PIPENET®

Leading the Way in Fluid Flow Analysis

SUNRISE

How to Model Valves in PIPENET

It is clear that modelling of items such as valves, control valves, surge relief valves, relief valves, rupture discs and regulators are essential aspects of transient analysis. PIPENET can model all such items. When it comes to valves, the data which is available may be incomplete and often is. PIPENET can model (i) any type of valve from any manufacturer and (ii) even when only partial data about the valve is available.

In this document we are discussing the following points:

1 – General methods and options for modelling valves.

2 – How to model control valves.

3 to 6 – Various pressure regulating devices.

1. Modelling Valves

Valves are modelled using the following basic equation. It can be seen that the valve co-efficient Cv depends on the valve position s.

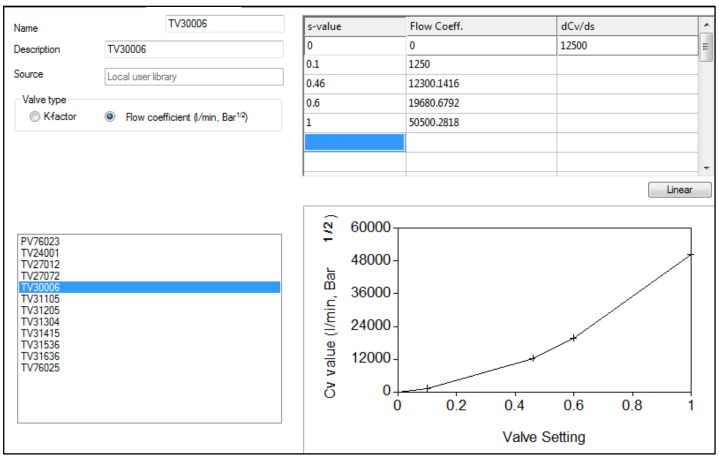
$$P_1 - P_2 = \frac{\rho Q|Q|}{\rho_0 C_{v(s)}^2}$$

There are 4 different ways in which a valve can be modelled depending on what data is available.

1. Full characteristic data for the valve is available:

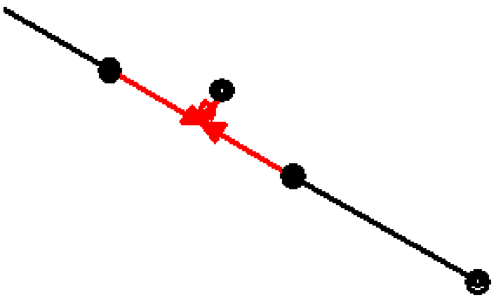
If the curve of how ‘Cv’ changes with the valve position ‘s’ is known as a graph or as a table it can be input into PIPENET library. The dialog box for this is shown below.

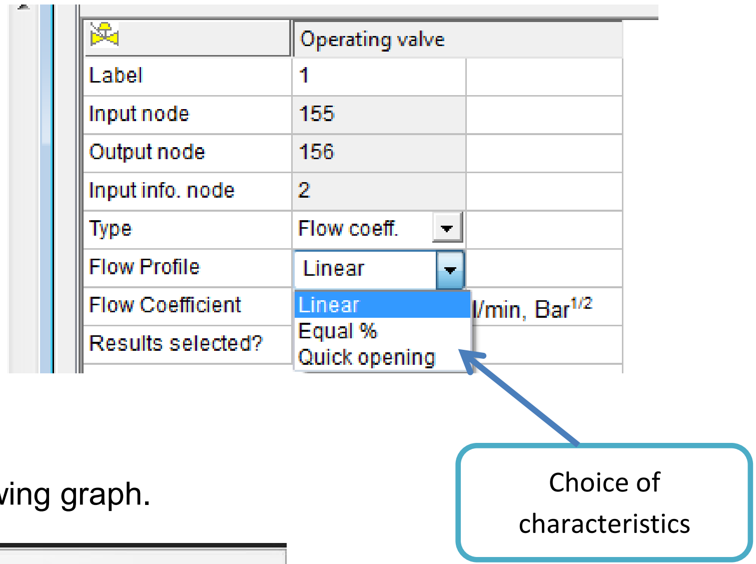
In this dialog box s = 0 means the valve is fully closed and s+ 1 means the valve is fully open.



