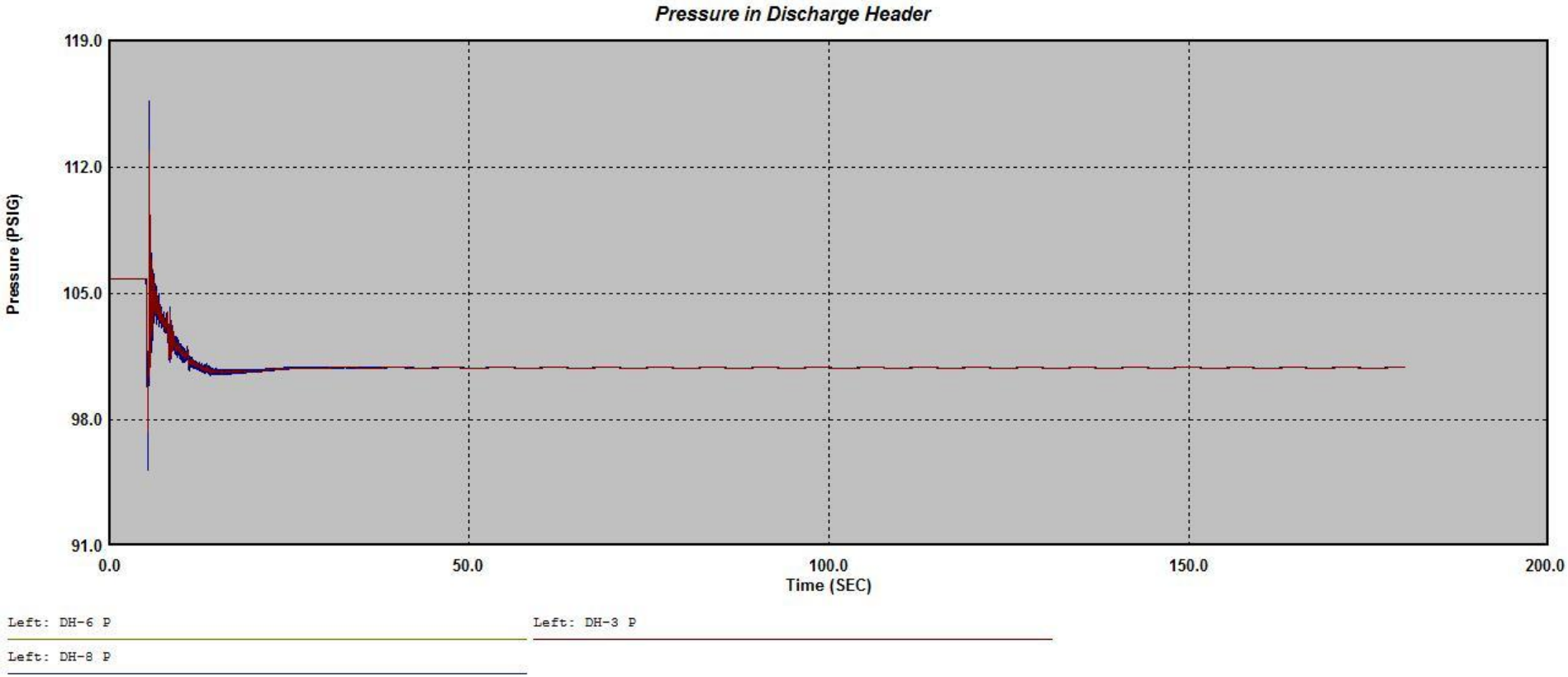


Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Valve
30-sec Emergency Closure

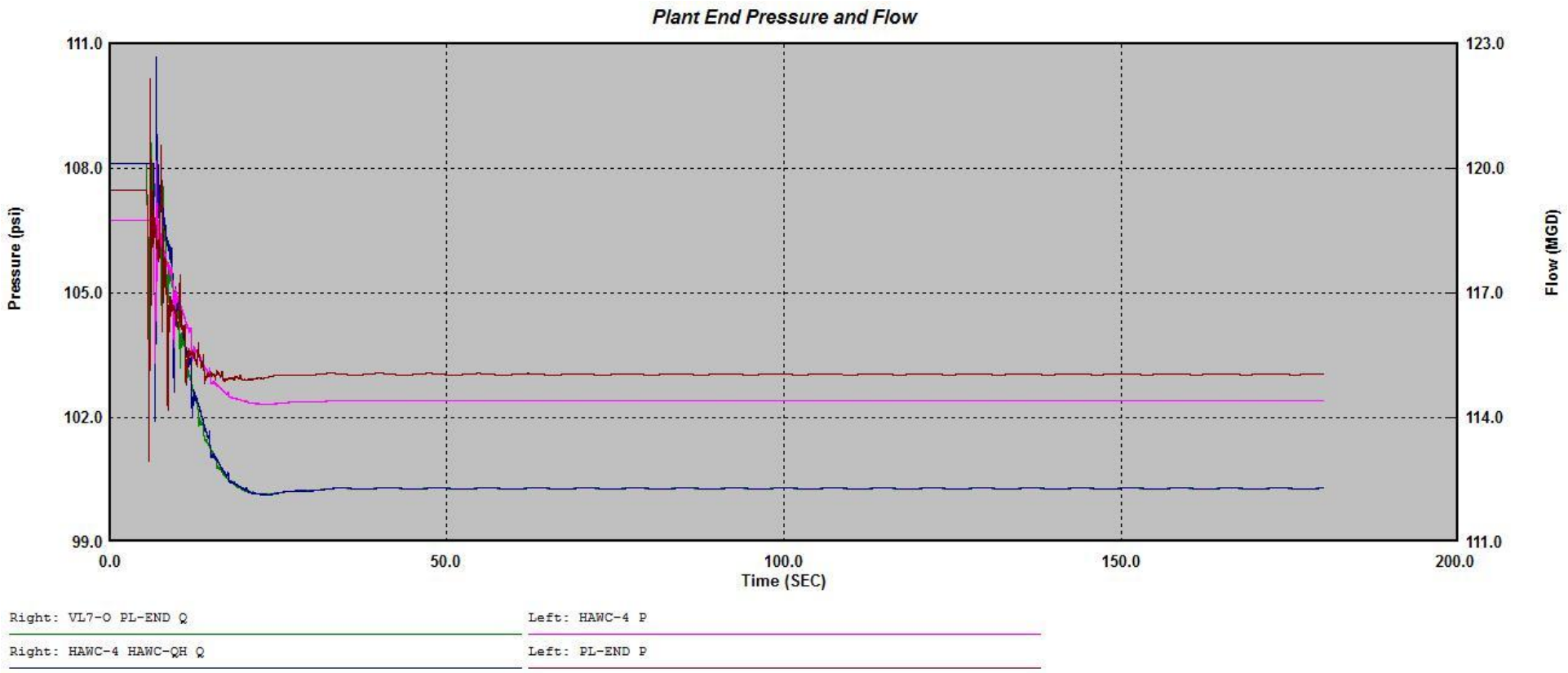


Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye 0.5-sec Emergency Closure

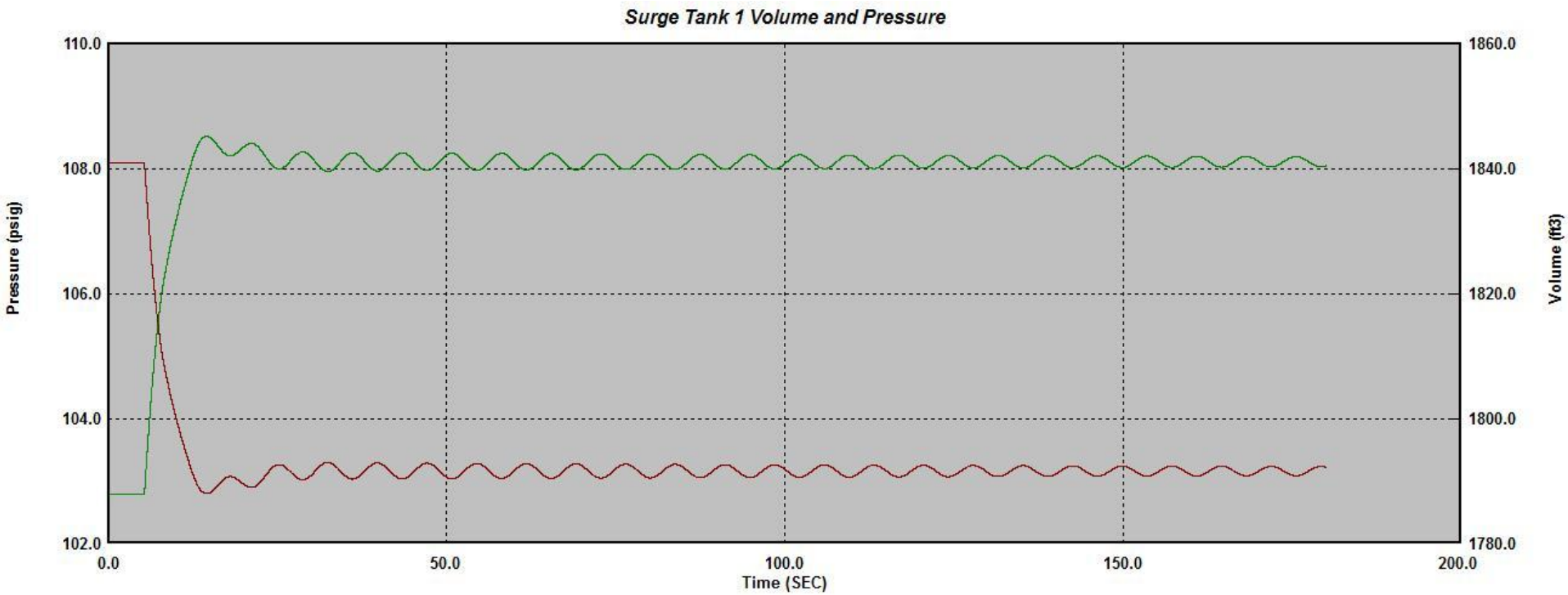
Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye
0.5-sec Emergency Closure



Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye
0.5-sec Emergency Closure



Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye
0.5-sec Emergency Closure

