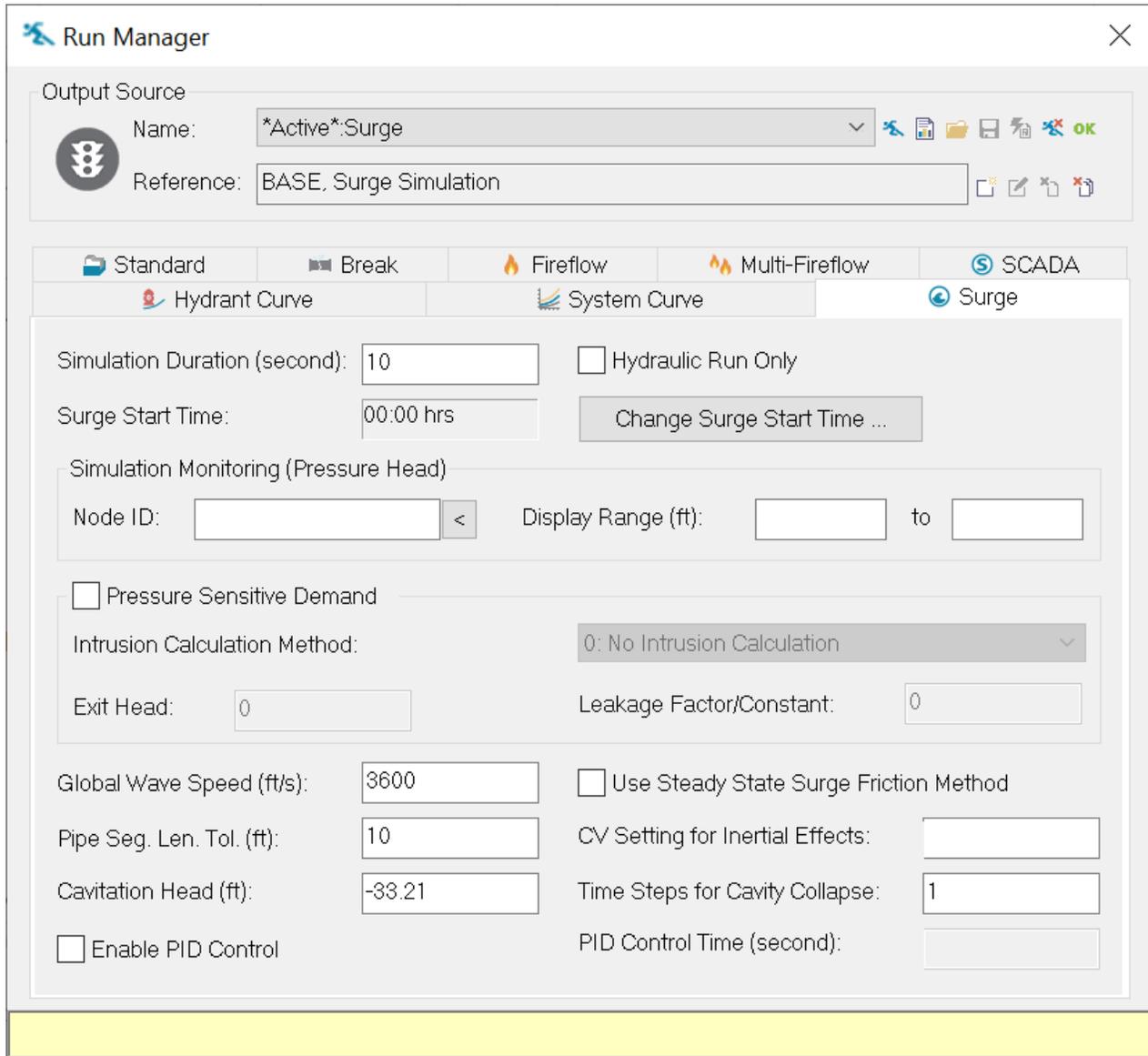# Running a Surge Analysis

Once your system is set up and you are ready to perform a surge analysis, click on the **Run Manager** Run button from the InfoWater Pro ribbon or from the InfoWater Pro menu select **Tools**> **Run Manager**> to open the Run Manager window shown below. The options for Surge analysis are accessed by selecting the tab marked Surge.

