PSV-2019

Fire Scenario

wetted Surface

PSV SIZING PROCEDURE FOR UNWETTED FIRE SCENARIO

1.Determine the scenario, using API-521

2.Calculate the relief load, using API-520 Part1

3.Calculate the orifice area, using API-520 Part1

4.Select proper PSV type by checking backpressure

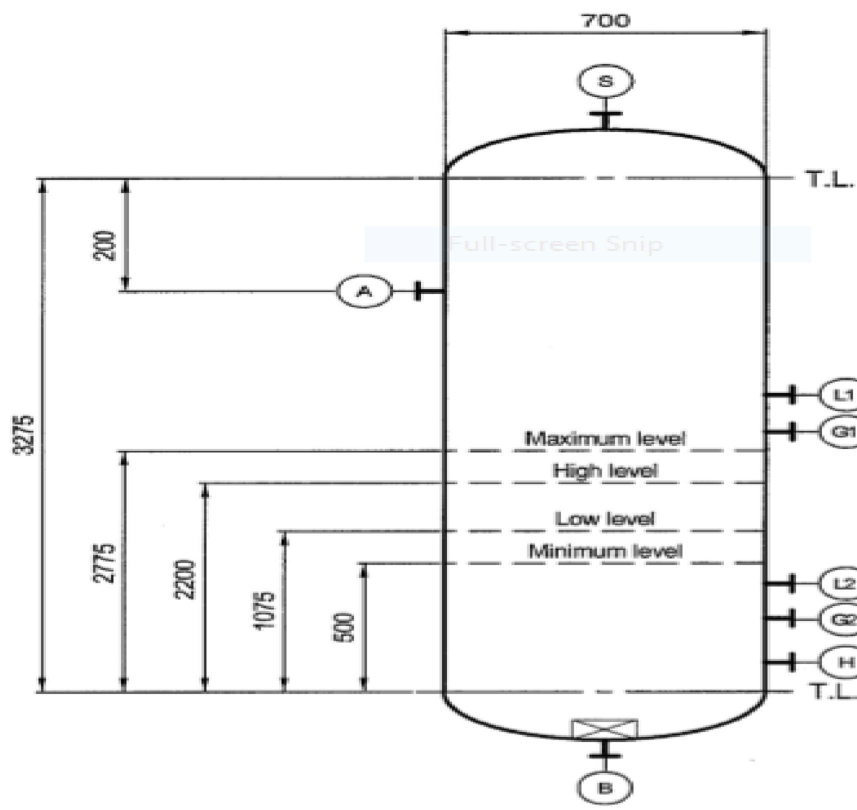
5.Use API-526 to determine the designation and the inlet and outlet sizing

6.Use API-520 Part2 to detail its construction

1.Determine the scenario, using API-521

Since it is exposed to fire then a fire scenario is defined.

Parameters	Value	Parameters	Value
Diameter	0.7 m	M	18.02
Height	3.275 m	Set Pressure	52 barg
Fluid	Steam Condensat	Relieving Pressure	63.9 bara
Z	0.78	Accumulation	0.21
Cp/Cv	1.09	Material	CS



2.Calculate the relief load, using API-520 Part1

$$Q = C_1 \times F \times A_{ws}^{0.82} \tag{7}$$

where

Q is the total heat absorption (input) to the wetted surface, expressed in W (Btu/h);

C_1 is a constant [= 43,200 in SI units (21,000 in USC units)];

F is an environment factor (see Table 5);

A_{ws} is the total wetted surface, expressed in m^2 (ft^2).

NOTE 1 See 4.4.13.2.2 and Table 4.

NOTE 2 The expression, $A_{ws}^{0.82}$, is the area exposure factor or ratio. This ratio recognizes that large vessels are less likely than small ones to be completely exposed to the flame of an open fire.

Where adequate drainage and firefighting equipment do not exist, Equation (8) should be used

$$Q = C_2 \times F \times A_{ws}^{0.82}$$

C_2 is a constant [= 70,900 in SI units (34,500 in USC units)].