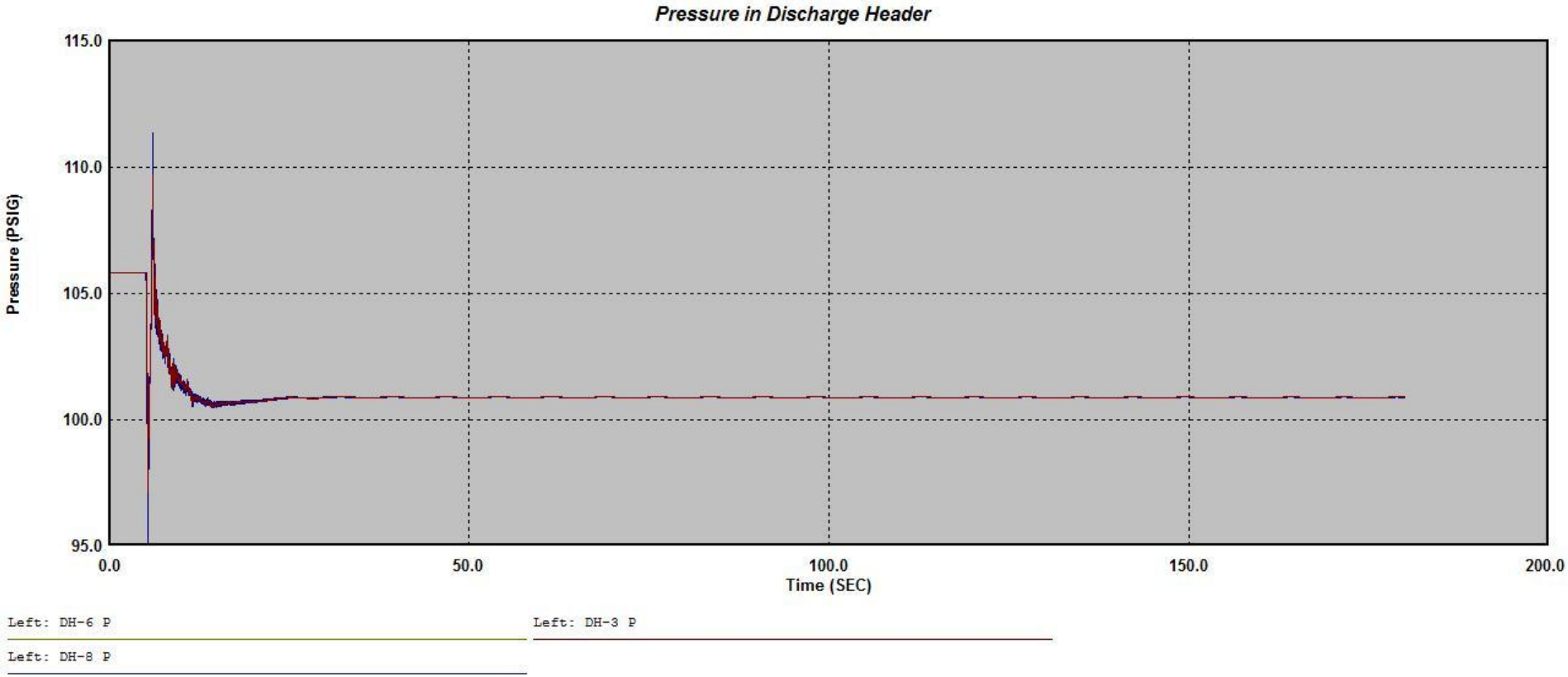


Left: AC1-I AC1-O AIRP

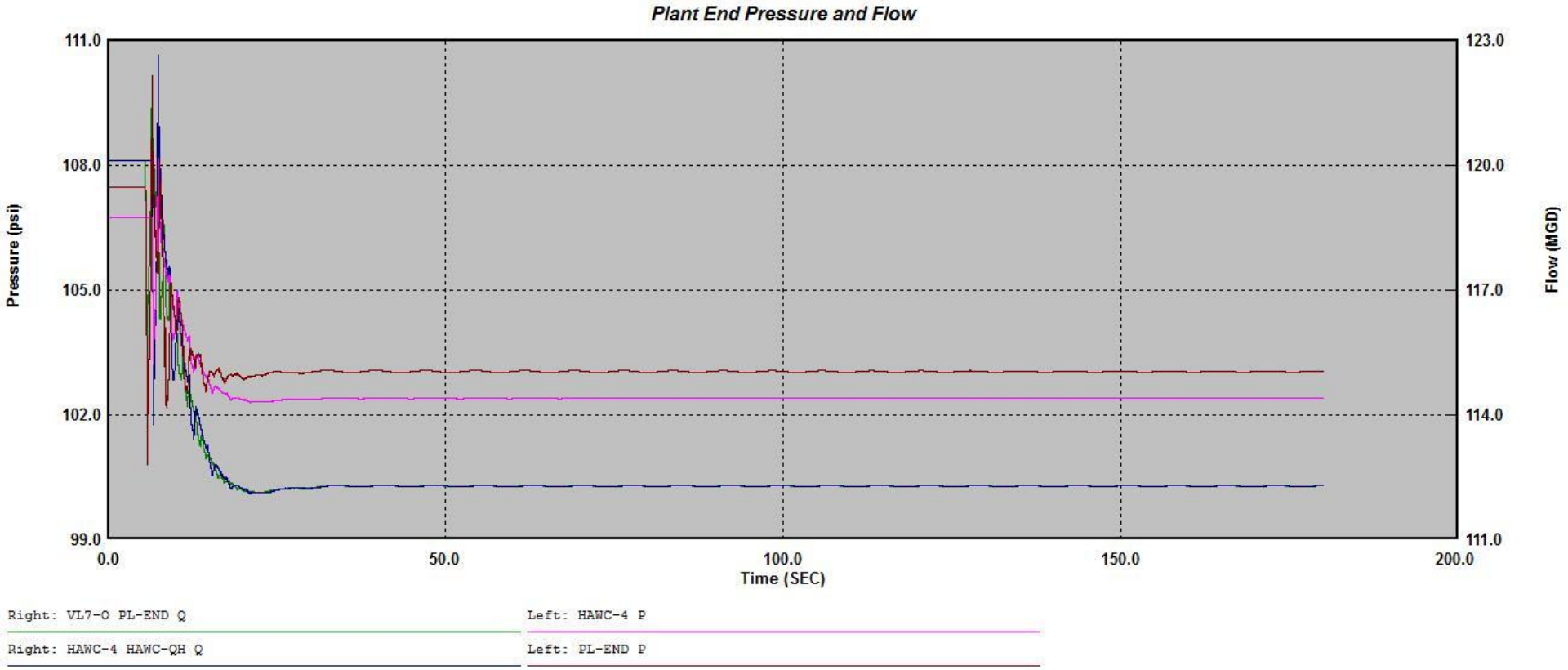
Right: AC1-I AC1-O VOL

Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye 1-sec Emergency Closure

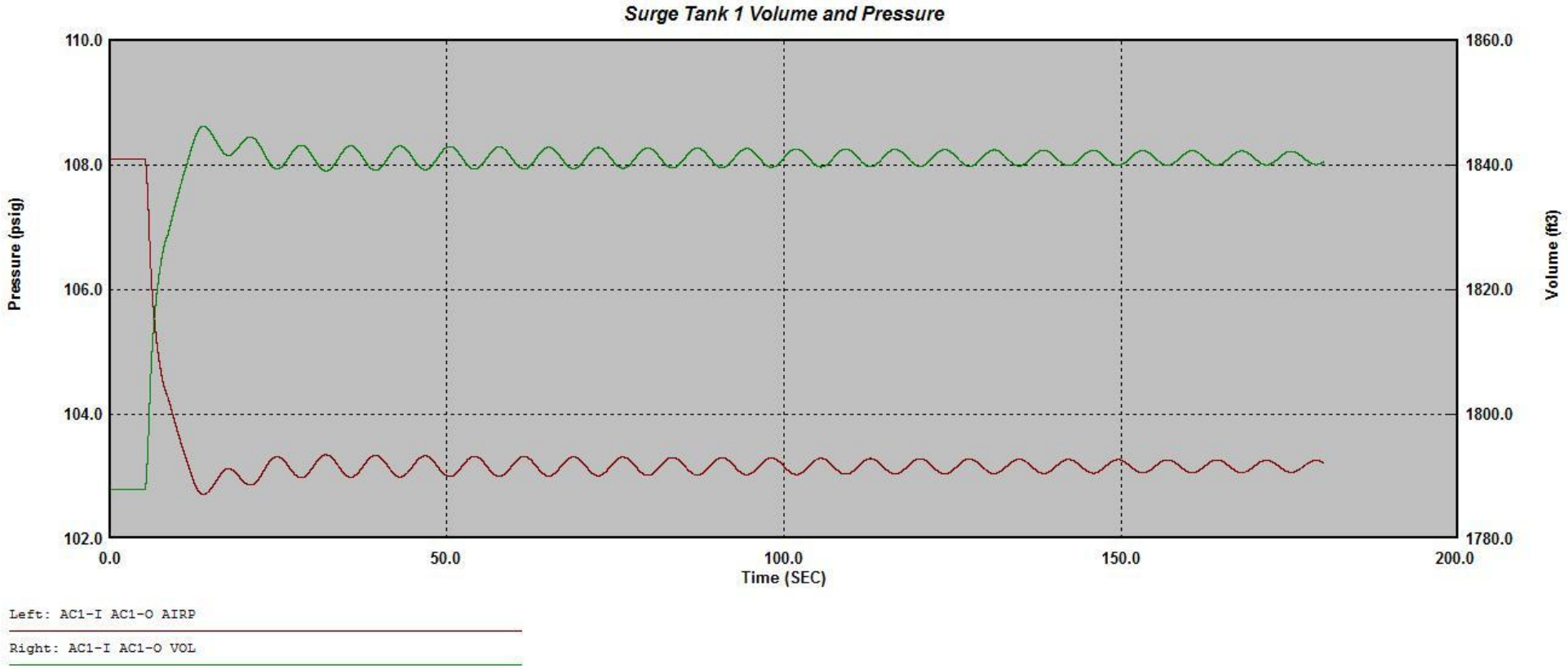
Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye
1-sec Emergency Closure



Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye
1-sec Emergency Closure

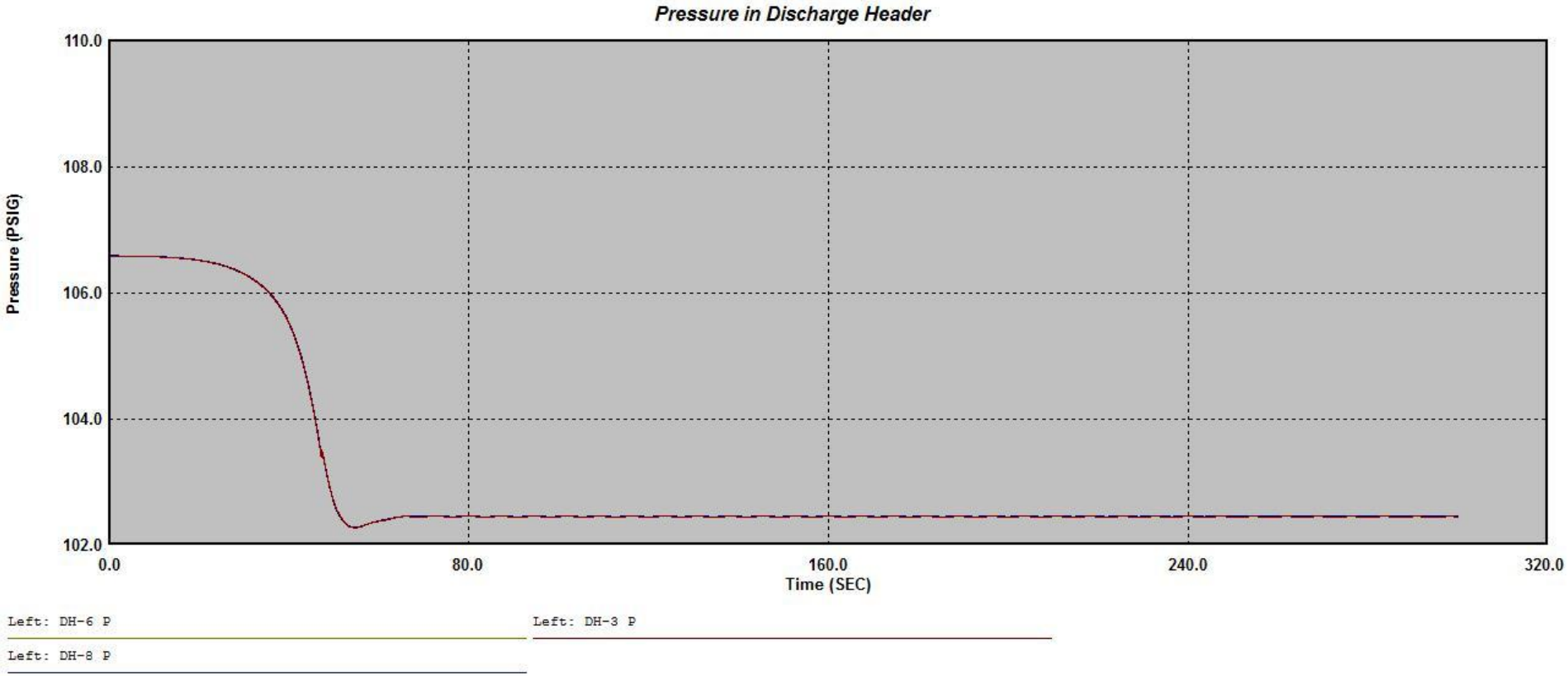


Proposed Pump Control Valves
Scenario 4 – Single Pump Failure with Five Pumps Running
GA 30-inch Ball Wye
1-sec Emergency Closure

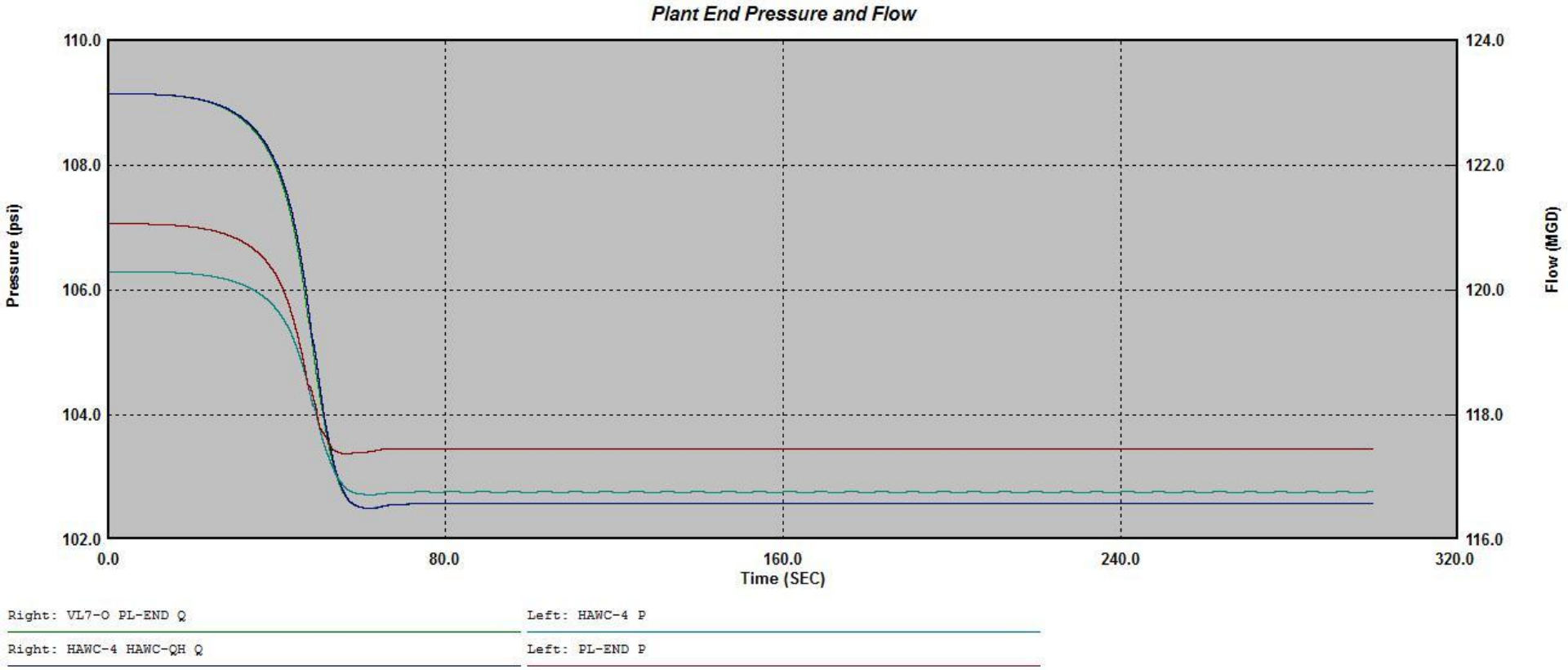


Scenario 5 – Emergency Pump 5 Shut Down with Five Pumps Running Adams 24-inch Disc Valve 60-sec Closure

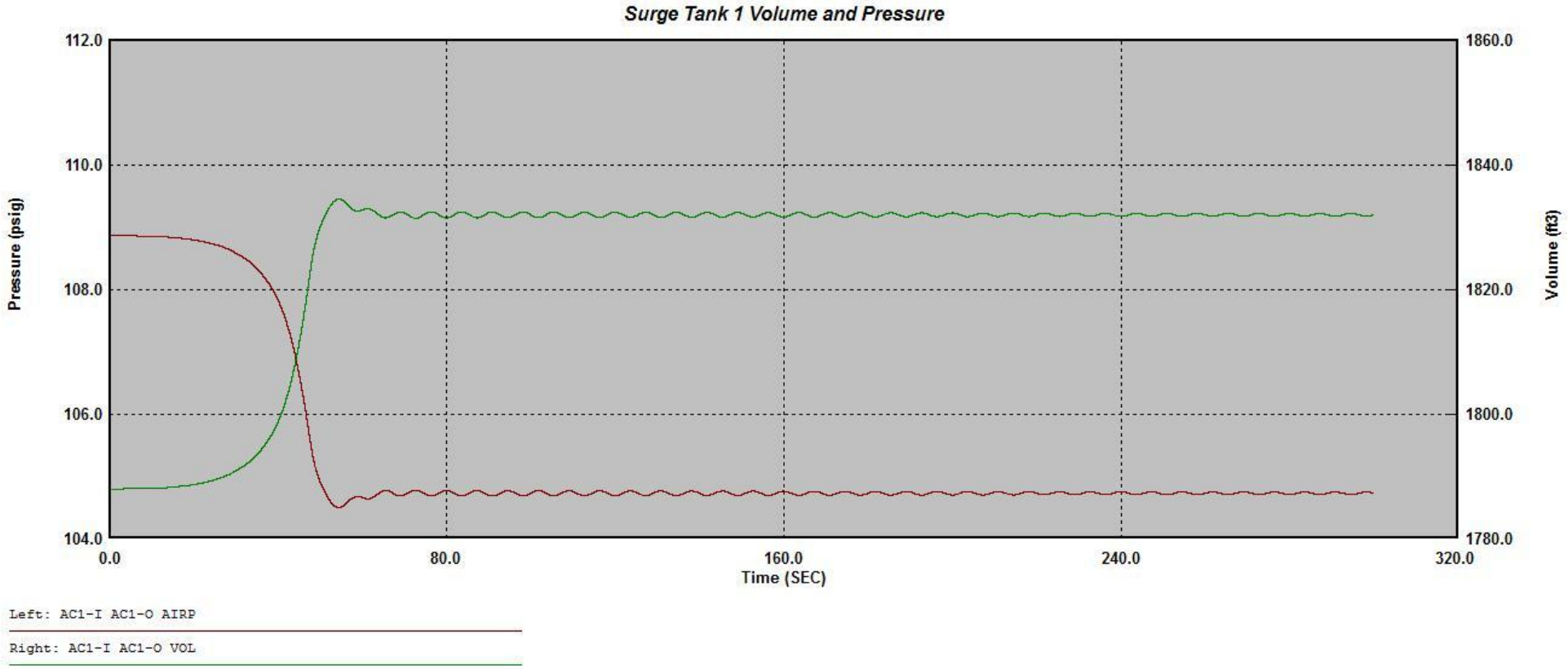
Proposed Pump Control Valves
Scenario 5 – Emergency Pump 5 Shut Down with Five Pumps Running
Adams 24-inch Disc Valve
60-sec Closure



Proposed Pump Control Valves
Scenario 5 – Emergency Pump 5 Shut Down with Five Pumps Running
Adams 24-inch Disc Valve
60-sec Closure

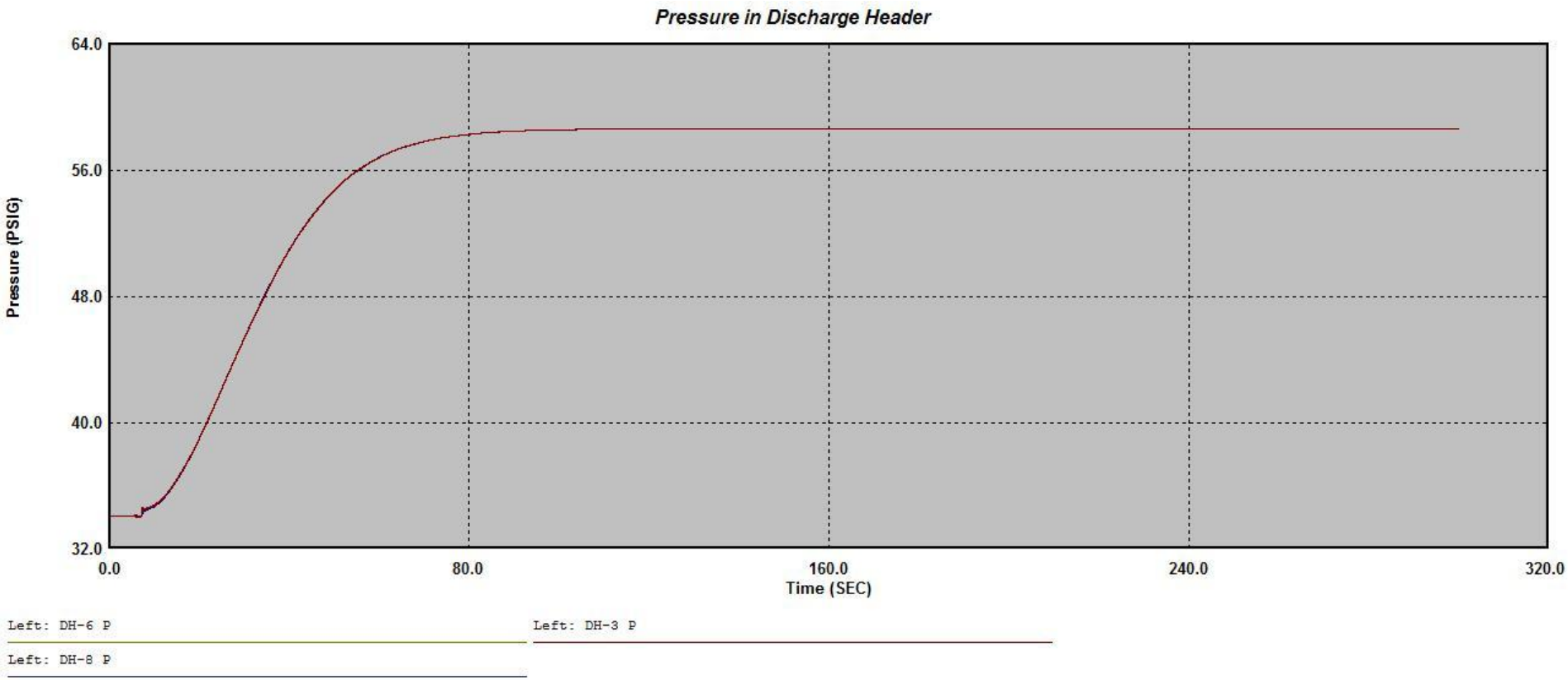


Proposed Pump Control Valves
Scenario 5 – Emergency Pump 5 Shut Down with Five Pumps Running
Adams 24-inch Disc Valve
60-sec Closure