To start the Surge analysis, select the **Run** Run button on the Run Manager toolbar. To display the simulation report, use the **Report Manager** Report Manager button on the Run Manager toolbar. Choose the Surge tab in the Run Manager dialog box as shown below.

Surge Simulation Options:

Global Wave Speed

This field sets up the wave speed to be used for pipes if the wave speed for a specific pipe has not be explicitly set. The Wave Speed Calculator can assist you in determining a reasonable value for this field.

Pipe Segment Length Tolerance

In order to facilitate a simplified system analysis, the program may attempt to adjust pipe lengths by up to the value provided in this blank. Using a small number (like 1 foot) may cause the analysis to take an exceptionally long time to run. A value of 10 feet (3.3 Meters) - 50 feet (16.5 Meters) is typically used.

Surge Start Time

The time at which the surge event will be simulated.

Cavitation Head

This field sets the value at which the fluid you are using will cavitate. For water this value is typically around -33 ft or -10 m.

Cavitation

Although water column separation and collapse is not common in large water distribution networks, it can have a significant effect on the transient behavior and this effect must be considered. Cavitation in water distribution systems occurs when the local pressure is decreased to the value of the vapor pressure at the ambient temperature. All the gases within the water are released, the water starts to evaporate, and pockets of vapor appear. Except for large pipelines, the low pressure seldom poses a problem and does not normally threaten the structural integrity of the piping system. What does cause problems is the collapse of the vapor cavity when the water columns rejoin at high speed producing a large pressure surge. In this case, both vacuum and strong pressure surges are present which may result in substantial damage. This problem is most common following a pump trip in a system pumping to an elevated storage tank. If the water column separates downstream from the pump, the elevation difference will eventually cause a cavity collapse and, sometimes, a very large pressure surge. The best design is one which prevents negative pressures and the formation of a vapor cavity.

InfoSurge can simulate water column separation and collapse with time and space to allow the user to assess the potential consequences and the need for remedial surge protection devices. The occurrence of cavitation due to low pressures that fall below vapor pressure and the associated growth and decay of cavity pockets are automatically computed and monitored. A vapor pocket can form on either or both sides of a network component (e.g., pipe junction, pump) if the pressure drops below the vapor pressure. The growth of the cavity (vapor cavity volume) is determined based on the magnitude of the velocity of the liquid adjacent to the cavity and the time over which given conditions persist. Subsequent actions can accelerate the growth of the vapor cavity or can produce a condition that causes a net flow toward the network component and the subsequent collapse of the vapor pocket. A negative pressure wave impinging on a vapor cavity will accelerate its growth while a positive pressure wave will decrease the growth rate and may initiate collapse of the vapor pocket. Significant pressure surges can be produced upon collapse of a vapor pocket and these are calculated based on the net flow velocity in the line (toward the cavity) just prior to the collapse. InfoSurge tracks the growth or collapse of the vapor cavity at each time step during the transient simulation so it can be determined whether or not a vapor cavity will be present when the next action takes place. This monitoring process continues until the end of the simulation period is reached.

Use Steady Date Surge Friction Method:

When the option is checked on, the steady state surge friction method is used; otherwise, the dynamic surge friction method is used. The default method is the dynamic surge friction method. The resistance is calculated based on the initial flow and pressure drop for the steady state method; while the resistance is evaluated at each time increment for the dynamic method.

CV Setting for Inertial Effect:

This allows you to incorporate inertial effects into the modeling of check valve, in the case that check valves are opening and closing repeatedly. CV Setting for Inertial Effects is a number between 0 and 1. The default is 0 and will result in no inertial effects.

Setting of 0 indicates there is no inertial effects. The check valve will operate solely based on flow direction.

Setting of 1 indicates there is huge inertial effects. The check valve will not operate (always open) no matter what flow direction changes.

Setting of 0.5 indicates there is certain inertial effects. When the valve is closing and the valve open ratio is smaller than 0.5, the valve will continue to close, no matter how the flow direction changes.

Time Step for Cavity Collapse:

Time Step for Cavity Collapse is an integer number representing the number of time increments for complete collapse of a vapor cavity. The default is 1, implying that the cavity collapses in one time increment. The purpose of this setting is to "soften" the effects of cavity collapse.

Enable PID Control:

When the option is checked on, PID control is enabled; otherwise, PID control is disabled.

PID Control Time:

PID Control Time is the time step to evaluate PID input/output and a number larger than zero.