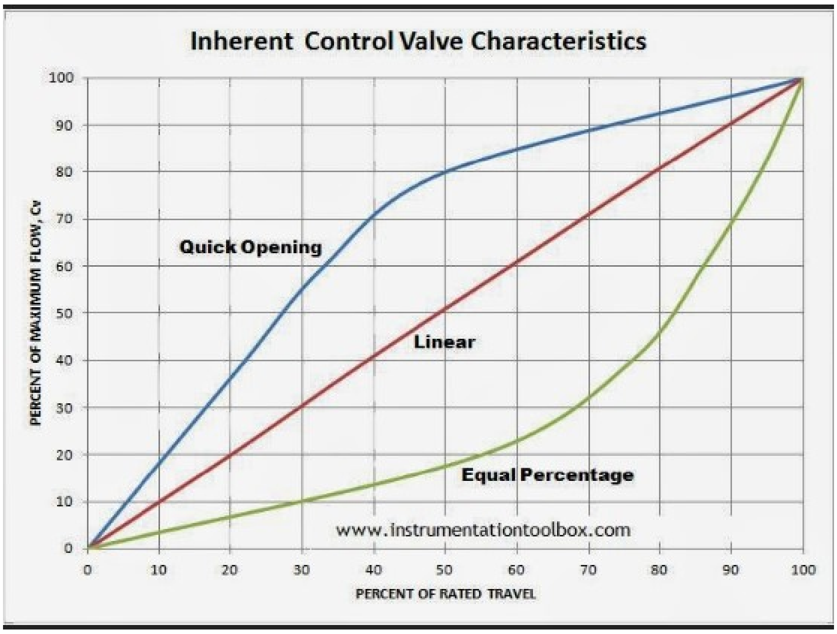
2. Fully open Cv is available:

If the manufacturer can only provide the Cv when the valve is fully open the following method can be used. The user can specify the Cv when the valve is fully open and select from one of the standard curves.





The flow profile is taken from the following graph.



3. Standard valve types:

If the manufacturer's data for the valve is not available, PIPENET can estimate its characteristics.

Built-in Standard Valve Types

Seven typical valves are available to the user. These can be chosen from gate valve, globe valve, butterfly valve, ball valve, diaphragm valve, angle valve and Y-valve. One or several of the following information is required to calculate the valve k-factor.

Inside diameter: insider diameter of upstream pipe.

Contraction ratio: ratio of valve seat diameter/area to pipe diameter/area, which must be a value between 0 and 1. The default value is 1.0.

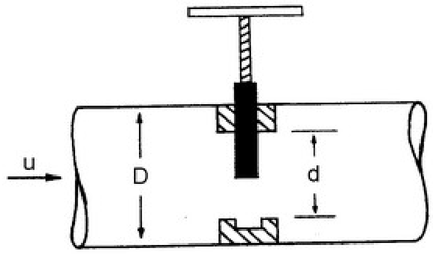
Disc shape: flat plate (default) or lenticular, only required for butterfly valve.

Disc thickness: valve disc maximum thickness, only required for butterfly valve.

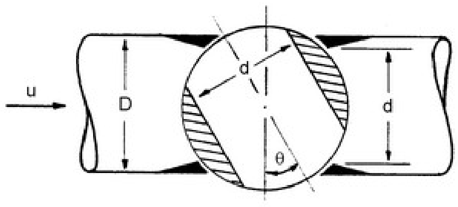
Body material: forged (default) or cast-body, only required for angle valve.

Stem inclined angle: < 50 degree (default) or > 50 degree, only required for Y-valve.

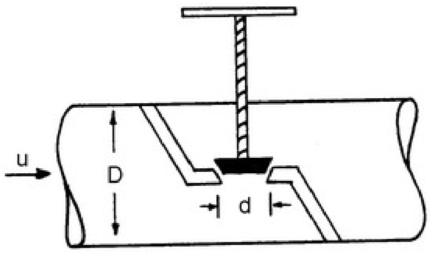
PIPENET can estimate the characteristics for the following valve types:



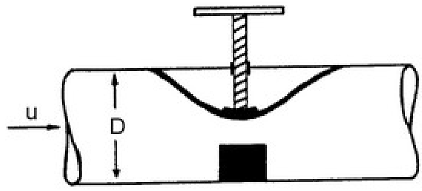
Gate Valve



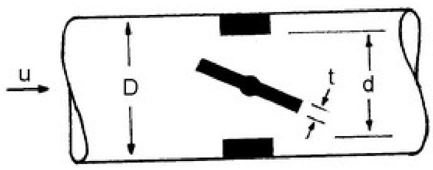
Ball Valve



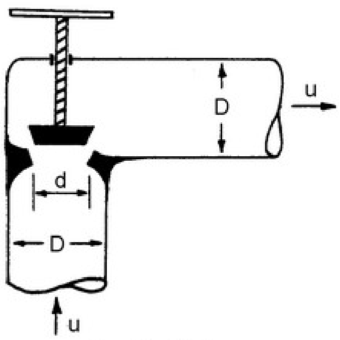
Globe Valve



Diaphragm Valve

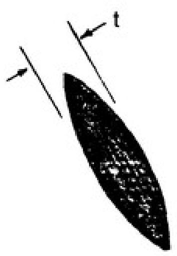


Butterfly Valve

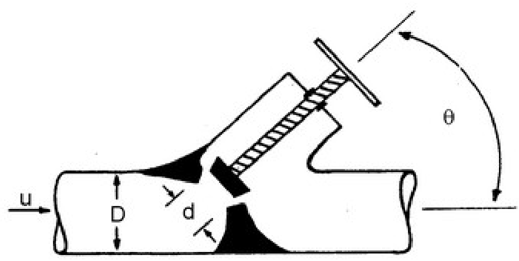


Angle Valve

(a) flat plate disc



(b) lenticular disc



Y-type Valve

4. Non-Operating Valve:

Non-operating valves are modelling using the following equation. Such valves simply give a pressure loss and do not operate during the simulation. They are modelled by using a fixed k-factor.

$$P = \frac{1}{2} k \rho u^2$$

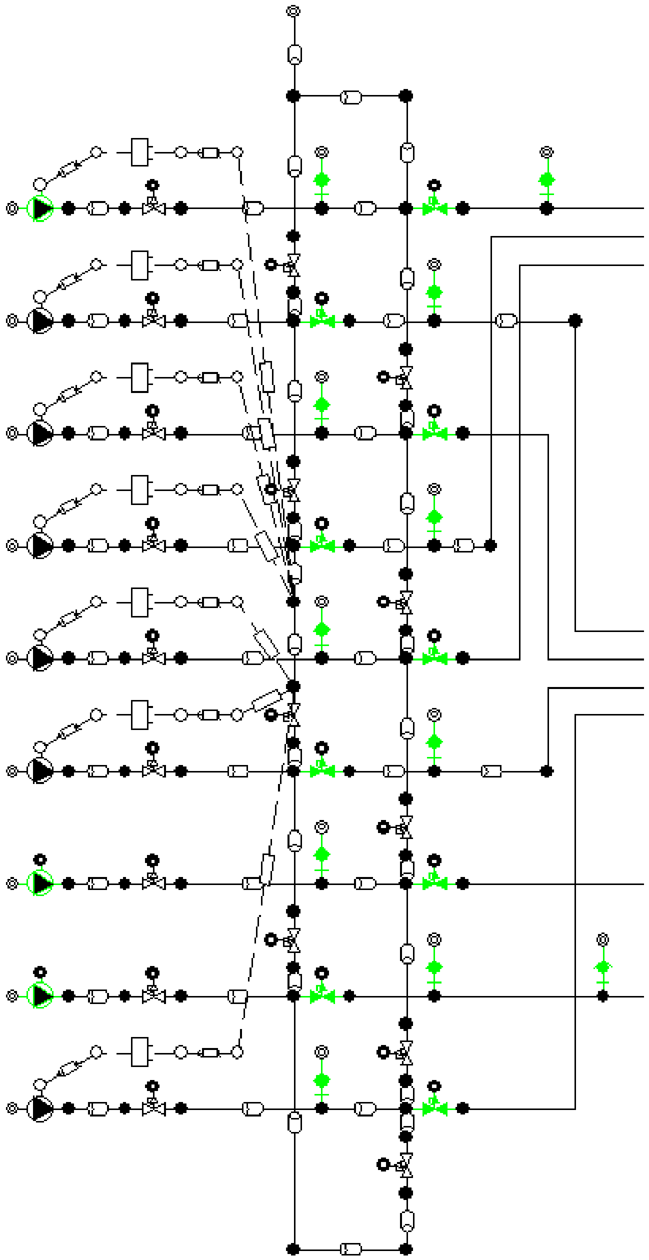
The value of k can be obtained from one of the following ways.