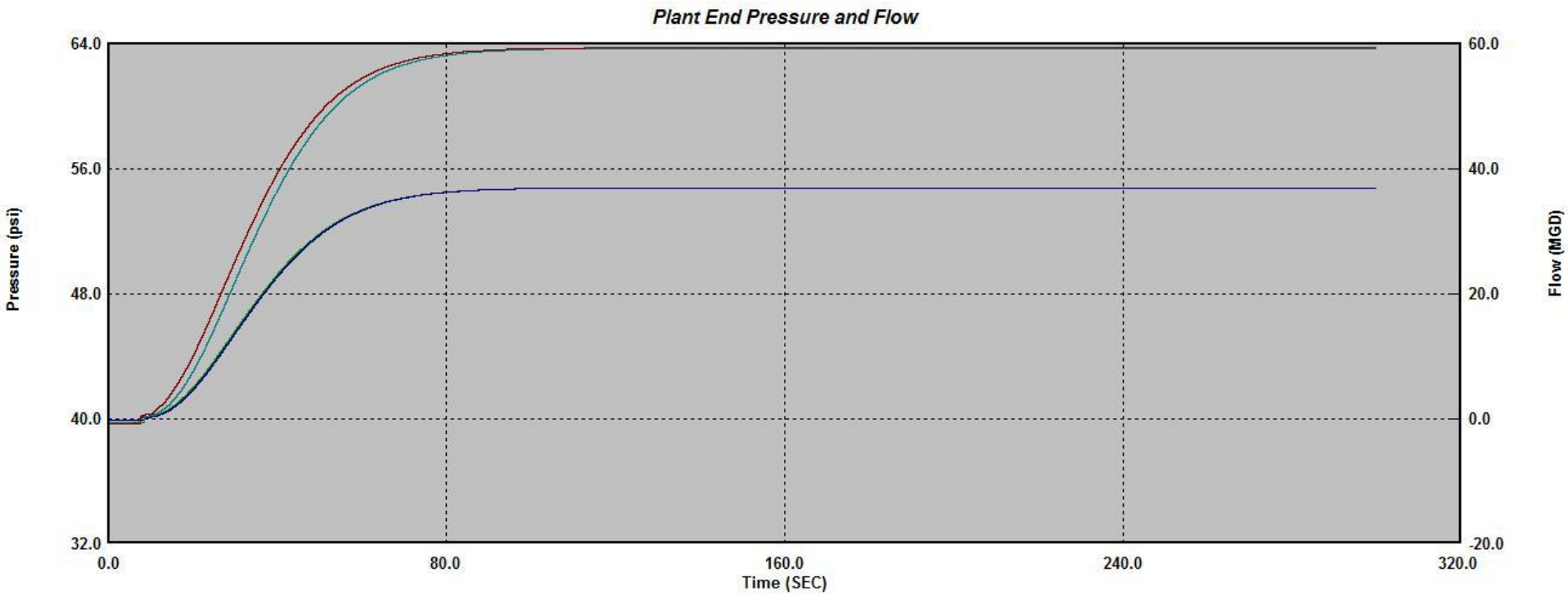


Scenario 6 – Emergency Pump 5 Start-Up with All Pumps Shut Down Adams 24-inch Disc Valve 30-sec Opening

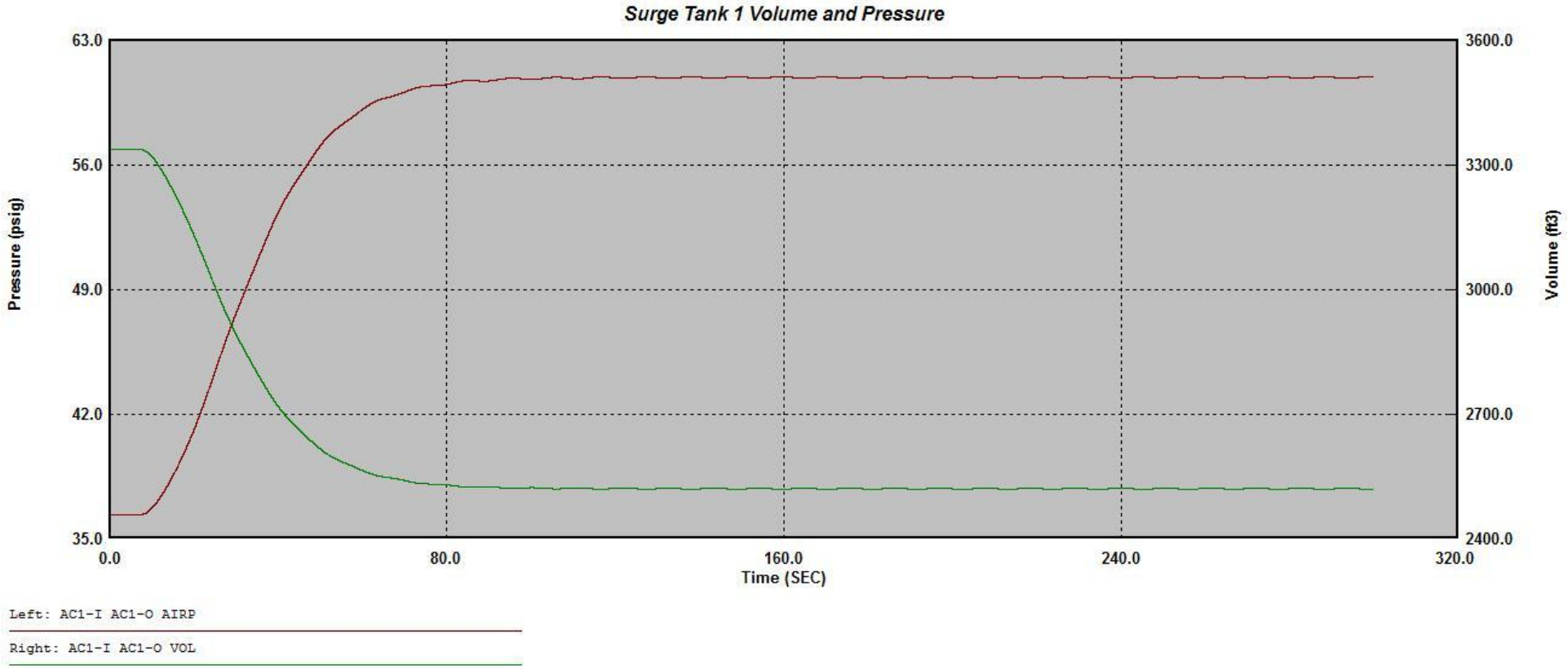
Proposed Pump Control Valves
Scenario 6 – Emergency Pump 5 Start-Up with All Pumps Shut Down
Adams 24-inch Disc Valve
30-sec Opening



Proposed Pump Control Valves
Scenario 6 – Emergency Pump 5 Start-Up with All Pumps Shut Down
Adams 24-inch Disc Valve
30-sec Opening



Proposed Pump Control Valves
Scenario 6 – Emergency Pump 5 Start-Up with All Pumps Shut Down
Adams 24-inch Disc Valve
30-sec Opening



Appendix G

Surge Tank Scenarios Results Graphs

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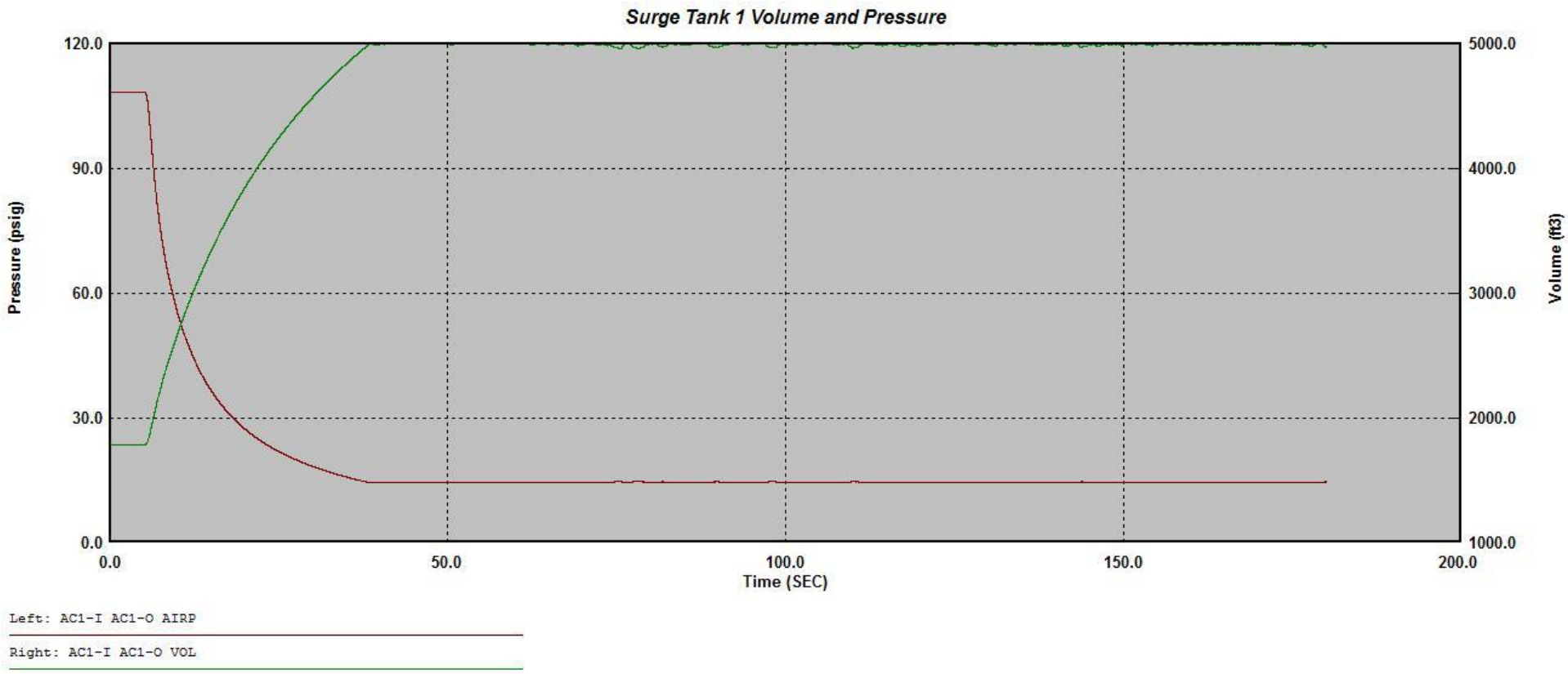
Scenario 1 - Simultaneous All Pump Failure at 120 MGD Existing Surge Tanks 65% Initially Full Without EWPP Backpressure

Scenario 1 - Simultaneous All Pump Failure at 120 MGD Existing Surge Tanks 80% Initially Full Without EWPP Backpressure

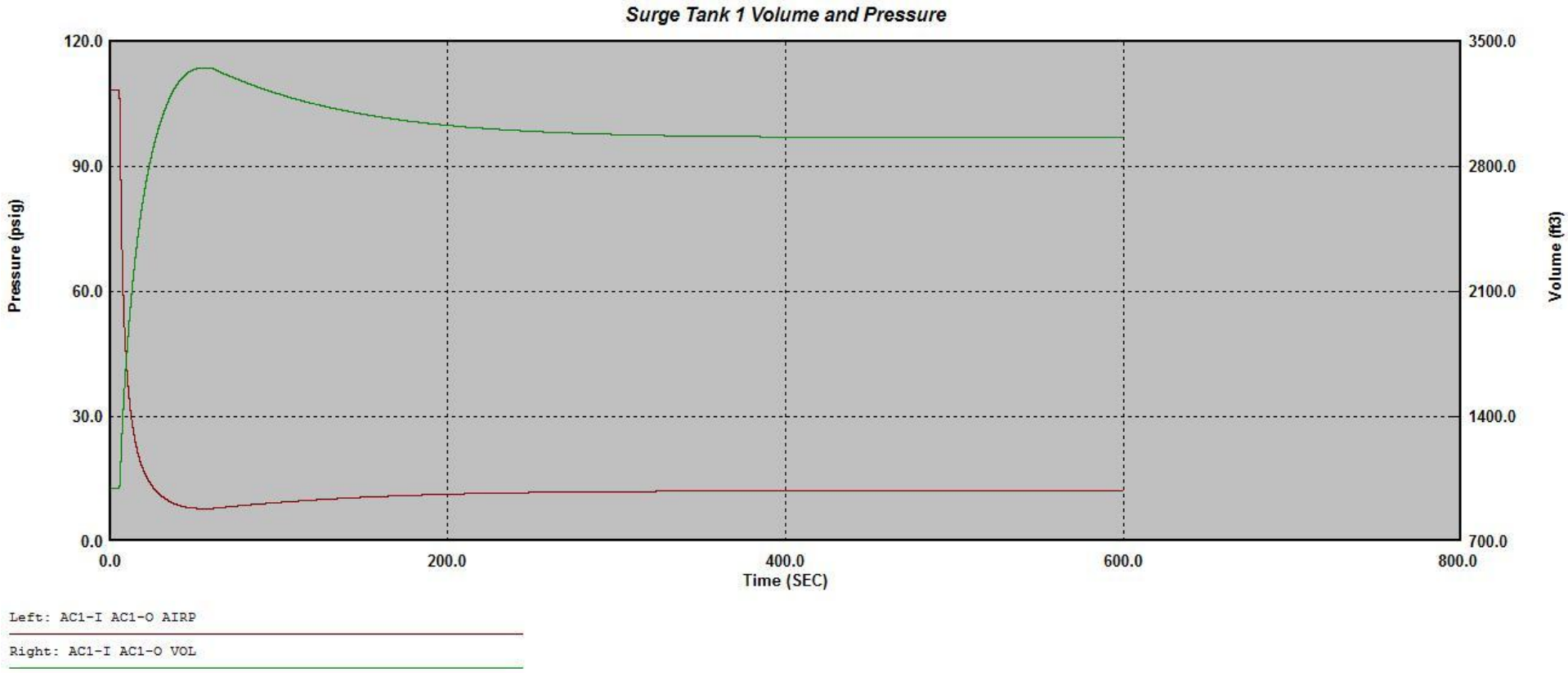
Scenario 1 – Simultaneous All Pump Failure at 120 MGD Two 10,000 cu ft Surge Tanks, Each 65% Initially Full Without EWPP Backpressure

Scenario 1 - Simultaneous All Pump Failure at 120 MGD
Existing Surge Tanks 65% Initially Full
Without EWPP Backpressure



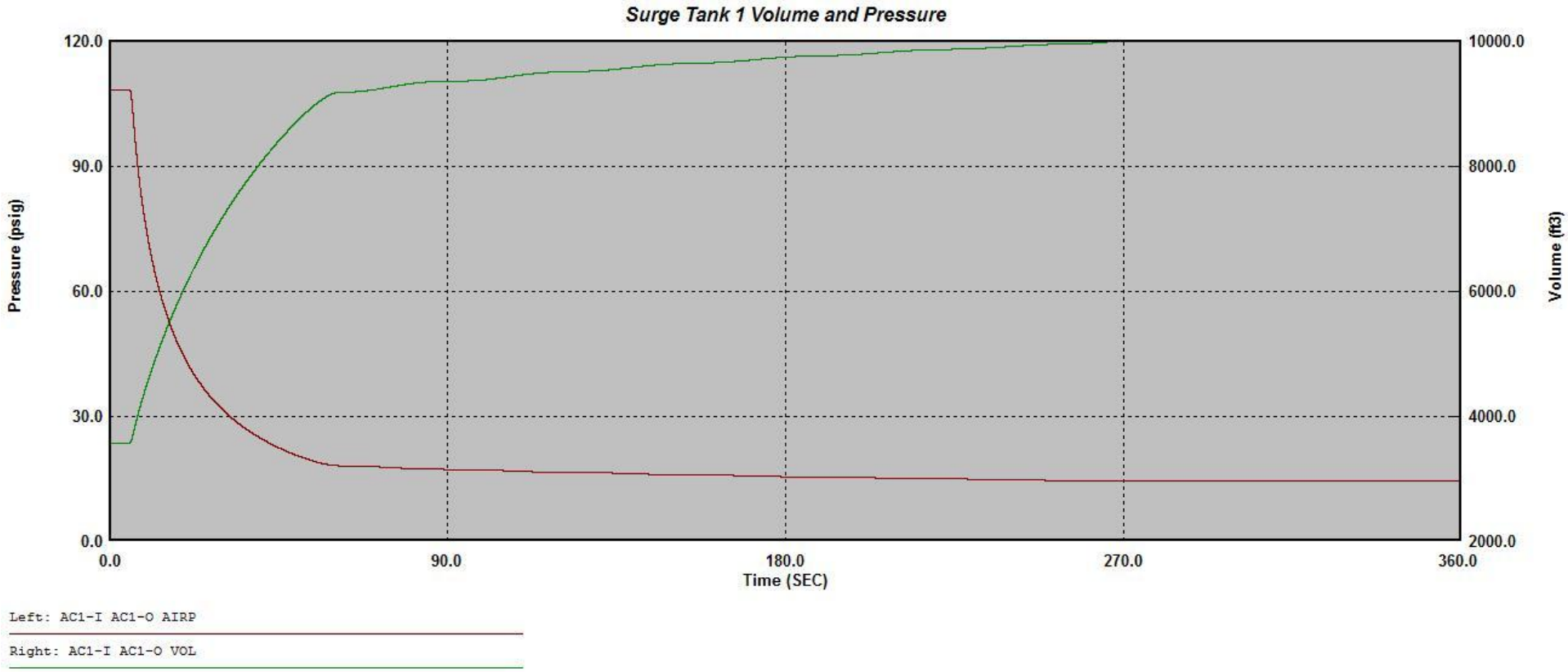
AIRP – Air Pressure in Surge Tank
VOL – Air Volume in Surge Tank