Simulation Run Duration

This field allows you to set the amount of time that will be simulated in the surge model. A typical value is 6 to 8 times the time it takes the transient to propagate to the most remote part of the system.

Change Surge Start Time

Press to select the time at which the surge event will be simulated.

Hydraulic Run Only

Selecting this option will cause only the initial steady state analysis to be run and not the complete surge simulation. Click the run icon to run the analysis.

Pressure Sensitive Demand

This causes all demands in the system to vary with the difference in the pressure in the pipe and the exit head.
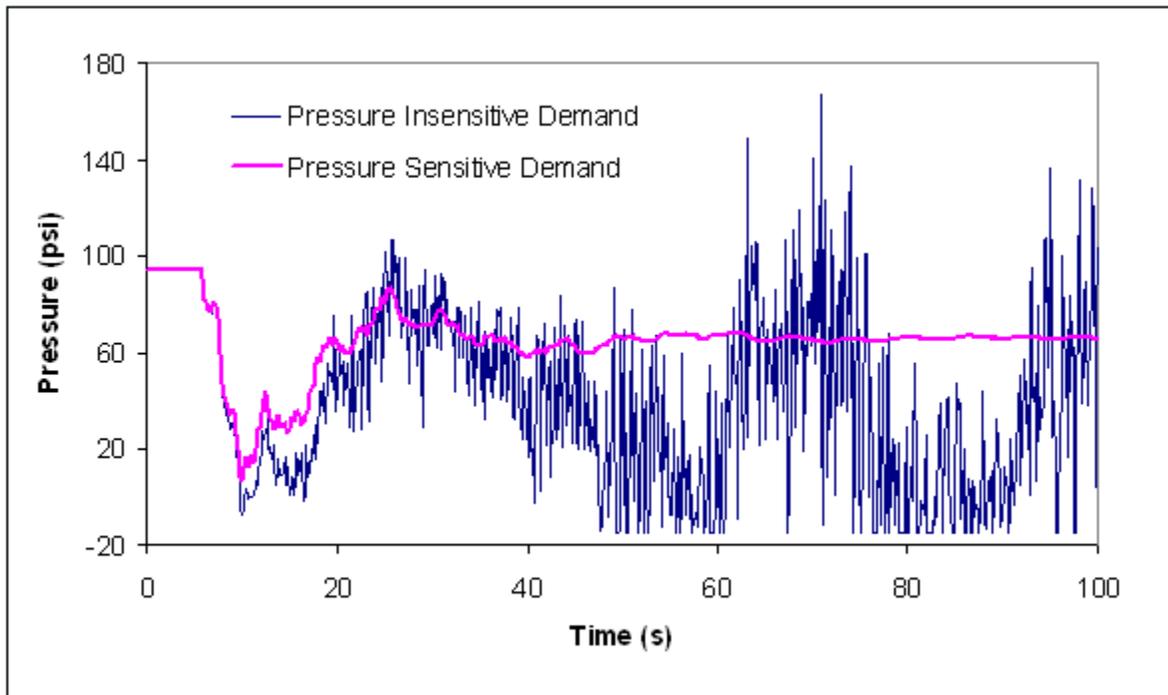
Pressure Sensitive Demand

One of major difficulties in a water distribution system modeling is water usage or demand, which continuously varies for many reasons. In order for a transient simulation to accurately reflect system dynamics, these demand fluctuations should be incorporated into the model; but, at least over short intervals, demands are typically modeled as constant, independent of both pressure and time. Especially considering surge characteristics: the fine time step of calculation and rapid head fluctuation, the accurate representation of demand is crucially important to provide an accurate transient modeling result.

InfoSurge has a feature of pressure sensitive demand based on the orifice relation ($Q = Cv \cdot [dP]0.5$). This feature can be applied by clicking Pressure Sensitive Demand in the Run Manager as shown below. Otherwise, demands remain constant during the transient. System demand are usually best modeled using this type of demands so the demands will response to pressure changes in the pipe system.

This graph below presents an example of difference between pressure sensitive demand and pressure insensitive demand.

Exit Head of Pressure Sensitive Demand

This is the pressure that is compared to the pressure in the pipes to determine the variance in demands. Using 0 means atmospheric pressure.