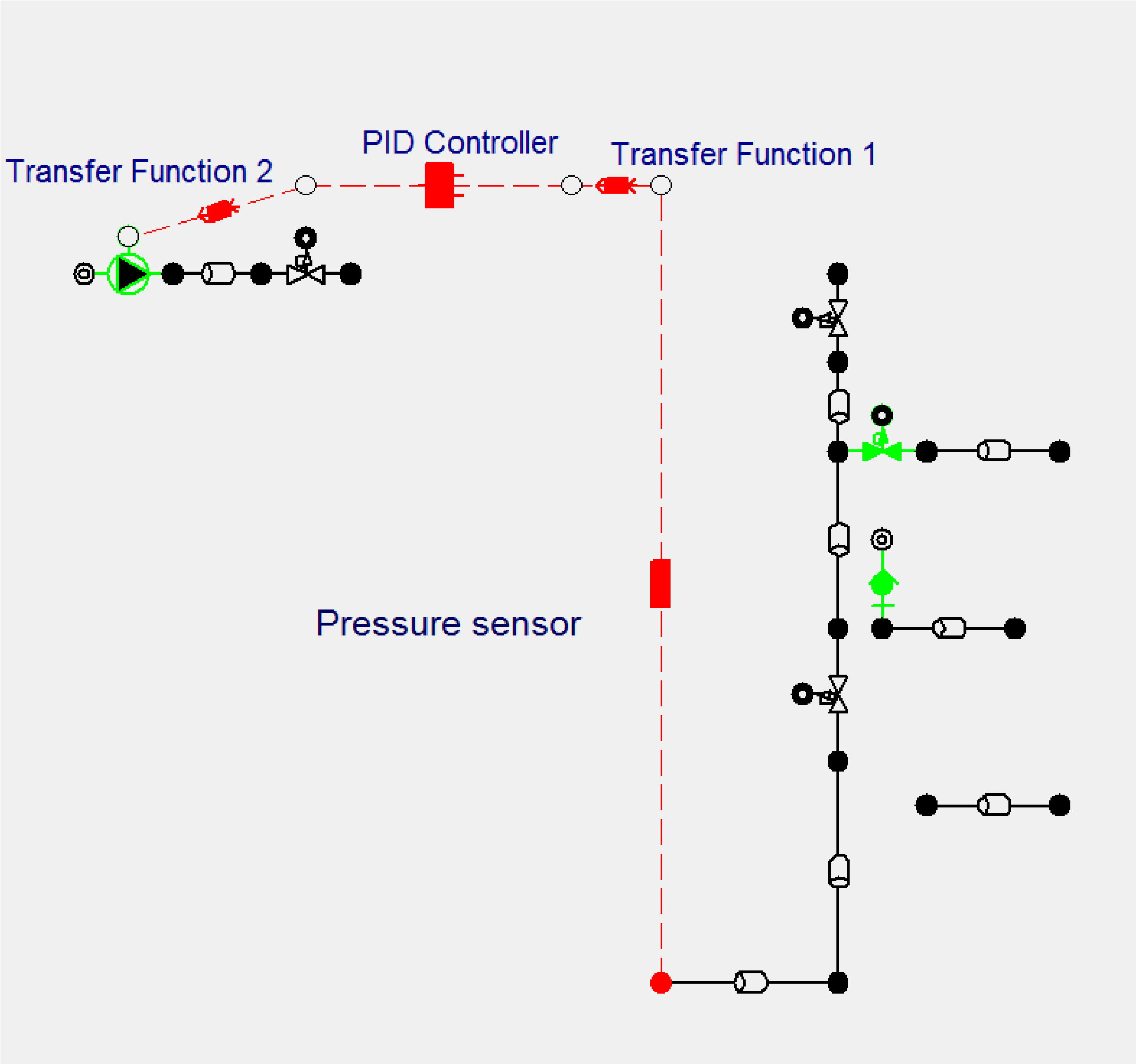
(i) Pick it up from the extensive built-in library in PIPENET
(ii) PIPENET can calculate it given required parameters
(iii) It can be input by the user

2. Control Valves (Pressure, Flow, Differential Pressure), Control of Variable Speed Pumps:

In the example below, we consider the speed control of a variable speed pump. The same principle applies to control valves and other control items. It is possible to use PID control or Cascade control in PIPENET.

Pump Speed Control:

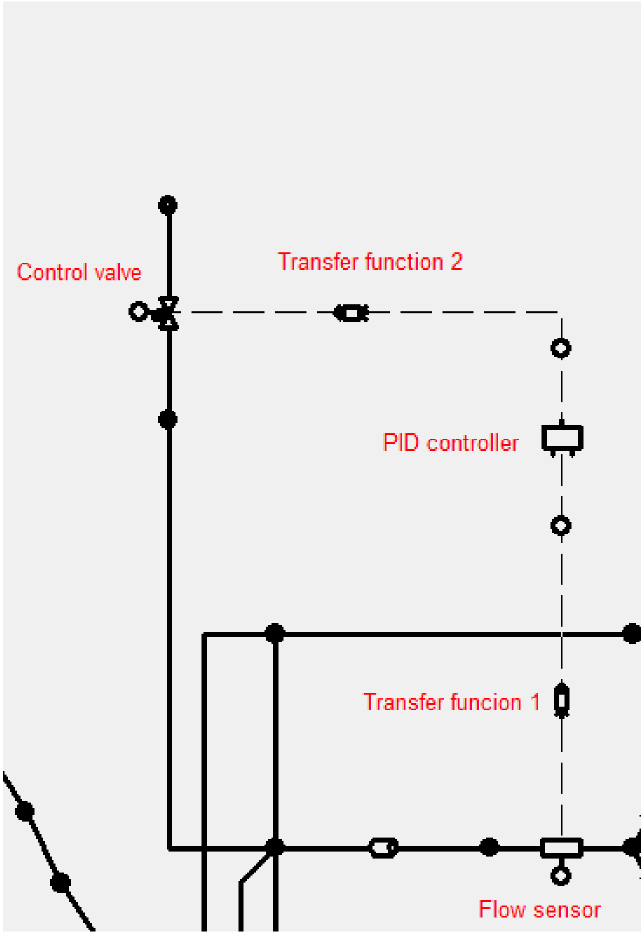




Pressure transients tend to be extremely fast. For this reason, the dynamics of items such as the flow transmitter have been taken into account by this user. In particular the following components form part of the control loop.

- A pressure sensor. It is also possible to use pressure or differential pressure sensors.
- A transfer function (specified to be first order) which models the dynamics of the pressure transmitter. In effect the pressure sensor and the transfer function together model the signal from the physical pressure transmitter.
- A PID controller. In this model the user has considered proportional and integral terms.
- A second transfer function which models the dynamics of the control valve. This represents the response of the control valve to the signal it receives from the PID controller.

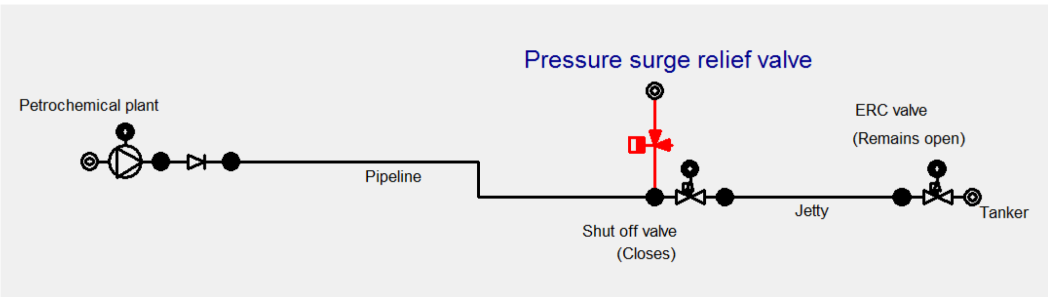
Flow Control Valve:



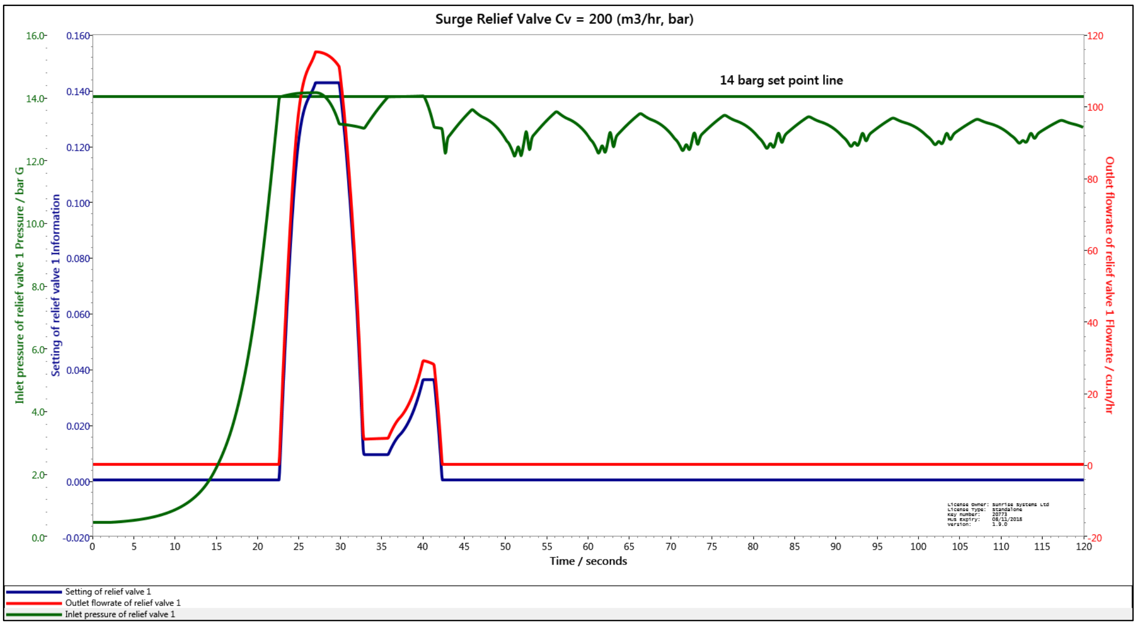
3. Pressure Surge Relief Valve:

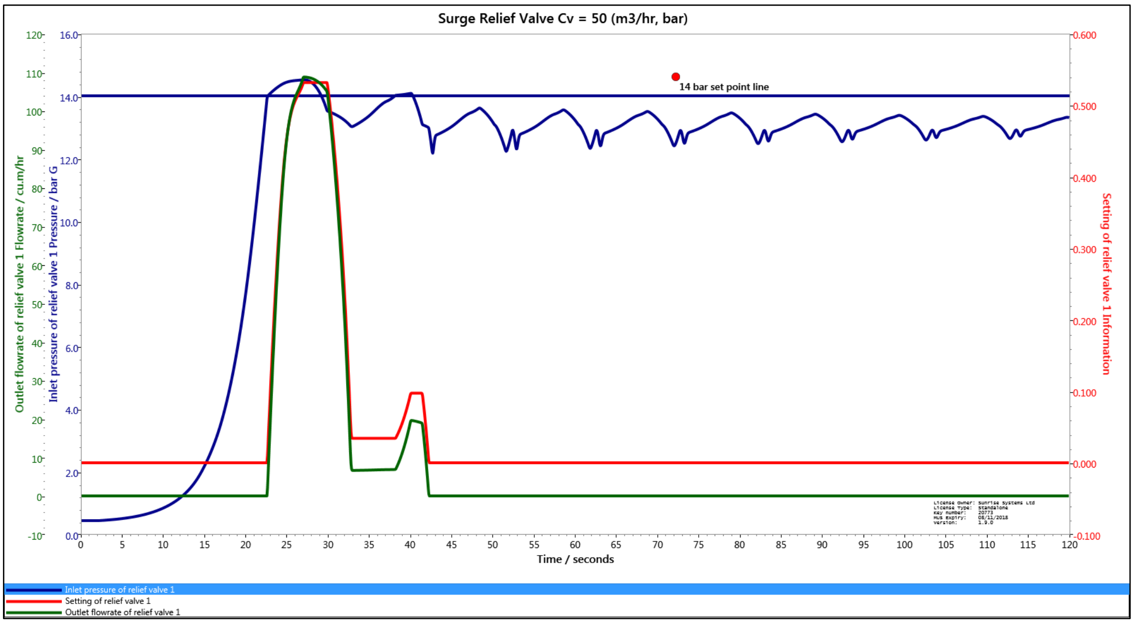
When a system experiences transient pressure surge resulting in a high pressure, it is extremely important for the relief valve to respond quickly. Relief valves which respond in this manner are called pressure surge relief valves and are usually assisted by pressurised nitrogen. Such valves are often used in loading/unloading systems which are essential in LNG plants.

An example of a pressure surge relief valve and its data are shown below.



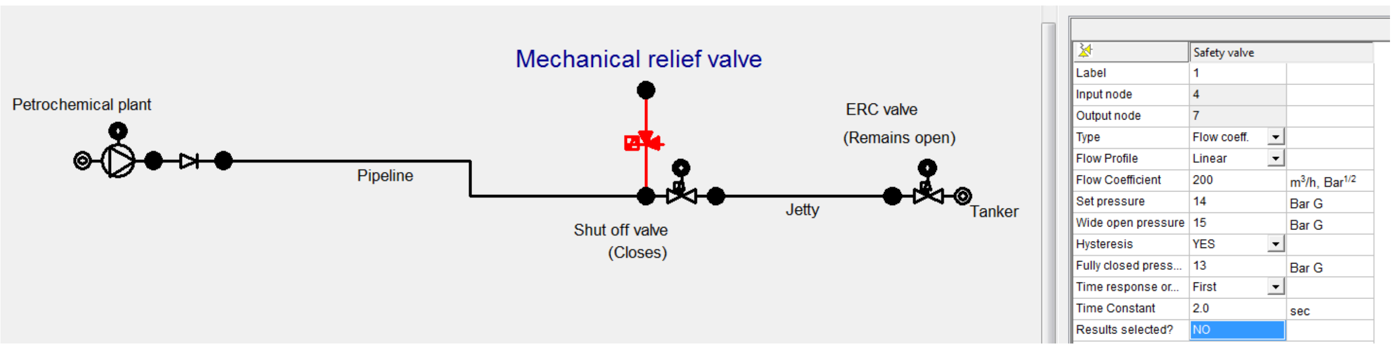
	Liquid surge relief valve	
Label	1	
Input node	4	
Output node	7	
Type	Flow coeff.	
Flow Profile	Linear	
Flow Coefficient	200	m^3/h, $Bar^{1/2}$
Set Pressure	14	Bar G
Wide Open Press...	15	Bar G
Hysteresis	YES	
Fully Closed Pres...	13	Bar G
Results selected?	YES	