Scenario 1 - Simultaneous All Pump Failure at 120 MGD
Existing Surge Tanks 80% Initially Full
Without EWPP Backpressure



AIRP – Air Pressure in Surge Tank
VOL – Air Volume in Surge Tank

Scenario 1 – Simultaneous All Pump Failure at 120 MGD
Two 10,000 cu ft Surge Tanks, Each 65% Initially Full
Without EWPP Backpressure



AIRP – Air Pressure in Surge Tank
VOL – Air Volume in Surge Tank

Appendix H

NHCRWA Valve Closure Mitigation Results

Index

Scenario 7 - NHCRWA Emergency Flow Control Valve Closure Surge Relief Valves

Scenario 7 - NHCRWA Emergency Flow Control Valve Closure Slower Valve Closure and NEWPP Failure

Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD Three 12-inch GA Surge Relief Valves set to open at 120 psi

Scenario 7 – NHCRWA Emergency Valve Closure 30-minute Valve Closure

Scenario 8 – Simultaneous All Pump Failure at the NEWPP

Scenario 7 - NHCRWA Emergency Flow Control Valve Closure
Surge Relief Valves

Scenario 7 Results (120 MGD with Three 12" GA Relief Valves at 120 psi)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	129.0	247.80	119.3	0.15
46750	Kingwood Take Point	124.5	242.40	111.5	5.50
32375	IAH Take Point	123.3	237.55	107.5	4.75
71A4532	IAH Take Point	123.4	145.45	102.9	1.75
D717314	Greenspoint Take Point	127.3	152.60	92.5	4.10
D710075	NHCRWA Take Point	129.1	150.25	91.5	1.75
14625	Aldine and GRP Group A Take Point	111.3	242.85	98.8	0.00
1365	City Main System Take Point	106.8	246.85	95.1	0.00
NH35222	Maximum Pressure - NHCRWA 54" Line	136.6	149.40	102.4	2.65
NH032VO	Minimum Pressure - NHCRWA Control Valve Outlet	71.7	4.25	9.9	140.00

135 second valve closure at 120 MGD with NHCRWA taking 45 MGD
Surge Relief Valve - Golden Anderson 12" Surge Relief Valve, with set pressure of 120 psi to open

Scenario 7 Results (120 MGD with Three 12"GA Relief Valves at 105 psi)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	128.5	459.90	119.3	0.15
46750	Kingwood Take Point	123.0	454.80	111.5	5.50
32375	IAH Take Point	120.8	450.00	107.5	4.75
71A4532	IAH Take Point	119.0	446.65	102.9	1.75
D717314	Greenspoint Take Point	116.4	147.55	92.5	4.10
D710075	NHCRWA Take Point	117.4	145.20	91.5	1.75
14625	Aldine and GRP Group A Take Point	109.4	455.30	98.8	0.00
1365	City Main System Take Point	105.0	459.30	95.1	0.00
NEWPP	Maximum System Pressure - NEWPP	128.5	459.90	119.3	0.15
NH032VO	Minimum Pressure - NHCRWA Control Valve Outlet	71.7	4.25	9.9	140.00

135 second valve closure at 120 MGD with NHCRWA taking 45 MGD
Surge Relief Valve - 3 Golden Anderson 10" Surge Relief Valves, with set pressure of 105 psi to open

Scenario 7 Results (80 MGD with Three 12" GA Relief Valves at 120 psi)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	134.5	293.60	118.4	0.15
46750	Kingwood Take Point	131.9	283.05	113.1	11.20
32375	IAH Take Point	130.5	283.65	109.9	10.35
71A4532	IAH Take Point	130.0	103.25	106.4	1.75
D717314	Greenspoint Take Point	133.1	104.50	98.0	3.10
D710075	NHCRWA Take Point	133.5	102.15	96.8	5.45
14625	Aldine and GRP Group A Take Point	117.6	282.40	101.0	10.25
1365	City Main System Take Point	105.7	292.70	92.3	14.25
71C570	Maximum Pressure - Hardy Tollway Crossing	142.5	104.95	107.7	2.65
NH032VO	Minimum Pressure - NHCRWA Control Valve Outlet	76.0	0.20	8.0	95.00

90 second valve closure at 80 MGD with NHCRWA taking 45 MGD
Surge Relief Valve - 3 Golden Anderson 12" Surge Relief Valves, with set pressure of 120 psi to open

Scenario 7 Results (80 MGD with Three 12" GA Relief Valves at 115 psi)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	134.2	420.20	118.4	0.15
46750	Kingwood Take Point	130.7	416.60	113.1	11.20
32375	IAH Take Point	129.2	411.35	109.9	10.35
71A4532	IAH Take Point	128.1	406.70	106.4	1.75
D717314	Greenspoint Take Point	129.0	103.35	98.0	3.10
D710075	NHCRWA Take Point	129.3	101.05	96.8	5.45
14625	Aldine and GRP Group A Take Point	116.6	416.80	101.0	10.25
1365	City Main System Take Point	105.0	420.80	92.3	14.25
71C570	Maximum Pressure - Hardy Tollway Crossing	138.5	103.85	107.5	2.65
NH032VO	Minimum Pressure - NHCRWA Control Valve Outlet	76.0	0.20	8.0	95.00

90 second valve closure at 80 MGD with NHCRWA taking 45 MGD
Surge Relief Valve - 3 Golden Anderson 12" Surge Relief Valves, with set pressure of 115 psi to open

Scenario 7 - NHCRWA Emergency Flow Control Valve Closure
Slower Valve Closure and NEWPP Failure

Scenario 7 Results (120 MGD with 6 Minute Valve Closure)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	126.7	402.65	116.8	23.30
46750	84-inch GRP Customers	126.8	391.80	109.5	11.05
71A4532	IAH Take Point	128.6	383.65	97.4	9.35
D717314	Greenspoint Take Point	133.2	373.35	79.8	19.70
D710075	NHCRWA Take Point	137.4	371.00	78.2	22.05
14625	Aldine and GRP Group A Take Point	123.3	392.25	102.7	0.80
1365	City Main System Take Point	124.5	396.25	101.5	3.20
MUD844	LHCS Take Point	102.5	407.05	96.2	19.85
NH26783	Maximum Pressure - NHCRWA 54" Line	148.8	366.30	68.4	26.75
NH03527	Minimum Pressure - NHCRWA 54" Line	144.1	365.15	59.0	27.90

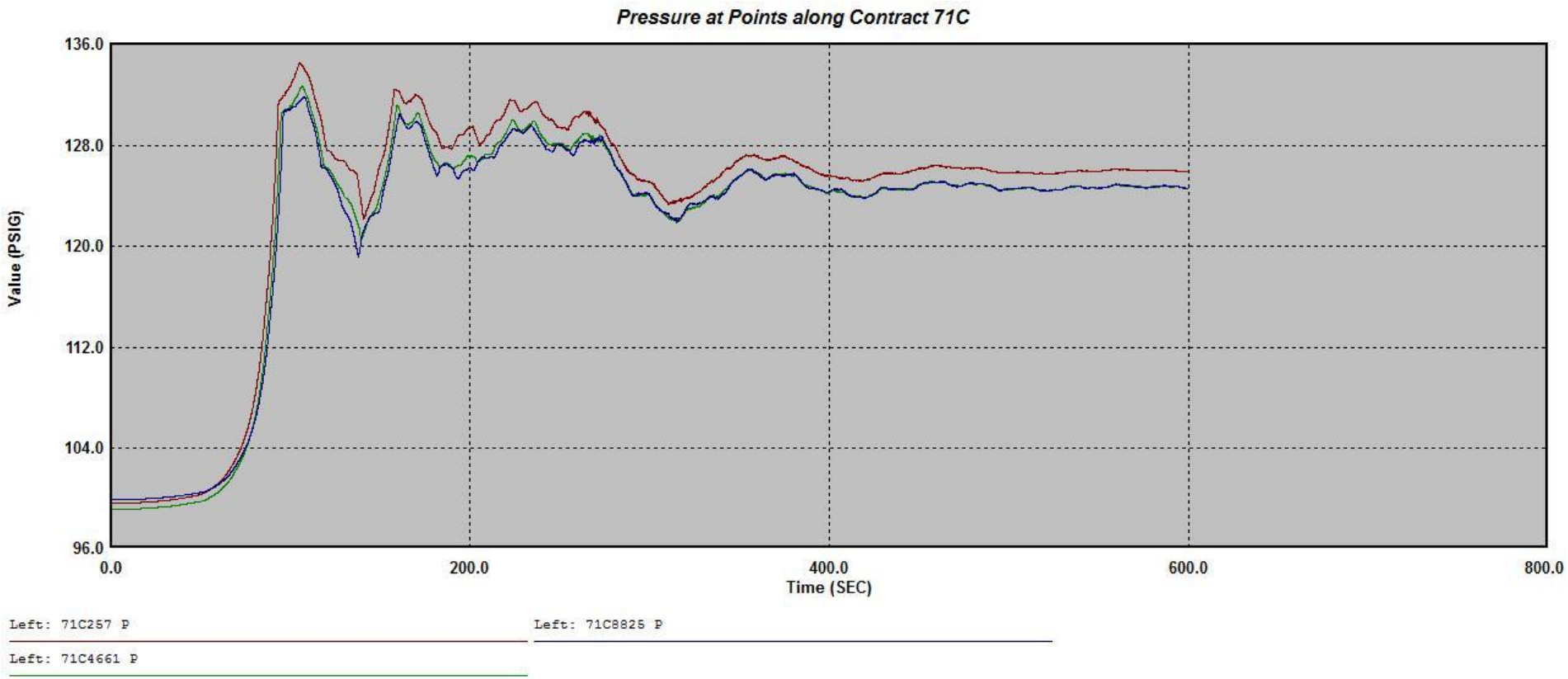
Scenario 7 Results (80 MGD with 30 Minute Valve Closure)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	128.5	459.90	119.3	0.15
46750	84-inch GRP Customers	123.0	454.80	111.5	5.50
71A4532	IAH Take Point	130.0	1823.65	104.5	8.70
D717314	Greenspoint Take Point	131.1	1813.35	93.7	19.05
D710075	NHCRWA Take Point	132.1	1811.00	92.6	21.80
14625	Aldine and GRP Group A Take Point	129.1	1832.25	109.0	0.60
1365	City Main System Take Point	128.6	1836.25	107.8	22.60
MUD844	LHCS Take Point	129.5	1840.65	114.6	19.20
71C570	Maximum System Pressure - Hardy Tollway Crossing	140.5	1813.80	103.6	18.55
NH26783	Minimum Pressure - NHCRWA 54-inch Line	124.9	1806.05	75.1	0.00

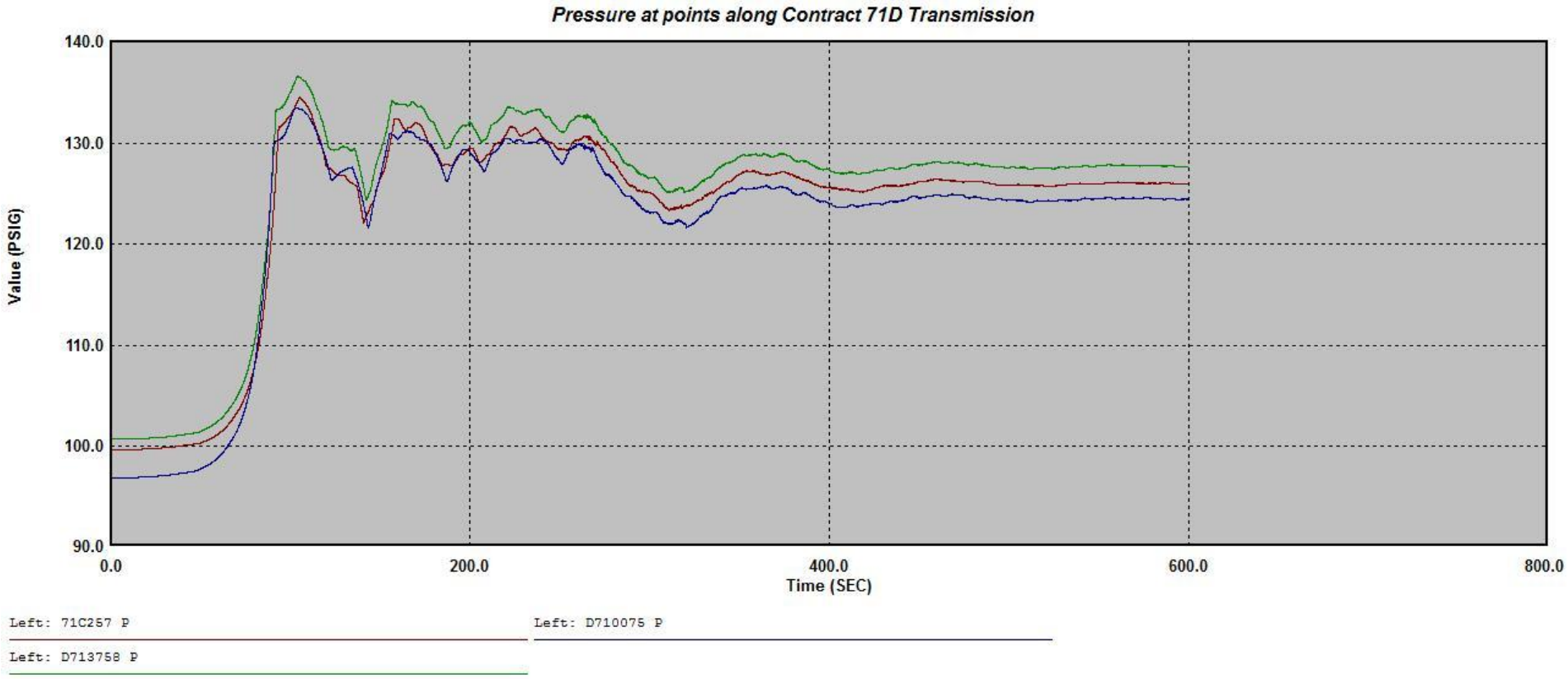
Scenario 7 Results (120 MGD NEWPP Failure)

Node	Location Description	Max Pressure (psi)	Max Pressure Time (sec)	Min Pressure (psi)	Min Pressure Time (sec)
NEWPP	NEWPP	116.6	0.00	-14.3	49.10
46750	Kingwood Take Point	109.4	10.30	-1.3	68.55
71A4532	IAH Take Point	97.5	15.90	1.9	147.05
D717314	Greenspoint Take Point	79.8	26.25	3.2	235.50
D710075	NHCRWA Take Point	78.2	28.60	3.2	238.45
14625	Aldine and GRP Group A Take Point	103.6	7.35	0.8	69.30
1365	City Main System Take Point	104.1	3.35	-0.4	275.00
71C570	Maximum Pressure - Hardy Tollway Crossing	120.0	2.30	-3.6	80.80