Intrusion Calculation Type

Select between the following:

- No Intrusion Calculation
- Intrusion Calculation with Leakage Factor
- Intrusion Calculation with Leakage Constant
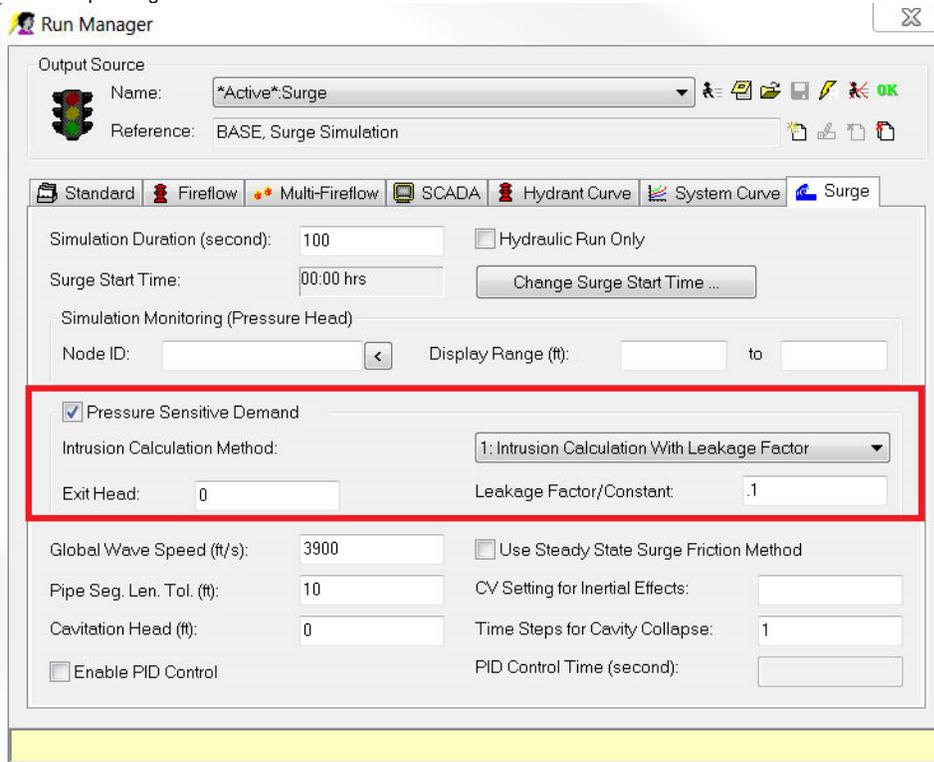
Intrusion

An objectionably low-pressure transient event, arising for example from a power failure or from an intermittent/interrupted supply, has the potential to cause the harmful intrusion of untreated, possibly contaminated groundwater into pipes with leaky joints or cracks as the risk of backflow increases significantly with reduced pressure. This is especially important in systems with pipes below the water table. Pathogens or chemicals in close proximity to the pipe can become a potential contamination source. In the event of a large intrusion of pathogens, the chlorine residual normally sustained in drinking water distribution systems may be insufficient to disinfect contaminated water, which can lead to damaging health effects.

InfoSurge automatically calculates the volume of intrusion due to objectionably low or negative system pressures. This will help you determine the extent of contamination and evaluate the most effective response strategies. After selecting pressure sensitive demand, two intrusion calculations are available (Leakage Factor and Constant). The "Leakage Constant" is defined using the relation Q(leak) = Lc*(pressure difference)^0.5. This is same concept as the orifice equation. For example, if Lc = 0.1, a leak of 0.1 gpm with a pressure difference of 1 psi occurs. The "Leakage Factor" is defined as the percent of leakage in the distribution system. For example, a leakage factor of 0.1 means that the leakage is 10% of the demand. From this factor, a leakage constant is calculated for each demand junction, which will discharge 10% of the flow at the initial pressure. For example, at a junction where the demand is 10 gpm at 64 psi (pressure difference) assume that 1 gpm (10% of the demand) is leaking through an orifice, the leakage constant is computed as Lc = 1/(64)^0.5 = 0.125.

