FLUIDFLOW

PRESSURE DROP SOFTWARE

Sizing Pressure Relief Valves

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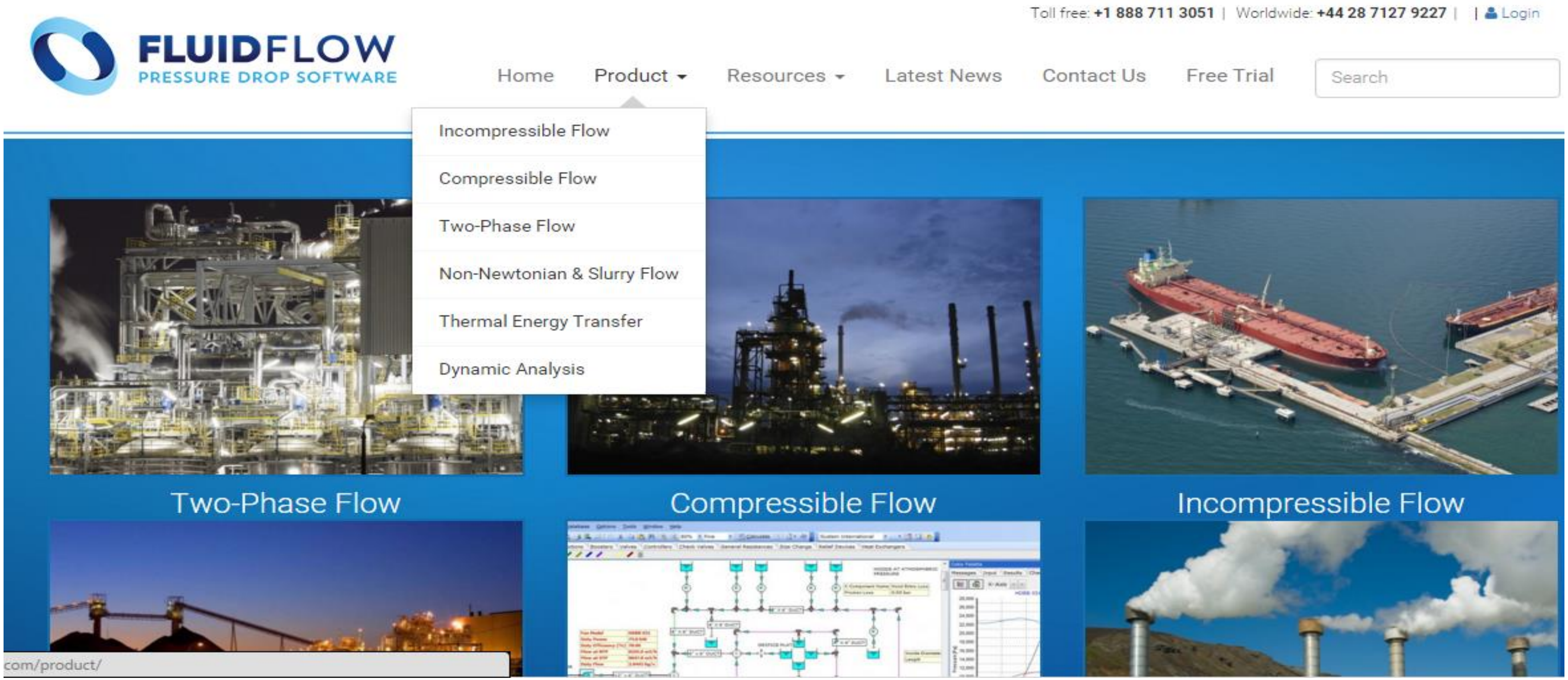
FluidFlow

FluidFlow is a modular product which means, you only purchase the modules which are of interest to you. As it's modular, you can model different fluids and phase state within one product.



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Automatic Equipment Sizing

FluidFlow allows engineers to automatically size a wide range of equipment items as outlined in Table 1.

Element	Design Sizing Criteria
Pipes	Design Velocity Design Pressure Gradient Economic Velocity
Pumps	Flow Rate Pressure Rise
Fans	Flow Rate Pressure Rise
Control Valves	Pressure or Flow Rate
Orifice Plates (Thin & Thick)	Flow Rate Pressure Loss
Venturi Tube	Flow Rate Pressure Loss
Nozzles	Flow Rate Pressure Loss
Relief Valves & Bursting Discs	API & ISO Standards

If you have a query on the above or have a piping system you wish to model, we would be happy to help.