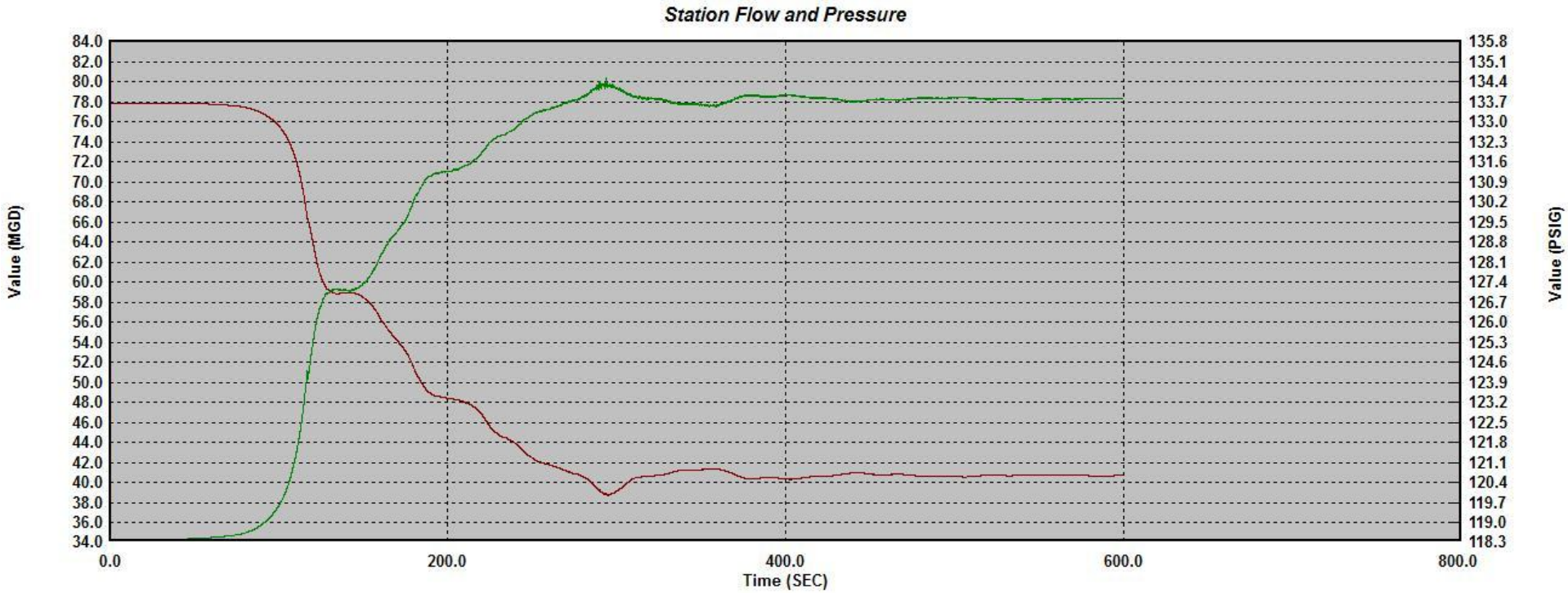
NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD
Three 12-inch GA Surge Relief Valves set to open at 120 psi



NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD
Three 12-inch GA Surge Relief Valves set to open at 120 psi



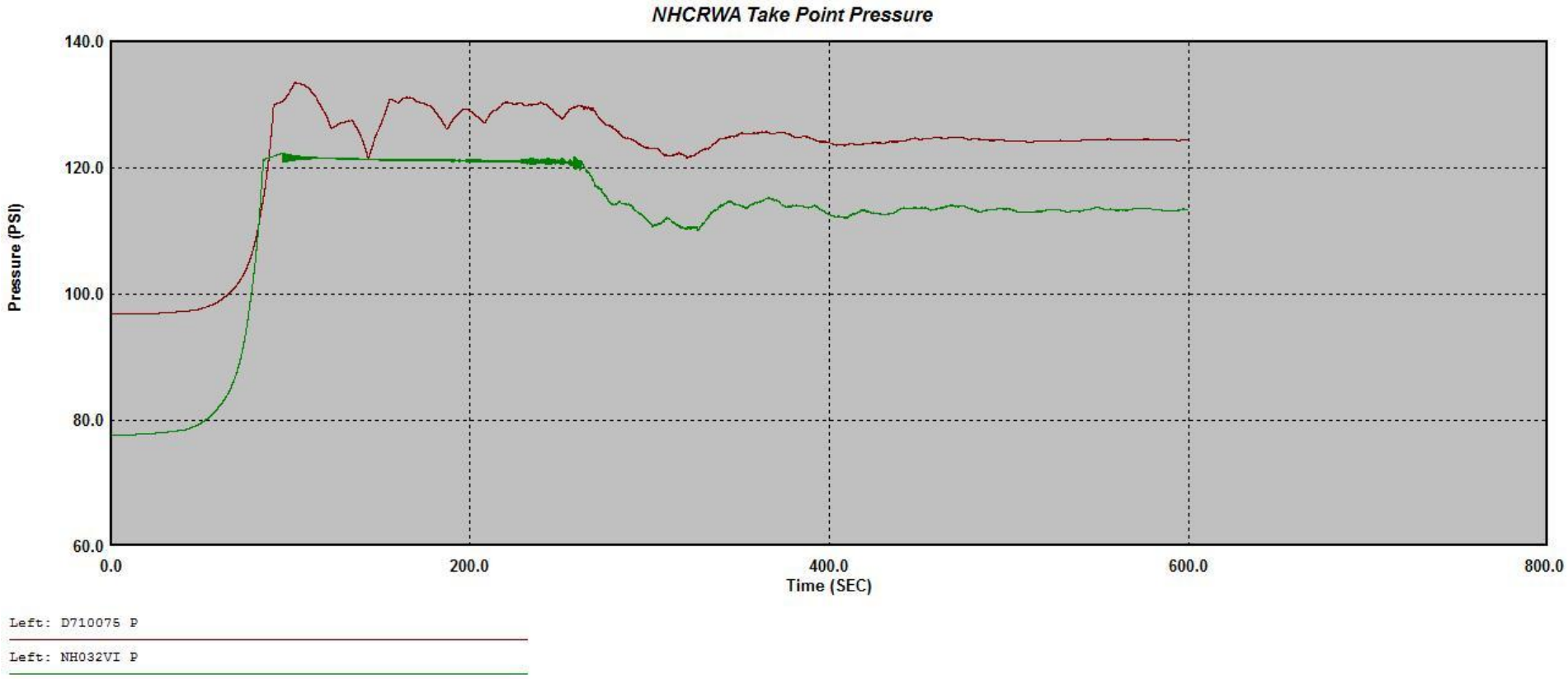
NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD
Three 12-inch GA Surge Relief Valves set to open at 120 psi



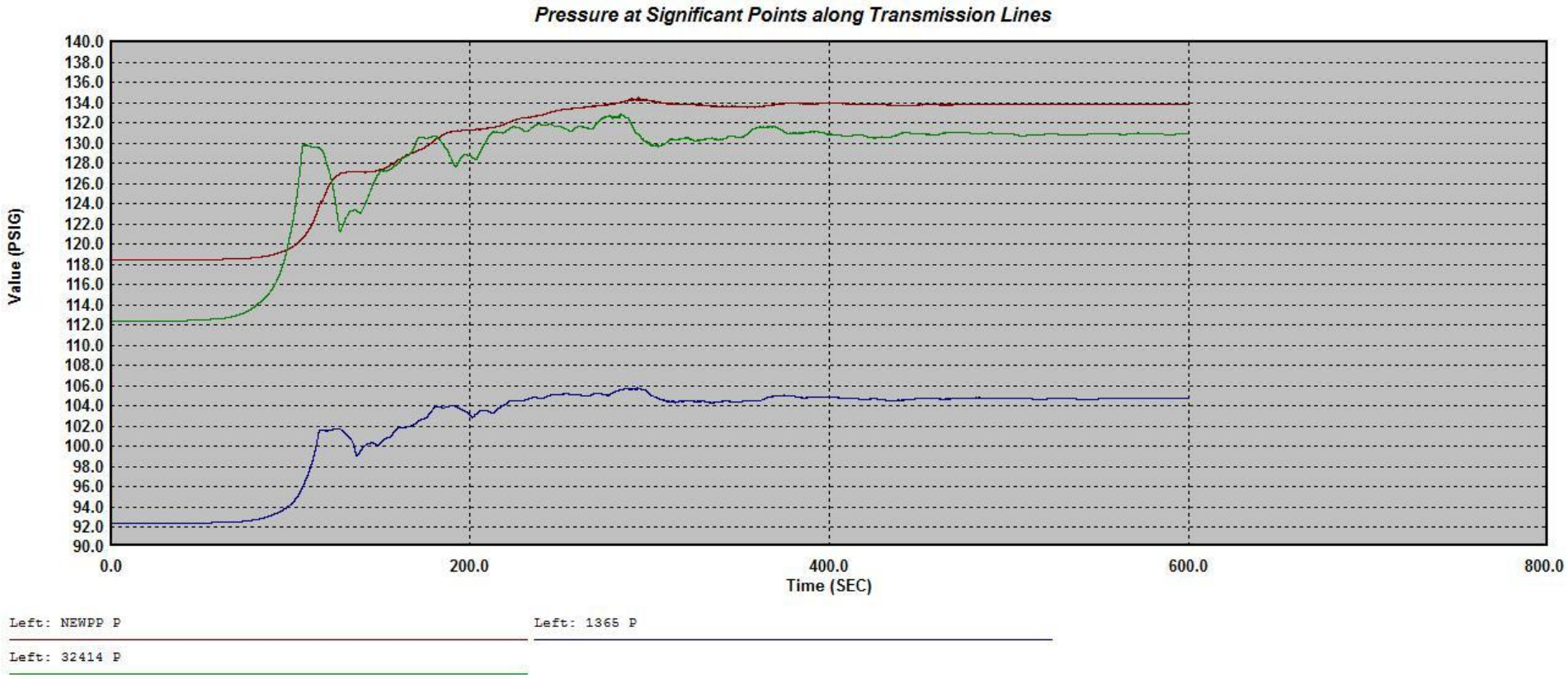
Left: SHEADER NEWPP Q

Right: NEWPP P

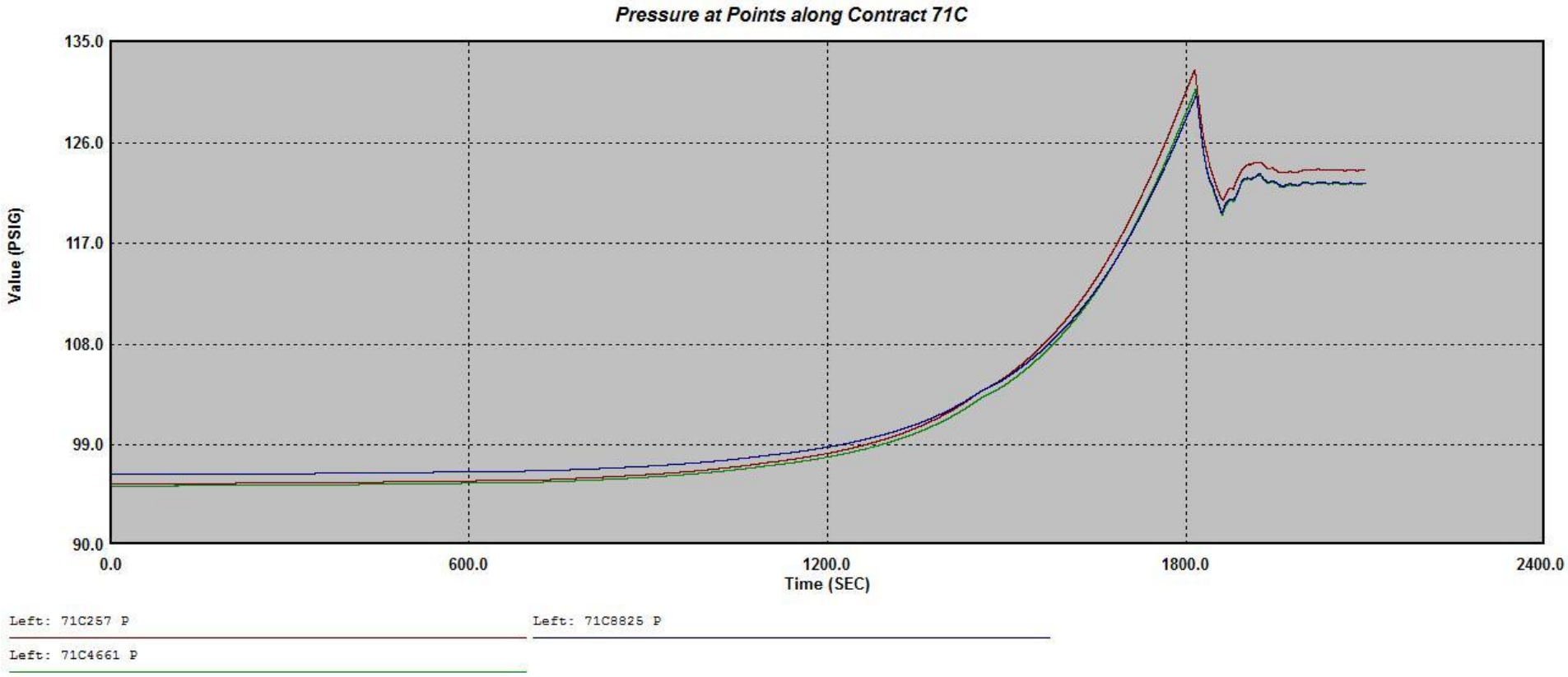
NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD
Three 12-inch GA Surge Relief Valves set to open at 120 psi



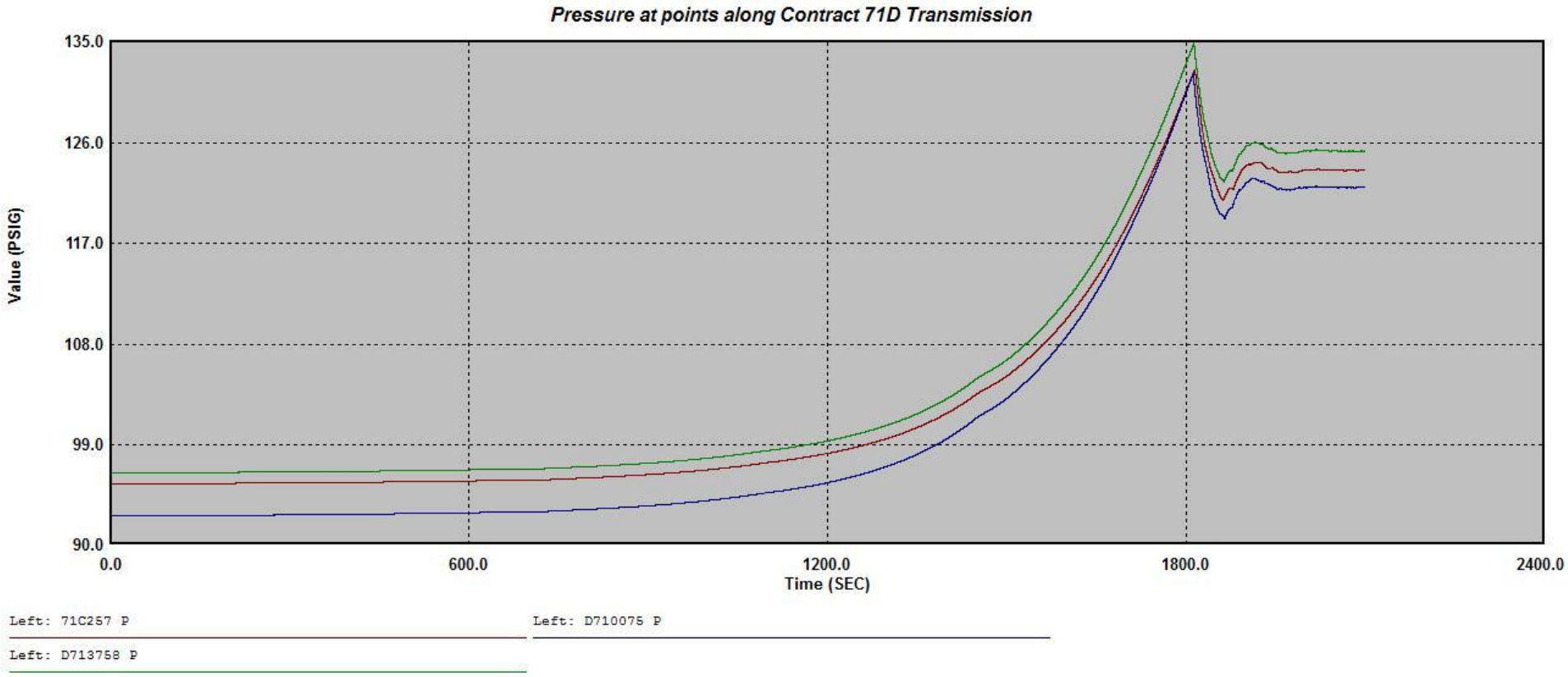
NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure at 80 MGD
Three 12-inch GA Surge Relief Valves set to open at 120 psi