The following presents the example of intrusion modeling. The intrusion (volume) is estimated based on either the leakage constant or the leakage factor assigned when the pressure gradient is negative (Pexit > Pline), where Pexit is the exit pressure and Pline is the pressure inside the pipeline system. The "Intrusion Integral" is defined as the negative area under the time plot of the curve of dP(Pexit – Pline)^0.5. For example, if a node experiences the negative pressure of 4 psi for 6 second (0.1 minute), the intrusion integral is 0.2 [= 0.1*(4)^0.5]. Therefore, the estimated intrusion volume is calculated by multiplying the intrusion integral by a leakage constant. For example, if the node has Lc = 0.1, the intrusion volume through the node is 0.02 gal (=0.1*0.2).

Example - Run intrusion modeling considering 10% of initial base demand is leak.

1. Check the box of Pressure Sensitive Demand and assign Exit Head. Select a intrusion calculation type (leakage factor or constant) and assign the corresponding valve.

2. After running a surge analysis, Output Report (see the following) presents two more report regarding intrusion (Surge Node Intrusion & Surge Intrusion Summary).
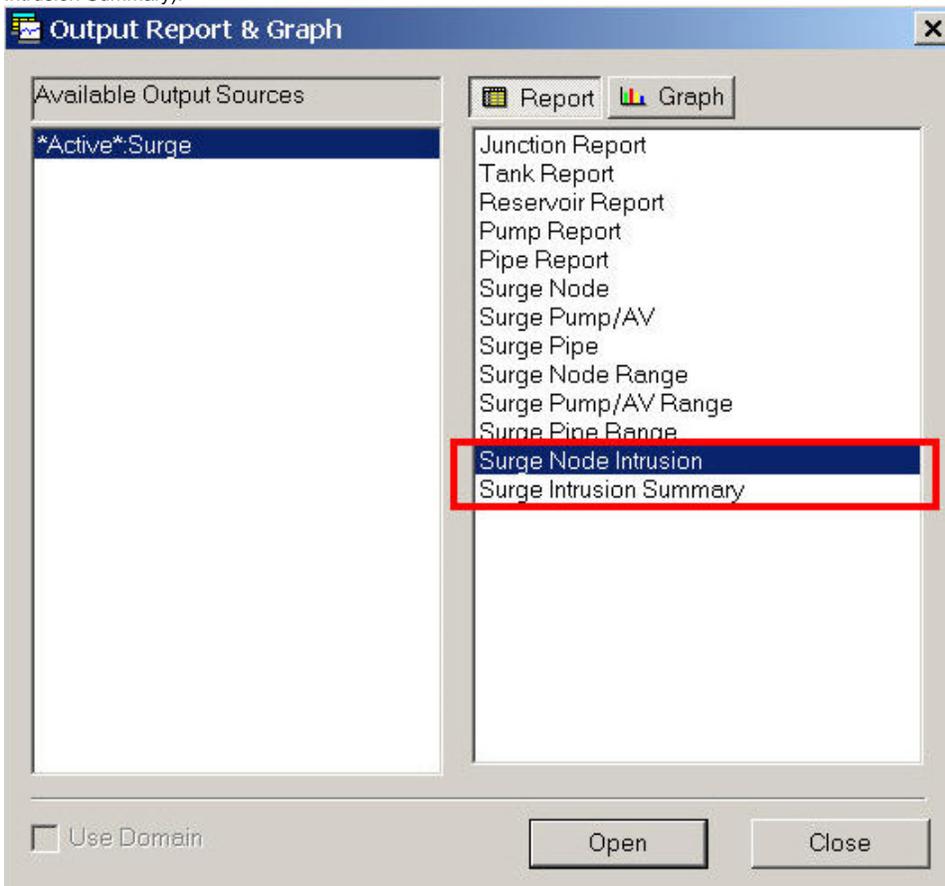
3. The report of Surge Node Intrusion presents the resulting values of intrusion integral and intrusion volume in each node.

		ID	Intrusion (gallon)	Intrusion Integral
1	☐	10	0.00	0.00
2	☐	11	2.44	1.54
3	☐	12	0.00	0.00
4	☐	13	0.00	0.00
5	☐	21	1.67	1.06
6	☐	22	0.65	0.41
7	☐	23	0.00	0.00
8	☐	31	0.00	0.00
9	☐	32	0.00	0.00
10	☐	9	0.00	0.00
11	☐	2	0.00	0.00