Sizing Pressure Relief Valves

Why do we need to size relief valves ???

- ***To determine the correct discharge area of the relief device require to protect process equipment.***

- ***To determine/evaluate the diameter of the associated inlet and outlet piping.***

- ***Consider fluid phase-state at inlet and outlet piping.***

- ***Ensure required mass flow rate can be passed through relieving stream and evaluate pressures.***

Sizing Pressure Relief Valves

We shall consider three examples as follows:

1. Hydrocarbon System (API Standard).
2. Two-Phase Propane System (API Standard).
3. Ethylene Relief System (ISO Standard).

Note, its important to consider that FluidFlow solves safety relief valves along with connected pipework whereas worked example calculations in the public domain often consider the relief valve only, i.e. in isolation of any connected pipework.

We may therefore occasionally notice a subtle difference in results when making a comparison.

1) Hydrocarbon System (API Standard).

This example case is taken from API Standard 520 Part I - Sizing & Selection.

The following relief requirements have been provided:

a) Required hydrocarbon vapor flow, *W*, caused by an operational upset of 53,500 lb/hr (24260 kg/h).
b) The hydrocarbon vapor is a mixture of butane (C4) and pentane (C5). The molecular weight of vapor, *M*, is 65.
c) Relieving temperature, *T*, of 627 R (167°F) (348 K).
d) Relief valve set at 75 psig (517 kPa) which is the design pressure of the equipment.
e) Back pressure of 14.7 psia (0 psig) (101.3 kPaa) (1 ATM).

Hydrocarbon System (API Standard) (cont'd).

In this example the following data was derived (described in API Standard 520):

a) Permitted accumulation of 10 %.
b) Relieving pressure, P1, of 75 x 1.1 + 14.7 = 97.2 psia (670 kPa).
c) Calculated compressibility, *Z*, of 0.84.
d) Critical flow pressure of 97.2 x 0.59 = 57.3 psia (42.6 psig) (395 kPaa). Note, since the back pressure (0 psig) is less than the critical flow pressure (42.6 psig), the relief valve sizing is based on the critical flow equation.

e) *Cp/Cv* = *k* of 1.09. From Table 8 of API Standard 520, C = 326.
f) Capacity correction due to back pressure, K_b of 1.0.
g) Capacity correction for rupture disk, K_c of 1.0.

Hydrocarbon System (API Standard) (cont'd).

The size of a single pressure relief valve is derived from Equation 3.2 of the API Standard 520 as follows;

$$A = \frac{W}{CK_d P_1 K_b K_c}\sqrt{\frac{TZ}{M}}$$

where;

A is the required effective discharge area of the device, in² (mm²).
W is the required flow through the device, lb/hr (kg/h).
C is the coefficient determined from an expression of the ratio of the specific heats ($k = C_p/C_v$) of the gas or vapor at inlet relieving conditions.
K_d is the effective coefficient of discharge.
P_1 is the upstream relieving pressure, psia (kPaa). This is the set pressure plus the allowable overpressure plus atmospheric pressure.
K_b is the capacity correction factor due to back pressure. This can be obtained from the manufacturer's literature or estimated for preliminary sizing from Figure 30 (API Standard 520).

Hydrocarbon System (API Standard) (cont'd).

K_c is the combination correction factor for installations with a rupture disk upstream of the pressure relief valve.

T is the relieving temperature of the inlet gas or vapor, K(°C + 273).