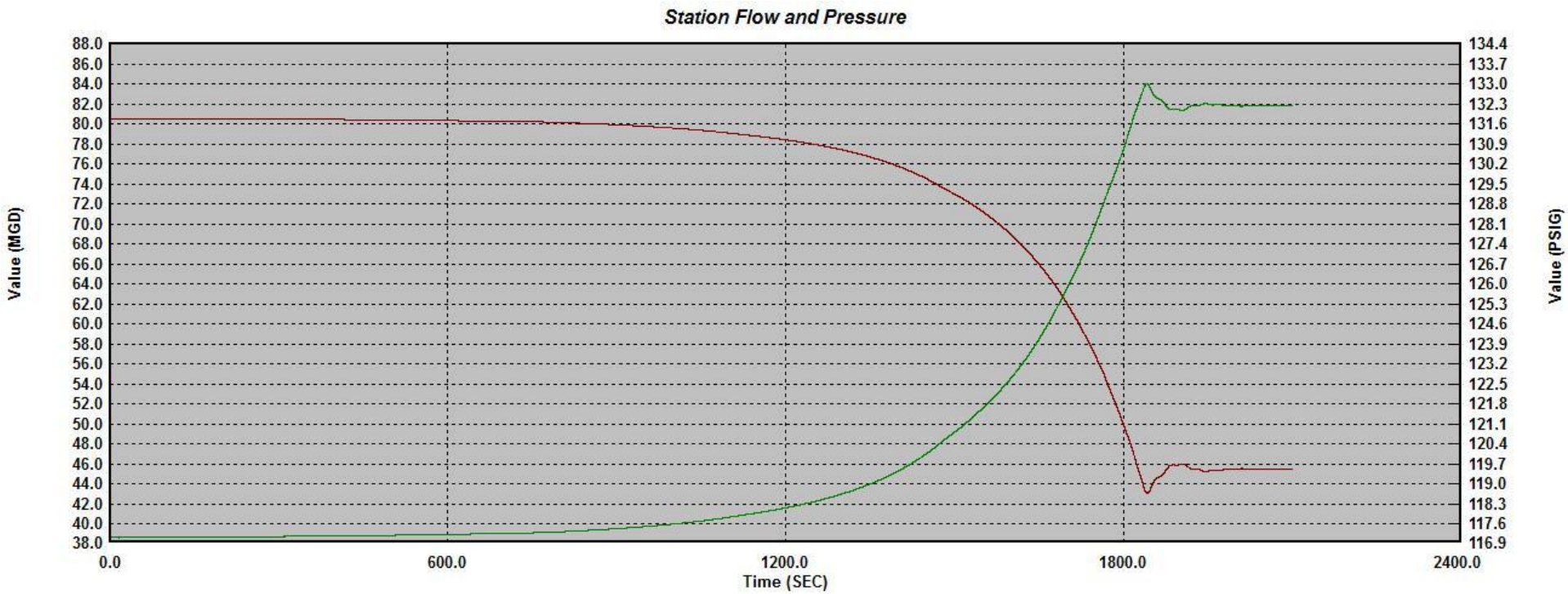
NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure
30-minute Valve Closure



NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure
30-minute Valve Closure



NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure
30-minute Valve Closure



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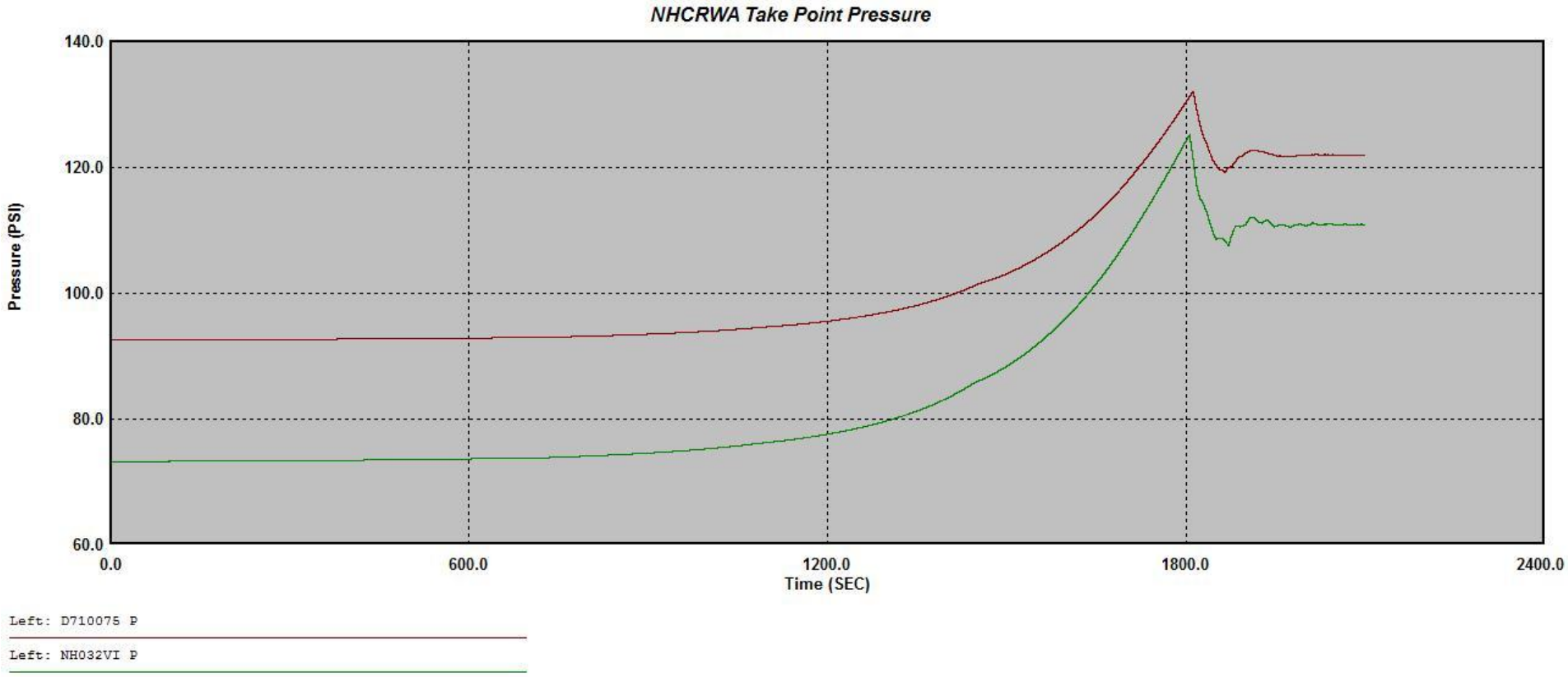
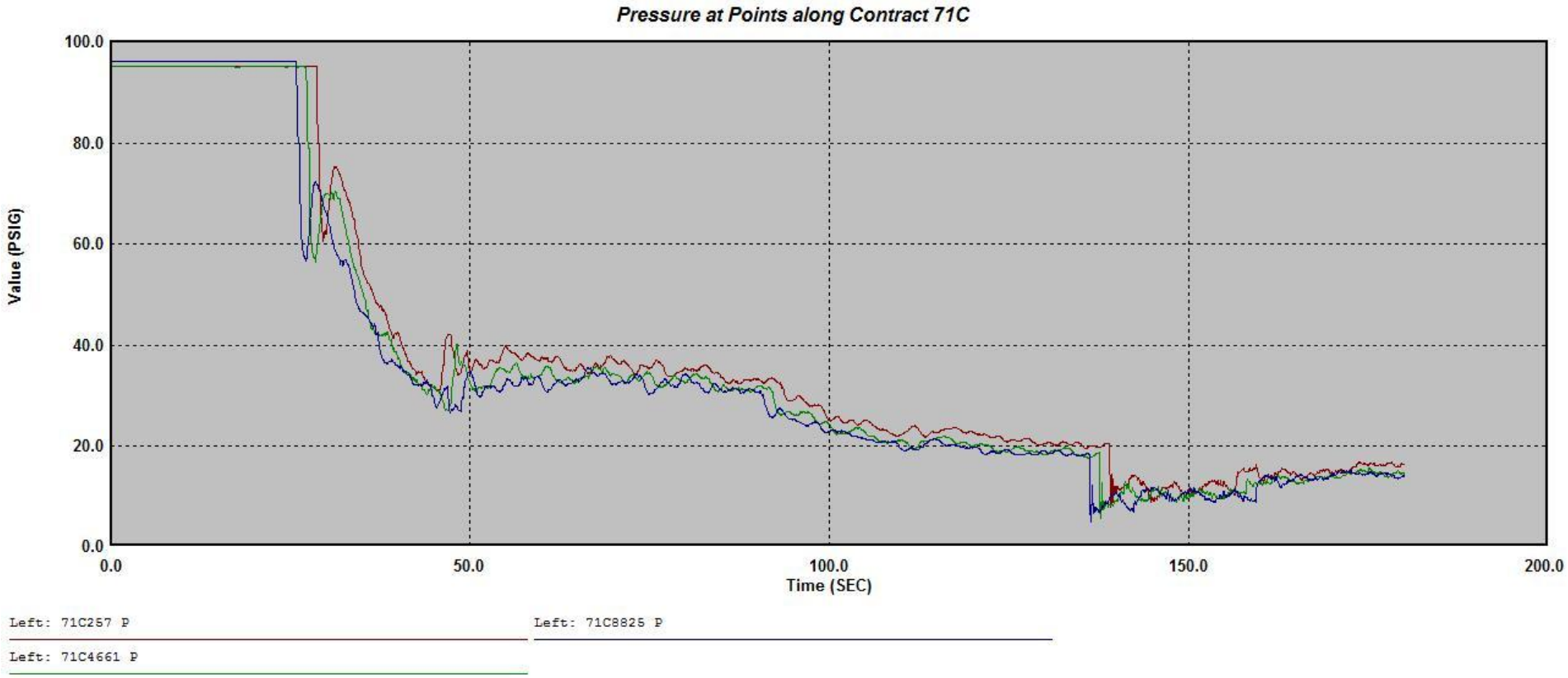
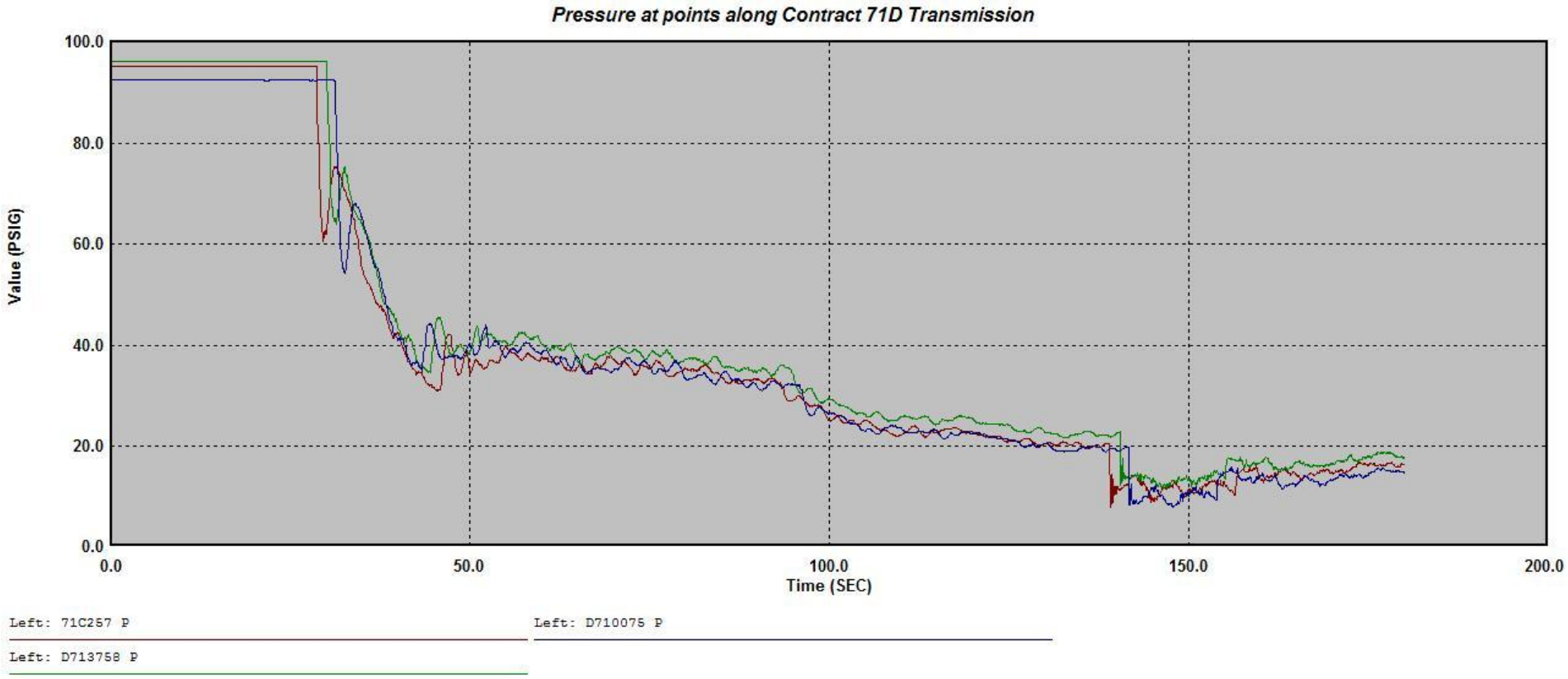
NHCRWA Mitigation
Scenario 7 – NHCRWA Emergency Valve Closure
30-minute Valve Closure



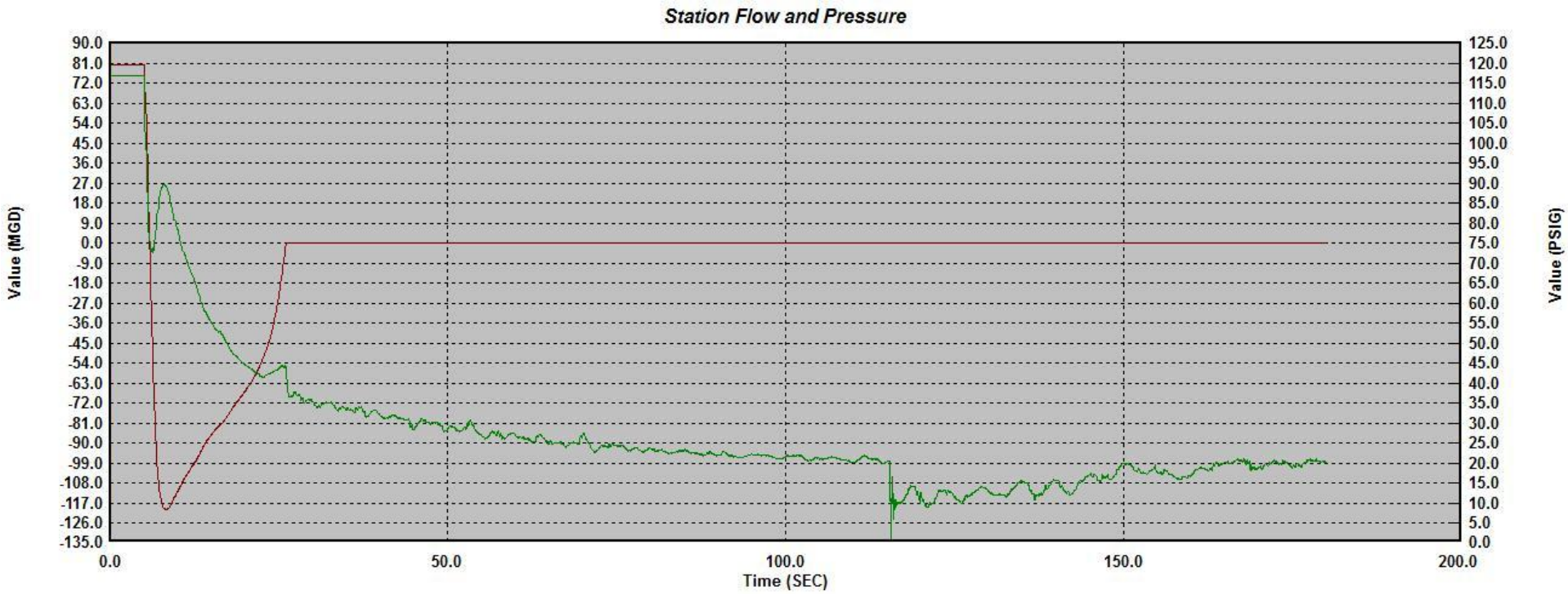
NHCRWA Mitigation
Scenario 8 – Simultaneous All Pump Failure at the NEWPP