Calculation

Parameters	Value
Aw	7.73 m2
C2	70900
F	1
λ	2880
Relief load	474 kg/h

3.Calculate orifice area

Determine if it is in critical flow:

$$\frac{P_{cf}}{P_1} = \left[\frac{2}{k+1}\right]^{\frac{k}{k-1}}$$

where

P_{cf} is the critical flow nozzle pressure;

P_1 is the upstream relieving pressure;

k is the ratio of specific heats (C_p/C_v) for an ideal gas at relieving temperature.

If so, then:

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

where

A is the required discharge area of the device, in.^{2} (mm^2) (see 5.2);

W is the required flow through the device, lb/h (kg/h);

C is a function of the ratio of the ideal gas specific heats ($k = C_p/C_v$) of the gas or vapor at inlet relieving temperature.

The coefficient, C, is determined as follows.

In USC units [for use in Equation (6) through Equation (8) only]:

$$C = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{(k+1)}{(k-1)}}} \tag{12}$$

In SI units [for use in Equation (9) through Equation (11) only]:

$$C = 0.03948\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{(k+1)}{(k-1)}}} \tag{13}$$

K_d is the coefficient of discharge; for preliminary sizing, use the following effective values:

— 0.975, when a PRV is installed with or without a rupture disk in combination;

— 0.62, when a PRV is not installed and sizing is for a rupture disk in accordance with 5.12.1.2;

P_1 is the upstream relieving pressure, psia (kPa); this is the set pressure plus the allowable overpressure (see 5.4) plus atmospheric pressure;

K_b is the capacity correction factor due to backpressure; this can be obtained from the manufacturer's literature or estimated for preliminary sizing from Figure 31. The backpressure correction factor applies to balanced bellows valves only. For conventional and pilot-operated valves, use a value for K_b equal to 1.0 (see 5.3). See 5.6.4 for conventional valve applications with backpressure of a magnitude that will cause subcritical flow;

K_c is the combination correction factor for installations with a rupture disk upstream of the PRV (see 5.12.2);

— equals 1.0 when a rupture disk is not installed;

— equals 0.9 when a rupture disk is installed in combination with a PRV and the combination does not have a certified value;

T is the relieving temperature of the inlet gas or vapor, °R(°F + 460) [K(°C + 273)];

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

M is the molecular weight of the gas or vapor at inlet relieving conditions; various handbooks carry tables of molecular weights of materials, but the composition of the flowing gas or vapor is seldom the same as that listed in tables. This value should be obtained from the process data. Table 10 lists values for some common fluids, lbm/lb-mole (kg/kg-mole);

V is the required flow through the device, SCFM (Nm^3/min);

G_v is the specific gravity of gas at standard conditions referred to air at standard conditions (normal conditions); in other words, G_v = 1.00 for air at 14.7 psia and 60 °F (101.325 kPa and 0 °C).

5.Use API-526 to determine the designation and the inlet and outlet sizing

Since it is less than 0.11 inch then D is selected. Also, by checking its rating and temperature limitation, 1D2 is selected. But Topsoe has selected 1E2 in site.

Designation	Effective Orifice Area ($in.^2$)
D	0.110
E	0.196
F	0.307
G	0.503
H	0.785
J	1.287
K	1.838
L	2.853
M	3.60
N	4.34
P	6.38
Q	11.05
R	16.00
T	26.00

Table 3—Spring-loaded Pressure-relief Valves "D" Orifice [f] (Effective Orifice Area = 0.110 $in.^2$)