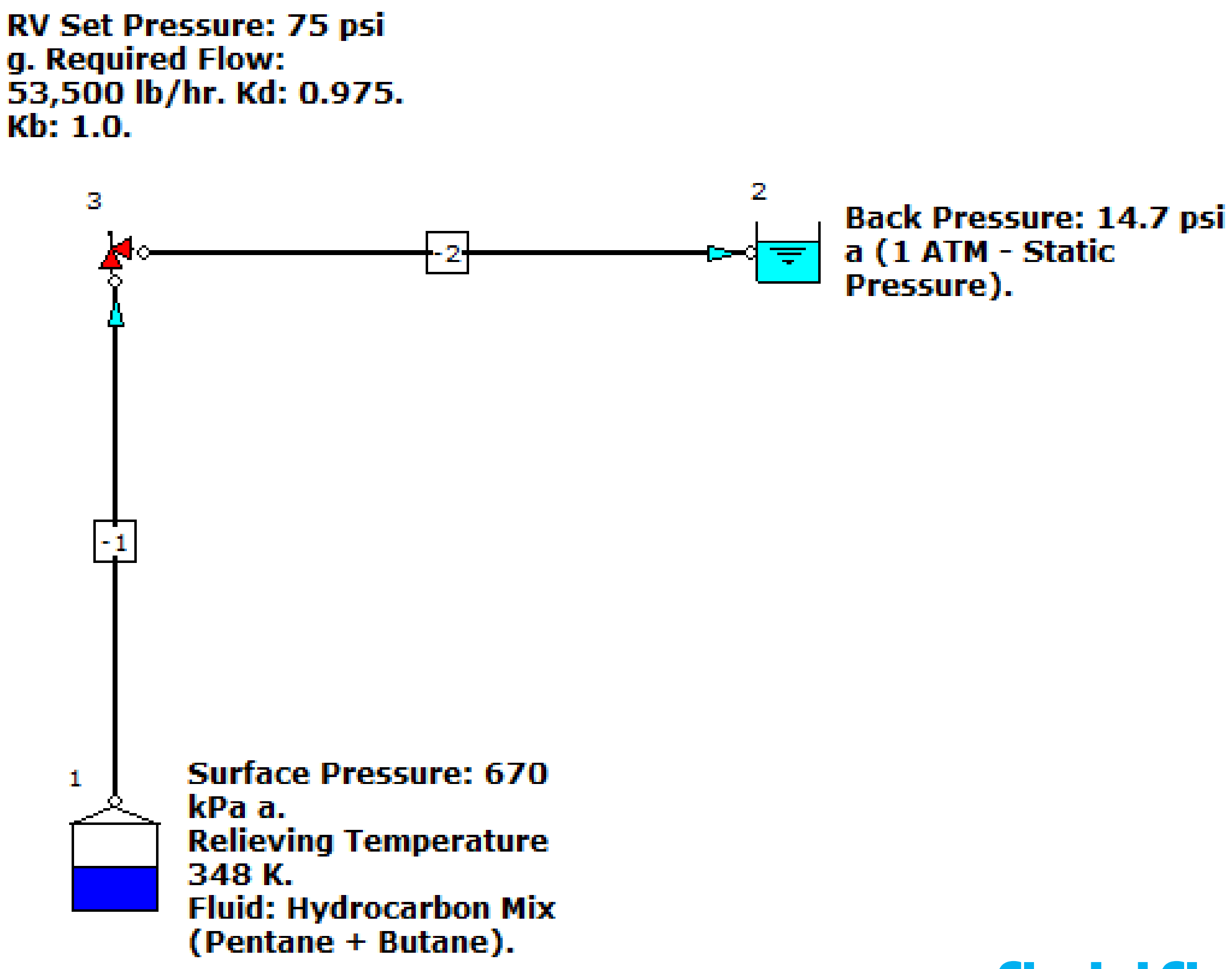
Z is the compressibility factor for the deviation of the actual gas from a perfect gas, a ratio evaluated at inlet relieving conditions.

M is the molecular weight of the gas or vapor at inlet relieving conditions.

FluidFlow software allows you to automatically size relief valves and bursting disks for liquids, gases, steam and two-phase systems to API & ISO standards.

Lets model this scenario using FluidFlow.