NHCRWA Mitigation
Scenario 8 – Simultaneous All Pump Failure at the NEWPP



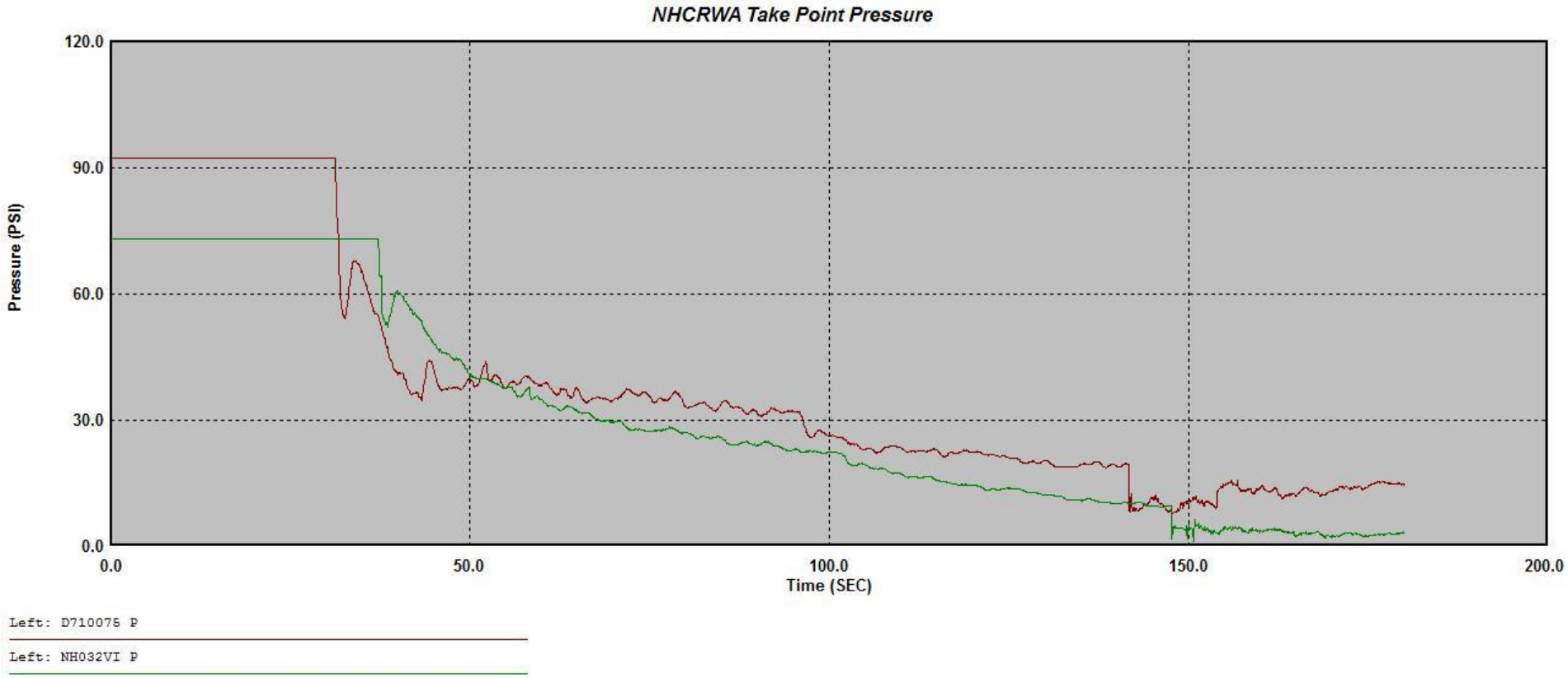
NHCRWA Mitigation
Scenario 8 – Simultaneous All Pump Failure at the NEWPP



Left: SHEADER NEWPP Q

Right: NEWPP P

NHCRWA Mitigation
Scenario 8 – Simultaneous All Pump Failure at the NEWPP



Appendix I

Meeting Minutes from Progress Meetings with City

Index

Kickoff Meeting July 23rd, 2013 Meeting Minutes

Preliminary Results September 6th, 2013 Meeting Minutes

Progress Meeting October 29th, 2013 Meeting Minutes

Final Progress Meeting December 20, 2013 Meeting Minutes

TBPE Firm Registration No. F-3043

Memorandum

To: *Distribution*

From: *CDM Smith / LAN*

Date: *July 23rd, 2013*

Subject: *City of Houston Northeast Water Purification Plant (NEWPP) Improvements Transient Analysis*
City Project WBS No. S-000066-0012-3
Kickoff Meeting

A project Kickoff meeting was held on Tuesday July 23, 2013 at 1:00 P.M. at the NEWPP Conference Room for the above referenced project. Those in attendance of the meeting are as follows:

Name	Firm	Phone	E-mail
Drew Molly	City	832-395-3785	andrew.molly@houstontx.gov
Russell Holley	City		russell.holley@houstontx.gov
Shannon Smith	City	832-395-3097	shannon.smith@houstontx.gov
Brent Nicholas	CDM Smith	713-423-7348	nicholasbw@cdmsmith.com
Yue Sun	CDM Smith	713-423-7376	sunyy@cdmsmith.com
Ty Thomas	LAN	713-821-0459	etthomas@lan-inc.com
Melissa Mack	LAN	713-821-0426	mcmack@lan-inc.com
Alan Moon	LAN	713-821-0419	ammoon@lan-inc.com

A meeting sign-in sheet and meeting agenda are attached to this memo. The following content presents a summary of the items discussed at the meeting.

I. Scope Discussion

1. The purpose of the transient analysis is to:

    - Confirm existing surge tank sizing
    - Recommend different surge protection devices
    - Evaluate existing pump control valve function and recommend improvements

2. Scenarios to be modeled were reviewed and discussed. These include:

    a. Scenario 1: Total Power Failure - all pumps (firm capacity)
    b. Scenario 2: Normal Shutdown - all pumps (firm capacity)
    c. Scenario 3: Normal Start-up - all pumps (firm capacity)
    d. Scenario 4: Partial Power Failure of one pump with other pumps running (firm capacity).
    e. Scenario 5: Start-up and Shutdown of the emergency diesel engine driven pump with other Pumps Running.
    f. Scenario 6: Start-up and Shut down of the emergency diesel engine driven pump with no other Pumps Running.
    g. Scenario 7: Distribution Valve Closure at Large Take-point 1.
    h. Scenario 8: Distribution Valve Closure at Large Take-point 2.
    i. Scenario 9: Distribution Valve Closure at Large Take-point 3.

3. LAN will provide results for two models, a micro model of the NEWPP and a macro model of the existing 84/66-inch and NEWPP.

4. The Macro model of the NEWPP and existing system needs to have updated customer demands. Also locations and sizes of existing air valves need to be verified per recommendations from previous modeling results. North Harris County Regional Water Authority (NHCRWA) needs 51 psi at their take point. The Macro model should also include the existing 42/36-inch Hirsch Road line up to the existing 36-inch butterfly valve at Little York. City currently has 36-inch valve at Little York closed to help pressures at the NEWPP.

5. NHCRWA will be one of the distribution valve closure Scenarios performed. City will decide upon which customer's valve closures to model for the other two distribution valve closure Scenarios.

6. NRG Generators are installed at the NEWPP. NRG has approximately 1 hour to get generators online when notified. Based on the use of the generators, Scenarios 5 and 6 were adjusted to reflect current plant operations. Scenario 5 will model the shutdown of the emergency diesel engine pump with other pumps running. Scenario 6 will model the start-up of the emergency diesel engine pump with no other pumps running.

7. Current Operations:

    a. Pump control check valves on the pump discharge lines are slamming; closure times and new pump control valves should be evaluated.

b. In pump start-up, butterfly valves on the discharge lines begin opening before pumps are brought online. Butterfly valves open to a specific time, which should be evaluated. Pumps are turned on individually; lag time between pump start-ups should be evaluated.

c. In power failure, the back-up power generators do not come on automatically. In power failure, butterfly valves fail in their set position at the time of failure.

d. Pressure relief valves attached to the existing surge tanks are per ASME pressure vessel requirements, and should be ignored in model. Shop drawings are needed for existing surge tanks.

e. The 2-inch air release valves attached to the pump cans should be ignored in the model. The valves are used for filling and draining the cans during pump start-up and shut-down.

f. Due to the high system demand, the high service pump station (HSPS) pumps typically run out on their curves.

8. City Drinking Water Operations stated the urgency regarding the lack of flow control at the High Service Pump Station by having all constant speed pumps. Consequently, NEWPP operators must throttle butterfly valves on the discharge side of the pumps as a primary control mechanism to achieve desired flows and pressures. CDM Smith acknowledged that City DWO desires VFDs addition for better control of produced water. As such, the team agreed that VFD's should be prioritized accordingly. A medium voltage electrical study will need to be performed prior to VFD design activities. *(Note: Per further discussion with the team, it should be noted that while VFD's would change the results for normal pump start-up and shut down modeling scenarios , the critical modeling scenario from a transient stand-point would be power failure of all pumps running and VFDs would not come into play in that scenario. Therefore, we don't anticipate the overall transient mitigation solutions changing.)*

9. Based on site visit and pump curves received from CDM Smith and Floway, LAN noted Pumps 1-4 appear to have the wrong name tags and do not reflect most recent curves dated 2005 from Floway.

10. LAN made inquiry about ratchet devices on existing pumps. Information is needed to assess pump backflow during failure of a single pump.

II. Action Items

1. LAN is to have results of the existing system Scenarios by the end of August. LAN is to have results of the existing system with mitigation by the end of September. A finalized report will be submitted in November.

2. City Planning and Development Services will provide LAN with updated customer demands from the NEWPP. City will decide on which customer valve closures LAN will model.

3. LAN will add the 42-inch water line along Hirsch Rd to the Macro model and update the demands along the existing 84-inch and 66-inch lines.

4. City and CDM Smith will look for information regarding programming of the pumps for start-up and shutdown at the high service pump station. LAN will provide recommendations for timing of operations based on results of analysis.

5. LAN to send pump curves to CDM Smith received from Floway for existing pumps.

6. CDM Smith to acquire record drawings for existing surge tanks. Suggestion for LAN to search plant library to obtain shop drawing information for the surge tank.

7. CDM Smith to provide LAN with alternate control valves to model.

8. CDM Smith to discuss addition of VFDs to design project scope at August project meeting.

9. CDM Smith to confirm existence of ratchet devices on pumps.

cc: Meeting Attendees
CDM Smith Project File No.

TBPE Firm Registration No. F-3043

Memorandum

To: *Distribution*

From: *CDM Smith / LAN*

Date: *October 4, 2013*

Subject: *City of Houston Northeast Water Purification Plant (NEWPP) Improvements*
High Service Pump Station
Transient Analysis Existing System Preliminary Results
City Project WBS No. S-000066-0012-3
CDM Smith P/N: 8138-92757: Transient Analysis

A preliminary results meeting was held on Friday September 6, 2013 at 1:00 P.M. at the NEWPP Conference Room for the above referenced project. Those in attendance of the meeting are as follows:

Name	Firm	Phone	E-mail
Drew Molly	City	832-395-3785	andrew.molly@houstontx.gov
Rajinder Singh	City	832-395-2321	rajinder.singh@houstontx.gov
Tuan Tran	City	832-395-2323	tuan.tran@houstontx.gov
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Shannon Smith	City	832-395-3097	shannon.smith@houstontx.gov
Chris Thompson	City	832-395-3792	christopher.thompson@houstontx.gov
Brent Nicholas	CDM Smith	713-423-7348	nicholasbw@cdmsmith.com
Yue Sun	CDM Smith	713-423-7376	sunyy@cdmsmith.com
Showri Nandagiri	NHCRWA	281-440-3924	showri@nhcrwa.com
Tom Rolen	AECOM	713-267-3181	tom.rolen@aecom.com
Michael Baugher	AECOM	713-267-2868	mike.baugher@aecom.com
Paul Walker	Carollo	512-809-4092	pwalker@carollo.com
Ty Thomas	LAN	713-821-0459	etthomas@lan-inc.com
Melissa Mack	LAN	713-821-0426	mcmack@lan-inc.com
Alan Moon	LAN	713-821-0419	ammoon@lan-inc.com

A meeting sign-in sheet, meeting agenda, and a summary of existing system preliminary results are attached to this memo. The following content presents a summary of the items discussed at the meeting.

I. Existing Results Discussion

- LAN has run all scenarios based on six 20 MGD pumps running at firm capacity of 120 MGD. There was discussion as to whether Pumps 1-4 are 20 or 27 MGD pumps based on conversations with the manufacturer (Floway), pump nameplates, and existing pump curves. LAN and CDM Smith stated, based on their separate conversations with manufacturer, pumps were confirmed 20 MGD pumps. Drew Molly also noted he thought the pumps to be 20 MGD pumps. Additional information and email correspondences with the pump manufacturer regarding existing pump ratings are attached to this memo.

- Scenarios 1-4 were run with and without surge tanks, to help determine if surge tanks are sized properly and how the existing system reacts under a transient condition with or without the surge tanks.

1. Scenario 1 – Simultaneous Failure of All Pumps
    - With pumps producing 120 MGD, surge tanks will empty. Volume of surge tanks should be increased.
    - The system is better protected when surge tanks do not empty. LAN noted that the surge tank water level observed on two field visits was 6.5 ft when plant was running at 80 psig. This is contrary to the O&M manual which recommends a level of 8.1 ft. The surge tank level will vary with system pressures. Additional field observations will need to be made to confirm current level settings.
    - Transients are an issue in simultaneous failure of all pumps with the surge tanks.
    - Combination air vacuum valves are needed down stream of check valves with surge tanks.
    - LAN noted a limitation with the model when the surge tanks empty. The model assumes the surge tanks to have bladders, which the existing surge tanks do not. This does not allow the air in the tanks to extend into the system. The volume of water in the surge tanks can be adjusted in the model so that they do not empty in the different scenarios.

2. Scenario 2 – Normal Pump Shut Down
    - With pumps producing 120 MGD, surge tanks will empty. Volume of surge tanks should be increased.

- Model was run with discharge control valve (currently butterfly valves) closure times of 60-, 90- and 120-seconds.
- Pressure results do not vary with or without surge tanks. Transients not a problem in normal pump shut down when model was analyzed with surge tanks at O&M water level.

3. Scenario 3 – Normal Pump Start Up
    - There is a problem with pumps running out on their curves during start up, depending on the pump control valve (butterfly valve) opening time. LAN suggested the minimum opening time of control valves should be 4 minutes to keep the pumps from running off their curves. 4 minutes keeps pumps on far right end of their curves.
    - DWO stated that initial boundary conditions should be 0 MGD at 40 psig supplied by the EWPP for this scenario, based on previous plant shut down. The NEWPP had been modeled as an independent system, with 15 psig at 0 MGD produced by the plant.
    - NHCRWA still takes 10 MGD when the NEWPP is down, from the EWPP. This is not represented in the model since the model focus on operations of the NEWPP.
    - LAN stated that in the model, the pumps are filling the surge tanks as well as trying to meet system demand. DWO will check SCADA to see what level the surge tanks are filled to when pump station is offline, during their Black Start.
    - Transients are not a problem in normal pump start up with or without surge tanks.

4. Scenario 4 – Single Pump Failure while Other Pumps Running
    - The model was analyzed at various check valve closure times, and the model is sensitive to the check valve closure time, producing significantly different pressure results at the various closure times. CDM Smith suggested LAN discuss normal check valve closure times with manufacturer for reference.
    - A shorter check valve closure time (0.1 seconds or 0.01 seconds) causes high pressure spikes. A longer check valve closure time (1.0 seconds) causes backflow in pumps (approximately 35 MGD), but unclear if this is an issue for pumps. The existing pumps have ratchet devices for backflow protection. CDM Smith to evaluate if backflow would be an issue.
    - CDM Smith noted a change in check valve closure times from what the existing check valve is capable of requires a change in check valves /reverse flow prevention philosophy.
    - Check valve of failed pump creates vapor cavities in single pump failure; transients are an issue in the pump discharge piping with and without surge tanks.

5. Scenario 7 – Macro Model Flow Control Valve Closure (NHCRWA)
    - The valve closing conditions modeled are emergency, worst case conditions.
    - LAN is still working on a valve closure profile for NHCRWA's Stealth flow control valve, but used a closure profile of a sleeve valve, which is a similar type of valve.
    - Pressures in excess of 150 psig occur on both the City's 66-inch and 84-inch lines and NHCRWA's 54-inch line due to "line packing". The pressures build gradually over time as the NHCRWA valve closes. LAN suggested a surge relief valve at the NHCRWA booster station and/or longer valve closure time may prevent pressure build ups. This will be investigated in the problem solution phase.
    - The model was analyzed for 120 MGD system flow, but will also be analyzed at 80 MGD (existing NEWPP capacity) with NHCRWA taking current peak hour demand (45 MGD)
    - Carollo asked if existing transmission system is protected with current surge devices if all pumps fail at the NEWPP. This scenario is not part of current project scope; however, LAN evaluated this scenario and recommended surge protection devices when the 66-inch water line was built. NHCRWA's 54-inch line was not in service or modeled at the time.
    - NHCRWA suggested that all pump failure should be looked at for the transmission system with NHCRWA's 54-inch line.