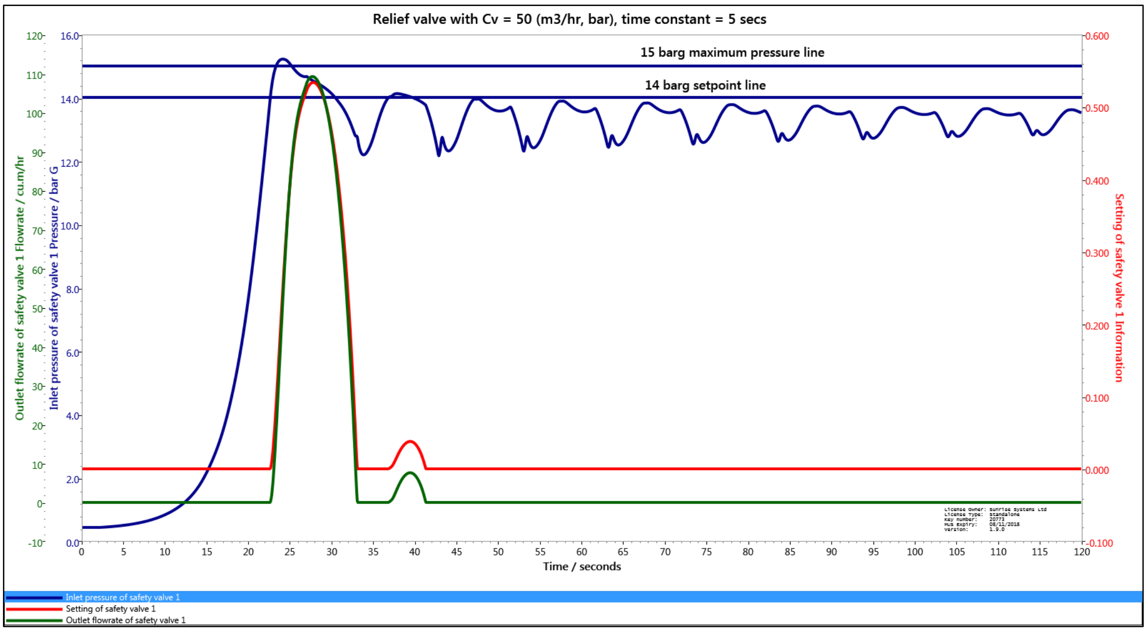




4. Relief Valve:

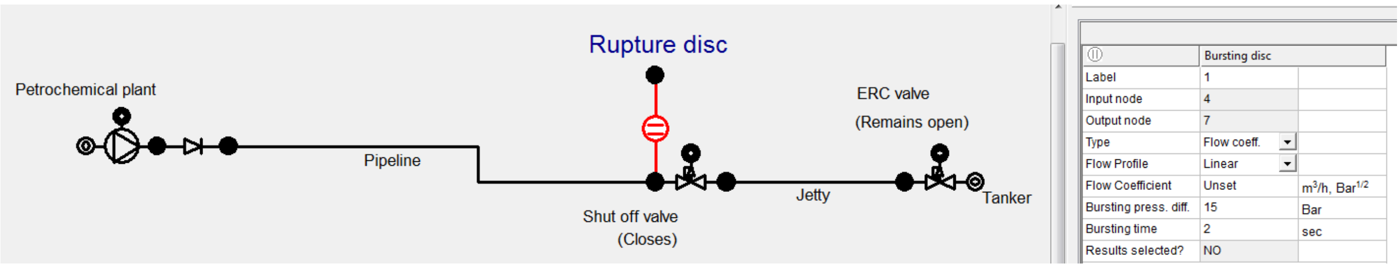
A relief valve is not a very fast acting valve and so the dynamics of its operation is relevant. For this reason, it may not be a good idea to use it as a pressure surge relief valve.