4. The report of Surge Intrusion Summary presents the total volume of intrusion.

		Description	Item
1	☐	Nodes with Integral = 0.0	7.00
2	☐	Nodes with Integral 0.0 - 0.1	1.00
3	☐	Nodes with Integral 0.1 - 0.2	0.00
4	☐	Nodes with Integral 0.2 - 0.3	0.00
5	☐	Nodes with Integral 0.3 - 0.4	0.00
6	☐	Nodes with Integral 0.4 - 0.5	1.00
7	☐	Nodes with Integral 0.5 - 0.6	0.00
8	☐	Nodes with Integral 0.6 - 0.7	0.00
9	☐	Nodes with Integral 0.7 - 0.8	0.00
10	☐	Nodes with Integral 0.8 - 0.9	0.00
11	☐	Nodes with Integral 0.9 - 1.0	0.00
12	☐	Nodes with Integral > 1.0	2.00
13	☐		
14	☐	Total Intrusion (gallon)	4.76
15	☐	Total Intrusion Time (seconds)	63.84

Leakage Factor/Constant

The Leakage Constant is defined using the relation $Q(leak) = Lc*(pressure difference)^{0.5}$. This is same concept as the orifice equation. For example, if Lc = 0.1, a leak of 0.1 gpm with a pressure difference of 1 psi occurs.

The Leakage Factor is defined as the percent of leakage in the distribution system. For example, a leakage factor of 0.1 means that the leakage is 10% of the demand. From this factor, a leakage constant is calculated for each demand junction, which will discharge 10% of the flow at the initial pressure. For example, at a junction where the demand is 10 gpm at 64 psi (pressure difference) assume that 1 gpm (10% of the demand) is leaking through an orifice, the leakage constant is computed as $Lc = 1/(64)^{0.5} = 0.125$.

Monitoring Node ID

Enter the node ID to be monitored and displayed in the Simulation Progress view. Use to **Browse** button to locate the node on the map display.

Monitoring Pressure Head Range

Pressure Head Range during simulation. Input the Minimum and Maximum head range to be displayed in the simulation progress view.

Pressure Head (ft) at Node: 5
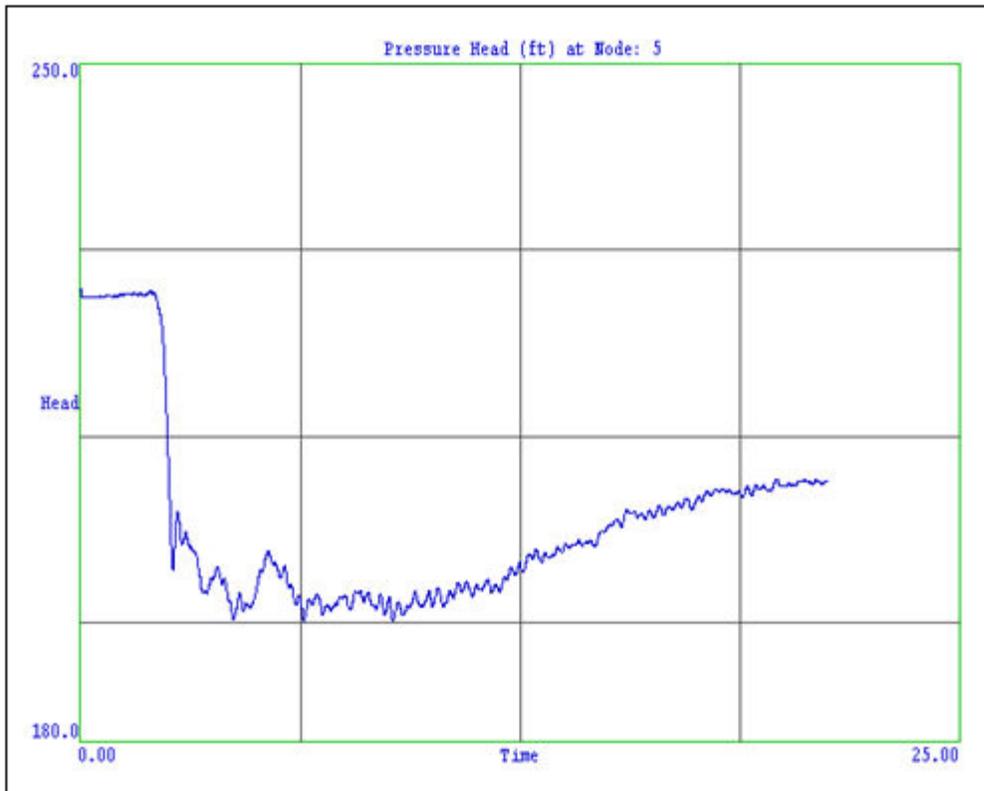
Simulation Progress View

Upon completion of the surge analysis, you can find a summary of possible error messages.