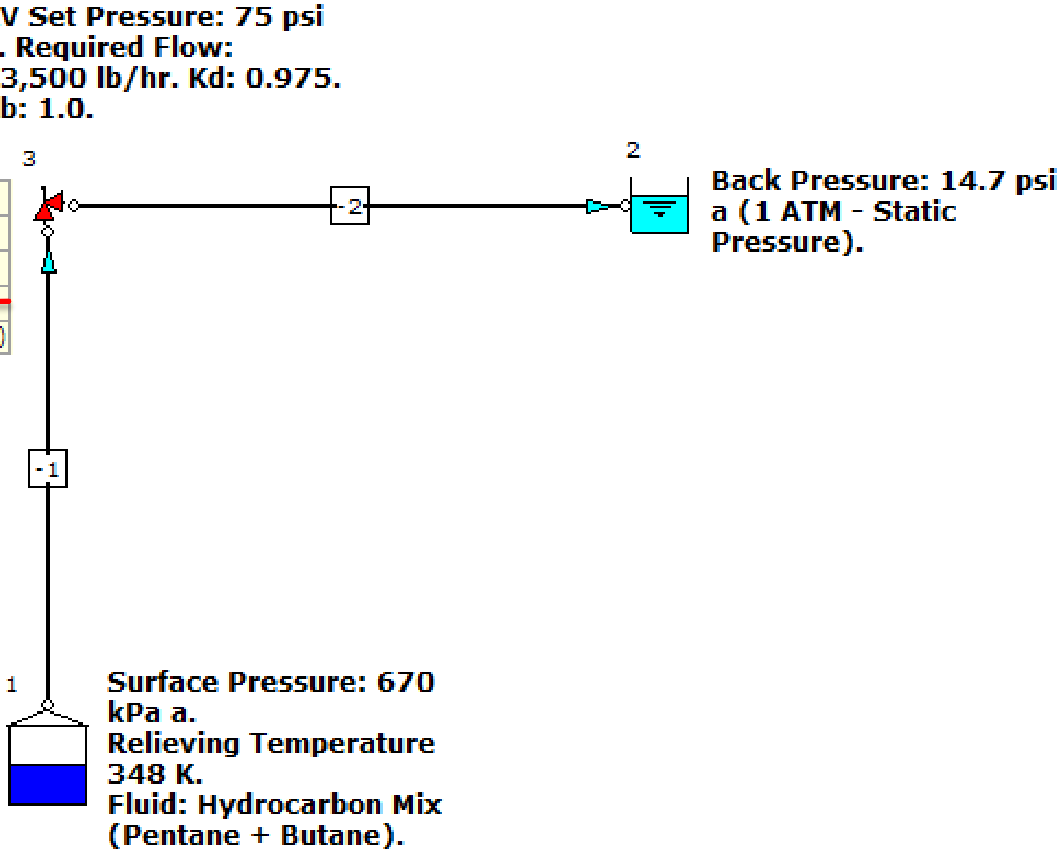
A model of this system was created as shown below.



- A new mixture of butane and pentane was created using the fluids database. A ratio of 52% pentane and 48% butane was used in an attempt to develop a molecular weight of close to 65.
- The inlet pressure was set to 670 kPaa and the relieving temperature set to 348 K.
- The relief valve pressure loss model was set to API RP 520 Part I. The valve was set to Automatically Size with a set pressure of 75 psig, design flow of 53500 lb/h and a discharge coefficient set to 0.975.
- The outlet static pressure was set to 1 ATM.
- The pipe upstream of the relief valve was defined as 6 inch schedule 40 with a length of 1 inch.
- The pipe downstream of the relief valve was defined as 6 inch schedule 40 with a length of 1 ft.

FluidFlow Results (v3.33):

Discharge Coefficient (Kd)	0.97
Flow	1351.3 m3/h
Calculated Size	3244.4 mm2
Calculated Size at MAWP	3178.6 mm2
Standard Orifice Size	P - 6.38 in2 (4120 mm2)



- API Standard 520 calculates a relief valve orifice size as follows:

$$A = \frac{53{,}500}{326 \times 0.975 \times 97.2 \times 1.0 \times 1.0}\sqrt{\frac{627 \times 0.84}{65}}$$

$$= 4.93 \text{ in.}^2 \ [3179 \text{ mm}^2]$$

- FluidFlow has calculated a size of 3178.6 mm² at MAWP which correlates well with the API Standard.

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2) Two-Phase Propane System (API Standard).

This example case is taken from API Standard 520 Part I - Sizing & Selection.

The following relief requirements have been provided:

a) Required propane volumetric flow rate of 100 gal/min.
b) Relieving temperature at the relief valve, T, 60ºF.
c) Relief valve set at 260 psig which is the design pressure of the equipment.
d) Back pressure of 10 psig.
e) Liquid propane density at the PRV inlet 31.92 lb/ft^3.
f) Permitted accumulation of 10 %.
g) Relieving pressure of 300.7 psia (1.1 * 260 = 286 psig or 300.7).
h) Back pressure correction factor = 1.0.
i) Discharge coefficient = 0.65 (since propane is subcooled).