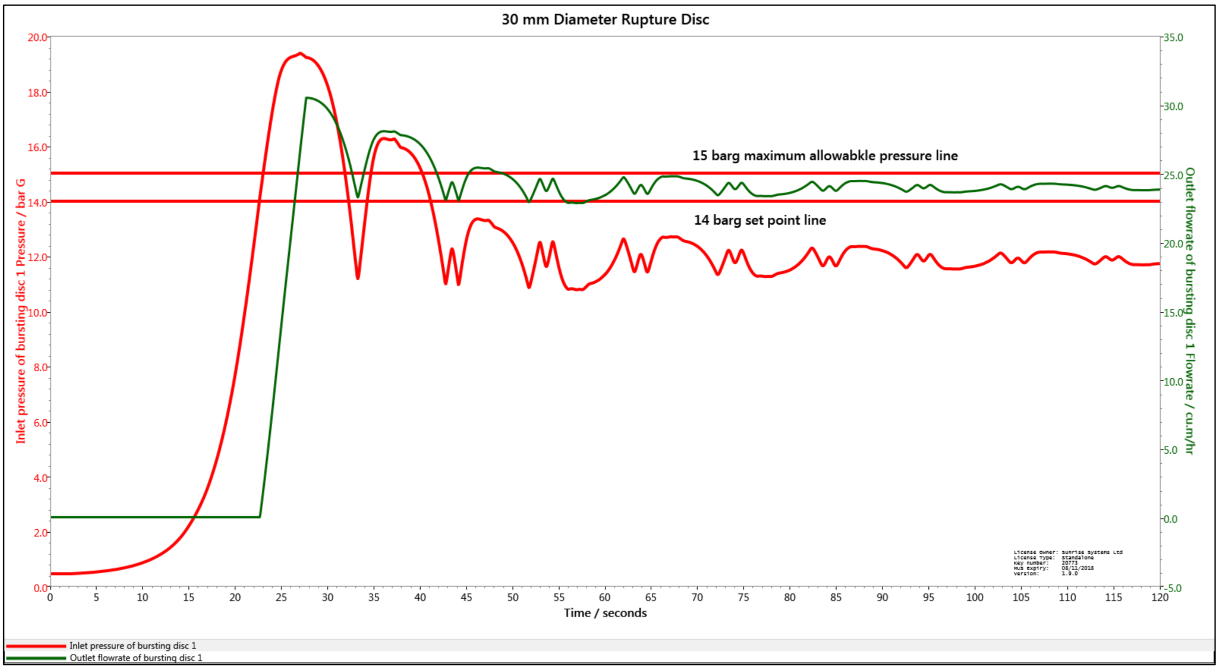


5. Rupture Disc:

This similar to a relief valve except that once it opens it will remain open and will not close again. It is often used because it is cheaper than a relief valve.

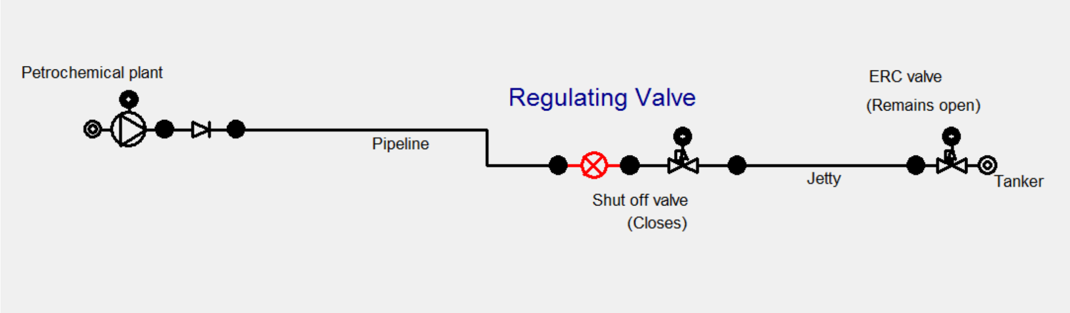


	Bursting disc	
Label	1	
Input node	4	
Output node	7	
Type	Flow coeff.	
Flow Profile	Linear	
Flow Coefficient	Unset	m^3/h, $Bar^{1/2}$
Bursting press. diff.	15	Bar
Bursting time	2	sec
Results selected?	NO	



6. Pressure Regulating Valve:

This can be an upstream or downstream pressure regulating valve. As pressure transients are extremely fast the dynamics of a regulating valve needs to be modelled.



	Regulator valve	
Label	1	
Input node	4	
Output node	7	
Type	Flow coeff.	
Flow Profile	Linear	
Flow Coefficient	500	m^3/h, $Bar^{1/2}$
Close pressure	14	Bar G
Open pressure	15	Bar G
Time response or...	First	
Time constant	2	sec
Type	Upstream	
Results selected?	NO	

Closing Remarks:

In this document we have shown that PIPENET has a very comprehensive range of models for valves. Virtually every situation in which valves are used can be modelled in PIPENET. Moreover, even if only partial data for a valve is available PIPENET can be used effectively.