Materials [b]	Valve Size	ASME Flange Class		Maximum Inlet Flange (Set) Pressure Limit [a] (psig)						Outlet Pressure Limit [a] (psig)		Center-to-Face Dimensions (in.)	
				Conventional and Balanced Bellows Valves									
Body/ Bonnet	Inlet by Orifice by Outlet	INLET	OUTLET	−450 °F to −76°F	−75 °F to −21 °F	−20 °F to 100 °F	450 °F	800 °F	1000 °F	Flange Rating Limit [a] 100 °F	Bellows Rating Limit [a] 100 °F	INLET	OUTLET
Temperature Range Inclusive −20 °F to 800 °F													
Carbon Steel	1D2	150	150			285	185	80		285	230	4 1/8	4 1/2
	1D2 [c]	300	150			(285)	(285)	(285)		285	230	4 1/8	4 1/2
	1D2	300	150			740	620	410		285	230	4 1/8	4 1/2
	1D2	600	150			1480	1235	825		285	230	4 1/8	4 1/2
	1 1/2D2	900	300			2220	1855	1235		(600)	500	4 1/8	5 1/2
	1 1/2D2	1500	300			3705	3090	2055		(600)	500	4 1/8	5 1/2
	1 1/2D3	2500	300			(6000)	5150	3430		740	500	5 1/2	7
Temperature Range Inclusive 801 °F to 1000 °F													
Chrome Molybdenum Steel	1D2	300	150					510	215	290	230	4 1/8	4 1/2
	1D2	600	150					1015	430	290	230	4 1/8	4 1/2
	1 1/2D2	900	300					1525	650	(600)	500	4 1/8	4 1/2
	1 1/2D2	1500	300					2540	1080	(600)	500	4 1/8	4 1/2
	1 1/2D3	2500	300					4230	1800	750	500	5 1/2	7

Select proper PSV type by checking backpressure

According to licensor data, superimposed and build-up backpressure are max 21barg. Even though selecting Conventional type is not fully recommended, Conventional type has been selected by LESER.

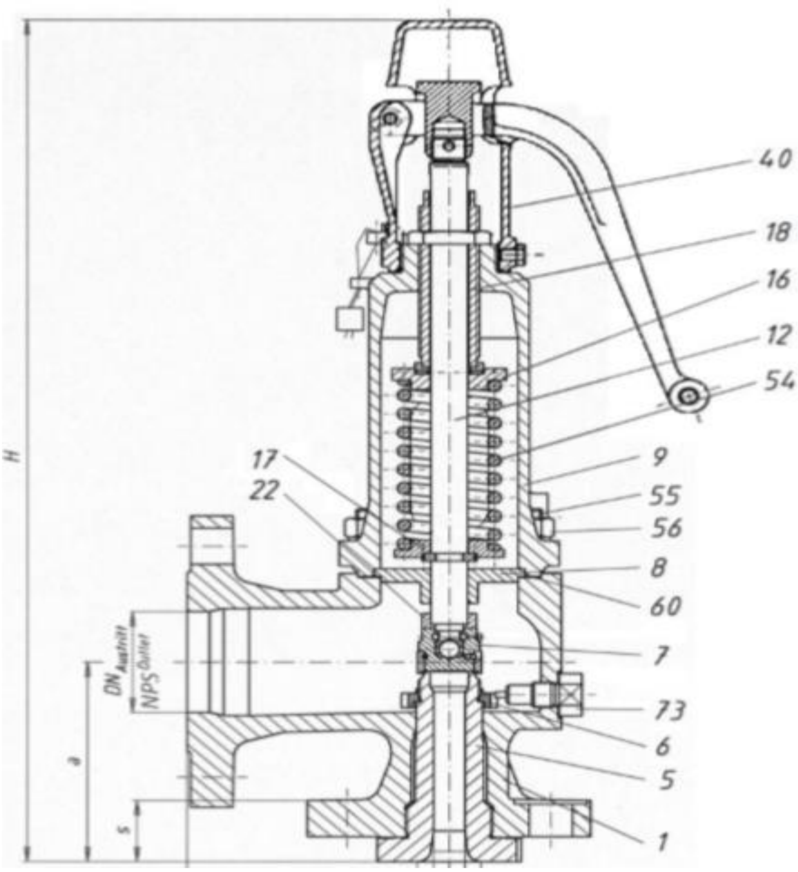
superimposed	Build-up	Total
0 barg	21 barg	21 barg
2.5%	30%	40%