Error Codes & Messages

The following is a list of the InfoSurge network simulator error messages and suggested solutions. When one or more of these errors occur, the Run Status Indicator (stop-light) on the Run Manager dialog box indicates red. It is possible for several of these conditions to exist at the same time.

Format: Error Number - Description

Go To Error Levels - 2000, 3000, 4000, 5000, 6000

Model Run Level: 2000s

General Errors: 2000s series

2001 - Surge hydraulic run module not initialized

2002 - Module memory error

2003 - Unable to output basic model network data

Hydraulic run errors: 2100s series

2101 - Unable to initialize hydraulic solver

Surge Data Level: 3000s

Base level data errors: 3000s

3001 - Unable to open Surge input file

3002 - Surge data memory error

Counter level data errors: 3100s

3101 - Surge pipes with wave speed data exceed network pipes

3102 - Surge pumps exceed network pumps

3103 - Active Valves exceed network valves

3104 - Surge Protection Devices exceed network junctions

Change data errors: 3200's

3211 - Invalid Surge Change data

SPD data errors: 3300s, output data line

3301 - Invalid Side Discharge Orifice data

3302 - Invalid Open Surge Tank data

3303 - Invalid One Way Open Tank data

3304 - Invalid Closed Surge Tank data

3305 - Invalid Bladder Surge Tank data

3306 - Invalid Rupture Disk data

3307 - Invalid Pressure Relief Valve data

3308 - Invalid Surge Anticipation Valve data

3309 - Invalid 1/2 Stage Air Vacuum Valve data

3310 - Invalid 3 Stage Air Vacuum Valve data

Time/option data errors: 3400s

3401 - Invalid time step for Surge hydraulic run

Organized Data Errors: 4000s

Surge model data errors: 4100s

4111 - Surge model does not support Chezy-Manning formulation

4112 - Invalid Check Valve definition for surge pipe

4113 - Invalid multi-pipe connections at pump

4114 - Invalid multi-pipe connections at active valve

4115 - Invalid multi-pipe connections at surge protection device

4116 - Invalid demand allocation to surge protection device

4117 - Invalid pressure demand definition to surge protection device

Surge/hydraulic model data errors: 4200s

4211 - Invalid fixed head node connection in hydraulic model

Create Surge File Data Errors: 5000s

TFL file data errors: 5100s

5101 - Unable to open Surge TFL file

5111 - Unable to output link data to Surge TFL file

5112 - Unable to output node data to Surge TFL file

SIC data errors: 5200s

5201 - Unable to open Surge SIC file

5211 - Unable to output system data to Surge SIC file

5212 - Unable to output pipe data to Surge SIC file

5213 - Unable to output component data to Surge SIC file

5214 - Unable to output surge protection device data to Surge SIC file

5215 - Unable to output pump data to Surge SIC file

5216 - Unable to output junction data to Surge SIC file

5217 - Unable to output fixed head node data to Surge SIC file

5218 - Unable to output bypass line data to Surge SIC file

5219 - Unable to output surge tank data to Surge SIC file

5220 - Unable to output surge valve data to Surge SIC file

5221 - Unable to output check valve data to Surge SIC file

5222 - Unable to output surge change data to Surge SIC file

5223 - Unable to output other surge data to Surge SIC file

IDS data errors: 5300s

5301 - Unable to open Surge IDS file

IDX data errors: 5400s

5401 - Unable to open Surge IDX file

5402 - Unable to output Surge IDX file data

LIM data errors: 5500s

5501 - Unable to open Surge LIM file

5502 - Unable to output Surge LIM file data

LIM data errors: 5600s

5601 - Unable to open Surge SRG file

5602 - Unable to output Surge SRG file data

CFile: 5700s

5701 - Unable to open CFile file

Surge Run Errors: 6000s

Output network data

6001 - Unable to output Surge run network data

Create DAT file

6101 - Missing Surge run input files

6102 - Missing Surge data generation program file

6103 - Unable to remove Surge .dat file

6104 - Unable to run Surge data generation process

6105 - Unable to create Surge *.dat file