Let's model this scenario in FluidFlow.

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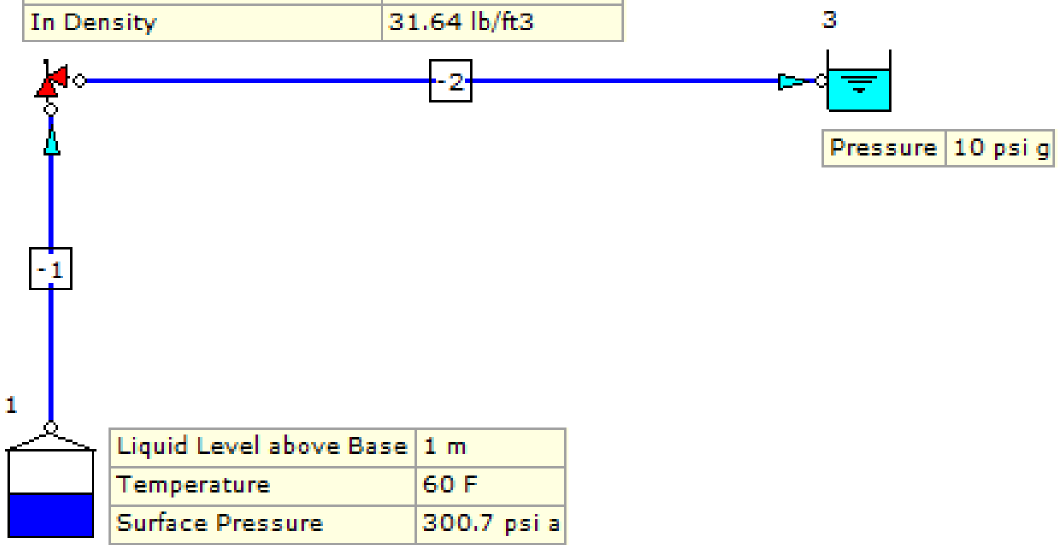
A model of this system was created as shown below.

Set Pressure	260 psi g
Overpressure Allow (MAWP)	Sole Device (10%)
Back Pressure Factor (Kb)	1
Discharge Coefficient (Kd)	0.65
Design Flow	100 usgpm
Pressure Loss Model	API RP520 Part1
In Fluid Phase	Liquid
Calculated Size	0.2072 in2
Calculated Size at MAWP	0.2072 in2
Out Density	0.86 lb/ft3
Out Fluid Phase	2 Phase
In Density	31.64 lb/ft3



Liquid Level above Base	1 m
Temperature	60 F
Surface Pressure	300.7 psi a
Fluid	propane

- The outlet stagnation pressure was set to 10 psig.
- The pipe upstream of the relief valve was defined as 6 inch schedule 40 with a length of 1 M.
- The pipe downstream of the relief valve was defined as 6 inch schedule 40 with a length of 1 M.
- API Standard 520 calculates a relief valve orifice size as follows:

$$A = 0.3208 \frac{Q\rho_{lo}}{K_d K_b K_c G}$$

- FluidFlow has calculated a size of 0.207 in^2 at MAWP which correlates well with the API Standard (0.208 in^2).
- FluidFlow has also calculated a liquid density of 31.64 which correlates well with the API Standard results of 31.92 lb/ft^3.

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3) Ethylene Relief System (ISO Standard).

This is a sub critical gas flow example case is based on a vendor sizing example to ISO Standard.