Table 9.1 Maximum backpressure percentages on gas/vapour applications

Backpressure Type	Effects on valves				Selection
	Value (% of set)	Conventional	Balanced Spring Valve	Pilot Operated	
Constant	<30% [1]	Set point increased by backpressure [3]	No effect	No effect	Conventional, balanced or POSRV
	30%–50%		Lift/capacity reduced (coefficient) [6]		
	>50% [2]	Set point increased by backpressure; flow becomes subsonic [4]	Generally unstable *Do not use*	Flow becomes subsonic [4]	Conventional or POSRV
Variable superimposed	<10%	Set point varies with backpressure [5]	No effect	No effect	Balanced or POSRV
	10%–30% [1]	Unstable			
	30%–50%	*Do not use*	Lift/capacity reduced (coefficient) [6]		
	>50% [2]		Generally unstable *Do not use*	Flow becomes subsonic [4]	POSRV only
Variable built-up	<10%	No effect	No effect	No effect	Conventional, balanced or POSRV
	10%–30% [1]	Unstable			Balanced or POSRV
	30%–50%	*Do not use*	Lift/capacity reduced (manufacturer coefficient) [6]		
	>50% [2]		Generally unstable *Do not use*	Flow becomes subsonic [4]	POSRV only

Material Selection

Since it is steam condensate then A-216 WCB is selected for its body



Specific Valve Data		
Pos	Description	Data
1	Purchase Order No.	A-2-LCN22101-Methanol/HK170414les-1
2	LESER Job No.	20329048
3	LESER Pos.	60
4	Type	5262.0175
5	Orifice	E
6	Inlet size	NPS 1"
7	Inlet pressure rating	600 lbs ASME B16.5
8	Inlet flange facing	Serr spiral finish, Ra=3,2-6,3
9	Outlet size	NPS 2"
10	Outlet pressure rating	150 lbs ASME B16.5
11	Outlet flange facing	Serr spiral finish, Ra=3,2-6,3
12	d0 [mm]	14,00
13	Set pressure	52,00
14	Pressure unit	bar-g
15	CDTP [bar-g]	52,75
16	Dimension a [mm]	105,00
17	Dimension b [mm]	114,00
18	Dimension s [mm]	30,00
19	Dimension H [mm]	433,00
20	Weight [kg]	17,30
21	Tag No. 1 + 2	PSV-2019
22	Tag No. 3 + 4	
23	Tag No. 5 + 6	
24	Tag No. 7 + 8	
25	Tag No. 9 + 10	
26	Tag No. 11+ 12	

List of Parts Main Valve			
Pos	Description	Qty	Material
1	Body	1	1.0619/ WCB/ WCC
5	Nozzle	1	1.4401/ 1.4404/ 316/ 316L (stellited)
6	Adjusting ring	1	1.4408/ CF8M
7	Disc AS	1	1.4401/ 1.4404/ 316/ 316L (stellited)
8	Guide AS	1	1.0501 / Carbon Steel
9	Bonnet	1	1.0619/ WCB/ WCC
12	Spindle	1	1.4021/ Chrome Steel
16	Spring Plate	1	1.4401/ 1.4404/ 316/ 316L
17	Spring Plate	1	1.0718 / Carbon Steel
18	Adjusting Screw AS	1	1.4104/ 430F + PTFE/ Glas
22	Lift stopper	1	1.4401/ 1.4404/ 316/ 316L
40	Cap/ Lifting Device AS	1	0.7040/ 60-40-18
54	Compression Spring	1	1.4310 / Stainless Steel
55	Stud	4	1.4401 / Stainless Steel
56	Hexagon Nut	4	1.4401 / Stainless Steel
60	Gasket	1	Graphit/ 1.4401 / Stainless Steel
73	Lock screw	1	1.4401/ 1.4404/ 316/ 316L

Discussion

1.The relief load calculated by TCC greatly differs by that of TOPSOE and that of mine which stems from λ value in calculation. The λ value for TCC is 1600 kj/kg while it is 2880 kj/kg.

2. Another matter is orifice designation dedicated. TOPSOE has selected 1E2 but it appears that 1D2 is also suitable.

3. According to total backpressure calculation, it seems that if balanced type had been selected, it would have more promising performance