6. The NEWPP system can work and be protected either with or without the surge tanks. If the surge tanks continue to be used, the combined volume of the tanks needs to be increased. Alternatively, the surge tanks can be replaced by additional air valves. The latter has not been analyzed to determine how many additional air valves would be needed.

7. Whether or not to use surge tanks comes down to operations and maintenance and whether DWO has had operational and/or maintenance issues with the surge tanks. DWO indicated that they have not had issues and do not have a problem keeping the surge tanks. The solutions phase will proceed with the surge tanks in the system.

8. The system should be re-evaluated in the future once the Second Source transmission line (Northeast Water Line) is installed.

II. Action Items

1. LAN to contact vendor about the existing check valve closure times.

2. City to schedule time for CDM Smith and LAN to witness and time normal pump start up and shut down sequence for use in the model.

3. LAN to look at Scenario 7, NHCRWA valve closure at 80 MGD with NHCRWA taking peak hour demand (45 MGD).

4. CDM Smith to provide LAN with three control valve technologies to analyze from transient perspective.

5. LAN to provide sizing of surge tanks, surge protection recommendations and model results at the next meeting.

The next meeting will be held either Friday, October 4th or Friday, October 18th, from 1-3 pm at the NEWPP tentatively.

cc: Meeting Attendees
CDM Smith Project File No. 8138-92757

Northeast Water Purification Plant Improvements

HSPS Transient Analysis Existing System Preliminary Results

September 6th, 2013

NEWPP Conference Room

1:00 P.M. - 3:00 P.M.

WBS No. S-000066-0012-3

Name	Firm	Email	Phone	Fax
Shouri Nandagiri	NHCRWA	shouri@nhcrwa.com	281 440 3924	
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Alan Moon	LAN	ammoon@lan-inc.com	713 821 0419	
Yue Sun	CDM Smith	sunyy@cdmsmith.com	713 423 7376	
BRENT W. NICHOLAS	CDM Smith	nicholasbw@cdmsmith.com	713-423-7348	
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PAUL WALKER	CAROLLO	pwalker@carollo.com	512 809 4092	

CDM Smith

Name	Firm	Email	Phone	Fax
Tom Rolen	AECOM	tom.rolen@aecom.com	713-267-3181	
Michael Baugher	AECOM	mike.baugher@aecom.com	713-267-2868	

CDM Smith

TBPE Firm Registration No. F-3043

Memorandum

To: *Distribution*

From: *CDM Smith / LAN*

Date: *October 29, 2013*

Subject: *City of Houston Northeast Water Purification Plant (NEWPP) Improvements*
High Service Pump Station
Transient Analysis Progress Meeting
City Project WBS No. S-000066-0012-3
CDM Smith P/N: 8138-92757: Transient Analysis

A progress meeting was held on Monday October 29, 2013 at 1:00 P.M. at the NEWPP Conference Room for the above referenced project. Those in attendance of the meeting are as follows:

Name	Firm	Phone	E-mail
Drew Molly	City	832-395-3785	andrew.molly@houstontx.gov
Rajinder Singh	City	832-395-2321	rajinder.singh@houstontx.gov
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Russell Holley	City	713-775-2608	russell.holley@houstontx.gov
Chris Thompson	City	832-395-3792	christopher.thompson@houstontx.gov
Ken Dement	City	832-309-2017	kenneth.dement@houstontx.gov
Scott Barker	City	713-562-2957	scott.barker@houstontx.gov
Brent Nicholas	CDM Smith	713-423-7348	nicholasbw@cdmsmith.com
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A meeting sign-in sheet, meeting agenda, summary of progress and results, Proposed Pump Control Valve Summary Tables, and Macro/Micro model exhibits are attached to this memo. The following content presents a summary of the items discussed at the meeting.

I. Existing System Results Discussion

- Scenarios analyzed up to this point include:
  - Scenario 1 – Simultaneous Failure of All Pumps
  - Scenario 2 – Normal Shutdown
  - Scenario 3 – Normal Start Up
  - Scenario 4 – Single Pump Failure while Other Pumps Running
  - Scenario 7 – NHCRWA Emergency Valve Closure
- Scenarios to be performed after the proposed improvements are identified:
  - Scenario 5 – Start-up of emergency diesel pump
  - Scenario 6 – Shutdown of emergency diesel pump
- There have been several updates since the September 6th Preliminary Results Meeting.
  - CDM Smith and LAN believe all pumps at the HSPS are rated for 20 MGD with 191 TDH based on correspondence with the manufacturer, Floway, which will be attached to the final report.
  - Pump Witness Testing occurred on September 18, 2013, to witness normal operations of pump start-up and shutdown. The timings gathered were then incorporated into the model.
  - Results have been updated to reflect the 40 psi backpressure from the EWPP when the NEWPP is down based on information provided during the September 6th meeting from the NEWPP operations staff.
  - Receipt of drawings and demand information for the 36-inch waterline off the 84-inch NEWPP transmission line that supplies the Summerwood area. The waterline consists of 36-/30-/24- and 16-inch piping and feeds several MUDs and subdivisions. Since the information was received after the Existing System Scenarios were performed, only select Scenarios were remodeled with the Summerwood waterline and change in demands to confirm the impact on the transient analysis.
- For the Existing System without Summerwood, Scenarios 1-4, the NEWPP surge tanks do not empty with the 40 psi backpressure from the EWPP. The critical Scenarios are the Pump Failure Scenarios (Scenarios 1 and 4), where pressures over 200 psi occur in the pump discharge lines and discharge header. Vapor cavities (-14.4 psi) also occur in the pump discharge lines in the pump failure scenarios due to the check valve slamming.
- The NHCRWA Emergency Valve Closure Scenario, was modeled with the NEWPP producing both 80 MGD and 120 MGD. It is assumed that NHCRWA is taking 45 MGD in each case, and the NHCRWA's flow control valve cycles from full open to full close in 90 seconds. Pressures over 200 psi occur in both the NHCRWA line and City lines. The pressures are higher in the 80 MGD Scenario due to NHCRWA taking a larger percentage of total flow produced by the NEWPP.
- Both the All Pump Failure and NHCRWA Emergency Valve Closure Scenarios were re-analyzed with the addition of the Summerwood water line. Results varied slightly

(1-5 psi) with and without the Summerwood water line; but, otherwise, the addition of the line did not make a difference.

- For the Existing System without Summerwood, Scenarios 2-4, the results vary little with and without surge tanks. In Scenario 1, All Pump Failure, the high pressure spikes over 150 psi do not occur without the surge tanks. Without the surge tanks, the maximum pressure is 115 psi, but vapor cavities still occur in the pump discharge lines due to the slamming of the check valves.
- There is concern about the allocation of demands in the Macro model for the NHCRWA Emergency Valve Closure Scenario.
  - NEWPP's current maximum pumpage is approximately 80 MGD. Although some scenarios were performed for 80 MGD, it was discussed during September 6th progress meeting that 120 MGD would be used as a worst case condition for the transient analyses given the NEWPP's firm pumping capacity and available storage. If an emergency were to occur requiring 120 MGD from the NEWPP, the system would be protected if a transient event occurred while pumping this flow.
  - CHCRWA water goes through the NHCRWA pump station. NHCRWA pumps the CHCRWA via their booster pump station.
  - In order to allocate the 120 MGD within the NEWPP system, peak day demands were identified for NCHRWA/CHCRWA, Greenspoint, Intercontinental Airport (IAH), the Main system, and Future Customers. The peak demands were provided by the City's Planning Group as part of the NEWPP Feasibility Study (May 2011) and confirmed as part of this project by Planning.
  - Demands for the Summerwood area where provided on October 18, 2013 for inclusion in the model (10 MGD average daily flow, 14 MGD peak day flow).
  - The question was raised as to whether a larger portion of the 120 MGD should go to NHCRWA/CHCRWA since the 120 MGD NEWPP flow is theoretical, the Summerwood area is currently taking less than 5 MGD, and the NHCRWA/CHCRWA area is growing faster than the Summerwood area.
  - The group's general consensus was to get Planning's input and clarification regarding the current and future customers, contractual agreements for average versus peak day flows, and a timeline for growth in the NEWPP system requiring the NEWPP to produce 120 MGD. Part of this will include confirmation of the location and quantity of flow to the City of Humble.
  - NHCRWA/CHCRWA's peak day flow will be provided by AECOM for consideration in the model along with the maximum flow the NHCRWA's 54-inch transmission main can transport.
  - Mike Baugher stated current flow take rate is 22,000 gpm (31.7 MGD) to 25,000 gpm (36 MGD).
  - The information received from Planning and AECOM will be used to refine the demand allocation. The revised allocations will be used to finalize the Macro model scenarios.

II. Proposed Pump Control Valves and Surge Mitigation

- CDM Smith presented sketches of the proposed pump control valve alternatives. Alternatives include 30-inch Adams Triple Offset Disc valve, 24- and 30-inch Golden Anderson Resilient Seated Ball valve, and 30-inch Golden Anderson Checktronic Wye Valve. The proposed pump control valves would replace the existing Globe Style Check valves, which cause problematic high (greater than 150 psi) and low (less than -10 psi) surge pressures. The electric actuators on the existing butterfly valves would be replaced by manual hand wheel actuators, and the butterfly valves will be used as isolation valves.
- Scenarios 1-4 were run with the proposed pump control valves and surge tanks with different closing and opening times. LAN handed out Proposed Pump Control Valve Summary tables with results from these Scenarios. The Golden Anderson Ball Valves and Adams Disc Valve mitigate the transients seen in the Existing Conditions Pump Failure Scenarios and yielded very similar pressure results. The Golden Anderson Checktronic Wye valve has a faster emergency closure time, which causes pressure spikes over 150 psi. CDM Smith and LAN do not recommend the Checktronic Wye valve due to the inability to control the valve's closure time under a pump failure condition.
- Scenario 1, Simultaneous Pump Failure, was run with an Adams 24-inch Disc valve <u>without</u> the surge tanks. Vapor cavities occurred with the fast closure time (5 seconds), but results vary slightly and were within acceptable pressure ranges with and without surge tanks for the 30- and 60-second closures. LAN does not recommend a fast closure time.
- Surge Relief devices were evaluated as potential solutions for the NHCRWA Emergency Valve Closure Scenario. Three 12-inch Golden Anderson surge relief valves were modeled at different pressure settings to open, for both 120 MGD and 80 MGD. In all cases, the maximum pressure was 100 psi lower with the surge relief valves installed, and all pressures were below 150 psi. In the 80 MGD scenario (worst case), the max flow rate through the each of the three surge relief valves is 9.8 MGD. The surge relief valves are open for approximately 126 seconds. LAN will evaluate four surge relief valves installed, but stated additional surge relief valves may not be needed.
- NHCRWA voiced concerns regarding pump failure at the NEWPP and impacts to the City's and NHCRWA's transmission mains if pump failure were to occur. An analysis will be performed, as discussed in the September 6th meeting, to evaluate this condition.

III. Primary Take-Aways

- The Adams Disc valve and Golden Anderson Ball valve mitigate the high and low pressure spikes that occurred in Pump Failure Scenarios (Scenarios 1 & 4). Final selection of pump control valve to be made during design.

- Pressure results are essentially the same for the proposed pump control valves, with or without the surge tanks.
- NHCRWA should not close their control/isolation valve in 90 seconds or less until improvements have been made.
- Surge Relief valves directly upstream of NHCRWA's flow control valve mitigate the high pressure spikes seen in NHCRWA Emergency Valve Closure Scenario.

IV. Action Items

1. NHCRWA/AECOM:
    a. Provide LAN with their current Peak Day and Hour flows.
2. LAN:
    a. Contact City Planning and obtain contracted flows for NEWPP customers. LAN will also get Peak Hour flow rates for customers.
    b. Reevaluate demands and flow rates for Macro model Scenario. LAN will note that demands are theoretical for theoretical plant production in the report.
    c. Run the remainder of proposed pump control valve scenarios with the addition of the Summerwood line. LAN will also run Single Pump Failure with existing conditions and the addition of the Summerwood line.
    d. Analyze the impacts of all pump failure at the NEWPP on the City's and NHCRWA's transmission mains.
    e. Evaluate having four surge relief valves in the NHCRWA Emergency Valve Closure Scenario.
    f. Remove 66-inch raw water line from Northeast Transmission system exhibit (Exhibit 2).

The next meeting will be held in early December at the NEWPP.

cc: Meeting Attendees
Shannon Smith, City of Houston
CDM Smith Project File No.

TBPE Firm Registration No. F-3043

Memorandum

To: *Distribution*

From: *CDM Smith / LAN*

Date: *January 3rd, 2014*

Subject: *City of Houston Northeast Water Purification Plant (NEWPP) Improvements*
High Service Pump Station
Transient Analysis Final Progress Meeting
City Project WBS No. S-000066-0012-3
CDM Smith P/N: 8138-92757: Transient Analysis

A progress meeting was held on Friday December 20, 2013 at 2:00 P.M. at the NEWPP Conference Room for the above referenced project. Those in attendance of the meeting are as follows:

Name	Firm	Phone	E-mail
Drew Molly	City	832-395-3785	andrew.molly@houstontx.gov
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Chris Thompson	City	832-395-3792	christopher.thompson@houstontx.gov
Shannon Smith	City	832-395-3097	shannon.smith@houstontx.gov
Yue Sun	CDM Smith	713-423-7376	sunyy@cdmsmith.com
Ty Thomas	LAN	713-821-0459	etthomas@lan-inc.com
Melissa Mack	LAN	713-821-0426	mcmack@lan-inc.com
Alan Moon	LAN	713-821-0419	ammoon@lan-inc.com

A meeting sign-in sheet, meeting agenda, Micro Model Summary Table, Macro Model Summary Table, a Macro Model exhibit with the revised theoretical demands and a Macro Model exhibit with the initial theoretical demand set are attached to this memo. The following content presents a summary of the items discussed at the meeting.

I. Proposed Pump Control Valves

- An issue with transients exists with the current system at 120 MGD total flow from the pump station. The check valves on the distribution lines slam in the Pump Failure Scenarios, causing high pressure spikes and vapor cavities. The Pump Failure

scenarios were also run without the surge tanks in the system, and an issue with transients still exists.

- CDM Smith's proposed pump control valves mitigate the transient issues seen in Pump Failure Scenarios based on the options provided by CDM Smith. LAN recommends either 24-inch or 30-inch Adams Triple Offset Disc Valve or Golden Anderson Resilient Seated Ball Valve. Information provided to CDM Smith for final design decision.

II. Surge Tanks and Hirsch Rd Flow Control Valve

- The Simultaneous All Pump Failure Scenario (worst case) was run with the proposed 24-inch Adams Disc Valve, with and without the existing surge tanks, and with and without the 40 psi backpressure from the EWPP (i.e. Hirsch Road Flow Control Valve closed).
- In the Scenario with the Hirsch Rd flow control valve closed, and the surge tanks 65% full (from LAN field visit) at the start of the failure, the surge tanks empty. Low (vapor) pressures are still an issue when the surge tanks empty.
- When the surge tanks' initial water level is at the O&M manual recommended level (about 80% full), the surge tanks do not drain in any situation, and transients are not an issue.
- With the proposed pump control valves and without the surge tanks in the system, transients are not an issue with or without the backpressure from the EWPP.
- Surge tanks should operate at 80% full until proposed pump control valves can be installed. After proposed pump control valves are installed, LAN recommends the surge tanks be removed.

III. NHCRWA Valve Closure

- Since the previous Progress Meeting, held October 28th, 2013, LAN has worked with Shannon Smith and Khanh Kim from City of Houston Planning and Developmental Services to revise the demands used in the Macro Model of the NEWPP Transmission System. The revised demands are based on City planning numbers for the system, on customers' purchased capacities, and NHCRWA's purchased capacity within the Greens Road 66-inch water line, per NHCRWA's agreement. The demand set for 120 MGD is theoretical in that it represents projected future peaking maximum daily demands of all customers. The demand set is only used as the basis for this model.
- Line packing is an issue with NHCRWA's current emergency valve closure time (90 seconds), causing excessive high pressure throughout the system.
- Four 12-inch Golden Anderson surge relief valves can be used at the NHCRWA Spears Rd pump station, set at 120 psi to open, to mitigate line packing.
- If surge relief valves are not used, the emergency valve closure time should be no faster than 30 minutes. NHCRWA should also notify NEWPP operations to adjust pumping rate before they begin to close their valve.

- Existing air valves on the discharge header and transmission system are adequate to protect the lines in the event of NEWPP simultaneous pump failure.

IV. Action Items

1. LAN will provide the transient report detailing the analysis results and recommendations to CDM Smith for submission to the City on February 14th, 2014.

The above reflects our understanding of this meeting and will become part of the project record. Please notify us of any modifications required in writing no later than Friday January 17, 2014.

cc: Meeting Attendees
Raj Singh, City of Houston
Brent Nicholas, CDM Smith
Showri Nandagiri, NHCRWA
Tom Rolen, AECOM
Michael Baugher, AECOM
CDM Smith Project File No.