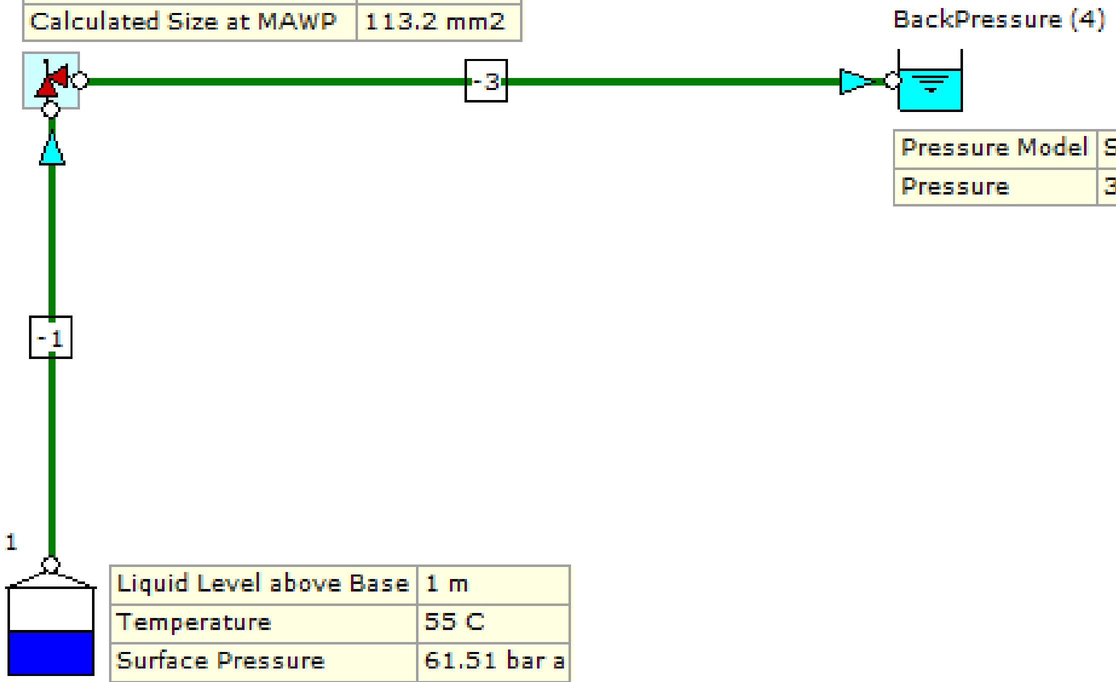
The following relief requirements have been provided:

a) Required flow caused by an operational upset is 4200 kg/h.
b) Relieving temperature, *T*, of 55°C.
c) Relief valve set at 55 barg which is the design pressure of the equipment.
d) Back pressure of 36.1 bara (static pressure).
e) Relieving pressure of 61.51 bara.
f) Back pressure correction factor = 1.0.
g) Discharge coefficient = 0.721.

Let's model this scenario in FluidFlow.

A model of this system was created as shown below.

Set Pressure	55 bar g
Back Pressure Factor (Kb)	1
Discharge Coefficient (Kd)	0.721
Design Flow	4200 kg/h
Pressure Unit	bar g
Pressure Loss Model	ISO 4126-1
Flow	4200 kg/h
Calculated Size	113.2 mm2
Calculated Size at MAWP	113.2 mm2



Pressure Model	Static Pressure
Pressure	36.1 bar a

Liquid Level above Base	1 m
Temperature	55 C
Surface Pressure	61.51 bar a
Fluid	ethylene

- The outlet static pressure was set to 36.1 bara.
- The pipe upstream of the relief valve was defined as 6 inch schedule 40 with a length of 1 in.
- The pipe downstream of the relief valve was defined as 6 inch schedule 40 with a length of 1 ft.

- FluidFlow has calculated a size of 113.2 mm² at MAWP which correlates well with the ISO Standard result of 107.2 mm² .

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Testimonial

"FluidFlow paid for itself the first time we used it. Pro-Tech Engenharia Química is a consultant engineering company specializing in the petro-chemical sector.

We had a very challenging job designing a large vapor collection system. We researched the market very thoroughly before selecting FluidFlow for its completeness and ease of use.

With this software, we were able to reduce the time of the job and do in two weeks what would have taken us well over four weeks. On this first job, the software paid for itself and because of that work we now have other similar job opportunities."

Pro-Tech Engenharia Química, Brazil

Do you need to automatically size relief valves to API or ISO standards or need to model a specific vendor relief device ?

Do you need to automatically size pipes, pumps, fans, flow control valves, pressure control valves, orifice plates, nozzles, venturi tubes etc.....FluidFlow takes the pain out of these calculations, allows you to size equipment accurately and evaluate equipment performance as installed in the system.

FluidFlow lets you take a total system design view, quickly evaluate alternative design scenarios, accelerates your design program, removes the guess work from design, eliminates costly errors.

Talk to one of our support team or visit our website for further details or to avail of a FREE TRIAL of the software.

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