PSV-1031-1038-1043

Fire Scenario

Unwetted 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 R-1001 and exposed to fire then a fire scenario is defined.

Parameters	Value	Parameters	Value
Diameter	4.45 m	M	16.54
Height	3.1 m	Set Pressure	55 barg
Fluid	Natural Gas	Relieving Pressure	67.55 bara
Z	1.01	Accumulation	0.21
Cp/Cv	1.18	Material	CS

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

$$A = \frac{F' \times A'}{\sqrt{p_1}} \qquad (9)$$

where

A is the effective discharge area of the valve, expressed in mm^2 (in.^{2});

A' is the exposed surface area of the vessel, expressed in m^2 (ft^2);

p_1 is the upstream relieving absolute pressure, expressed in kPa (psi);

NOTE p_1 is the set pressure plus the allowable overpressure plus the atmospheric pressure.

F' can be determined using Equation (10). If calculated using Equation (10) and the result is less than 182 in SI units (<0.01 in USC units), then use a recommended minimum value of $F' = 182$ in SI units ($F' = 0.01$ in USC units). If insufficient information is available to use Equation (10), then use $F' = 821$ in SI units ($F' = 0.045$ in USC units).

$$F' = \frac{C_9}{C \times K_D} \left[\frac{(T_W - T_1)^{1.25}}{T_1^{0.6506}} \right] \qquad (10)$$

where

C_9 is a constant [= 0.2772 in SI units (0.1406 in USC units)];

K_D is the coefficient of discharge (obtainable from the valve manufacturer);

NOTE A K_D value of 0.975 is typically used for preliminary sizing of PRVs (see API 520, Part 1).

T_W is the maximum wall temperature of vessel material, expressed in K (°R);

T_1 is the gas absolute temperature, at the upstream relieving pressure, determined from Equation (12), expressed in K (°R).

The coefficient, C, is given by Equation (11):

$$C = C_{10}\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}} \quad (11)$$

where

C_{10} is a constant {= 0.0395 (kg-mole-K)$^{0.5}$/(mm^2-kPa-h) in SI units [520 (lb-mole-°R)$^{0.5}$/(lbf-h) in USC units]};

k is the ideal gas specific heat ratio (C_p/C_v) of gas or vapor at relieving temperature.

$$T_1 = \frac{p_1}{p_n} \times T_n \quad (12)$$

where

p_n is the normal operating gas absolute pressure, expressed in kPa (psia);

T_n is the normal operating gas absolute temperature, expressed in K (°R).

The recommended maximum vessel wall temperature, T_w, for the usual carbon steel plate materials is 593 °C (1100 °F). If vessels are fabricated from alloy materials, the value for T_w should be based on the stress rupture data for that material. See 4.4.13.2.3, 4.4.13.2.6, 4.6.1, and Annex A for guidance on the potential for vessel failure from overtemperature due to fire exposure.

If $F' \geq 182$ in SI units ($F' \geq 0.01$ in USC units), the relief load, $q_{m,relief}$, expressed in kg/h (lb/h), can be calculated directly by rearranging the critical vapor equation and substituting Equation (9) and Equation (10), which results in Equation (13):

$$q_{m,relief} = C_{12}\sqrt{M \times p_1}\left[\frac{A'(T_w - T_1)^{1.25}}{T_1^{\,1.1506}}\right] \quad (13)$$

where

M is the relative molecular mass of the gas;

C_{12} is a constant [= 0.2772 in SI units (0.1406 in USC units)].

The minimum relief load recommended for sizing where $F' < 182$ in SI units ($F' < 0.01$ in USC units) is calculated by setting $F' = 182$ in SI units ($F' = 0.01$ in USC units), which results in Equation (14):

$$q_{m,relief} = C_{13} C A' \sqrt{\frac{M p_1}{T_1}} \quad (14)$$

where

C_{13} is a constant [= 182 in SI units (0.01 in USC units)].

NOTE To derive Equation (13) and Equation (14), Z, K_b, and K_c in API 520, Part 1, Equation (3) have each been assumed to have a value of 1. For Equation (14), K_D is conservatively assumed to have a value of 1.

Calculation

Parameters	Value	Parameters	Value
Aw	65 m2	KD	0.975
C9	0.2772	F’	131
C10	0.0395	Relief Load	3874 kg/hr
C	0.0254		

Note that since F’ is less than 182 the corresponding equation has been used in which F’ is set to 182. Remember that in F’ calculation T1 is set to max 400 C

Relief load	API-521	Topsoe	TCC
Value	3874	1200	3825

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

Use the following formula to calculate orifice area :

$$A = \frac{F' \times A'}{\sqrt{p_1}}$$

By setting F’, Aw, p1 to 132, 65 and 67500 kpa, we obtain 0.16 inch^2

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

Since it is more than 0.11 inch and less than 0.196, then E is selected. Also, by checking its rating and temperature limitation, 1E2 is selected.

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 4—Spring-loaded Pressure-relief Valves “E” Orifice [f] (Effective Orifice Area = 0.196 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						Flange Rating Limit [a]	Bellows Rating Limit [a]		
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	100 °F	100 °F	INLET	OUTLET
Temperature Range Inclusive –20 °F to 800 °F													
Carbon Steel	1E2	150	150			285	185	80		285	230	4 1/8	4 1/2
	1E2 [c]	300	150			(285)	(285)	(285)		285	230	4 1/8	4 1/2
	1E2	300	150			740	620	410		285	230	4 1/8	4 1/2
	1E2	600	150			1480	1235	825		285	230	4 1/8	4 1/2
	1 1/2E2	900	300			2220	1855	1235		(600)	500	4 1/8	5 1/2
	1 1/2E2	1500	300			3705	3090	2055		(600)	500	4 1/8	5 1/2
	1 1/2E3	2500	300			(6000)	5150	3430		740	500	5 1/2	7
Temperature Range Inclusive 801 °F to 1000 °F													
Chrome Molybdenum Steel	1E2	300	150					510	215	290	230	4 1/8	4 1/2
	1E2	600	150					1015	430	290	230	4 1/8	4 1/2
	1 1/2E2	900	300					1525	650	(600)	500	4 1/8	5 1/2
	1 1/2E2	1500	300					2540	1080	(600)	500	4 1/8	5 1/2
	1 1/2E3	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 1.5 and 18.5 barg. Since the backpressure is constant and the maximum backpressure is 36% a balanced type could be selected.

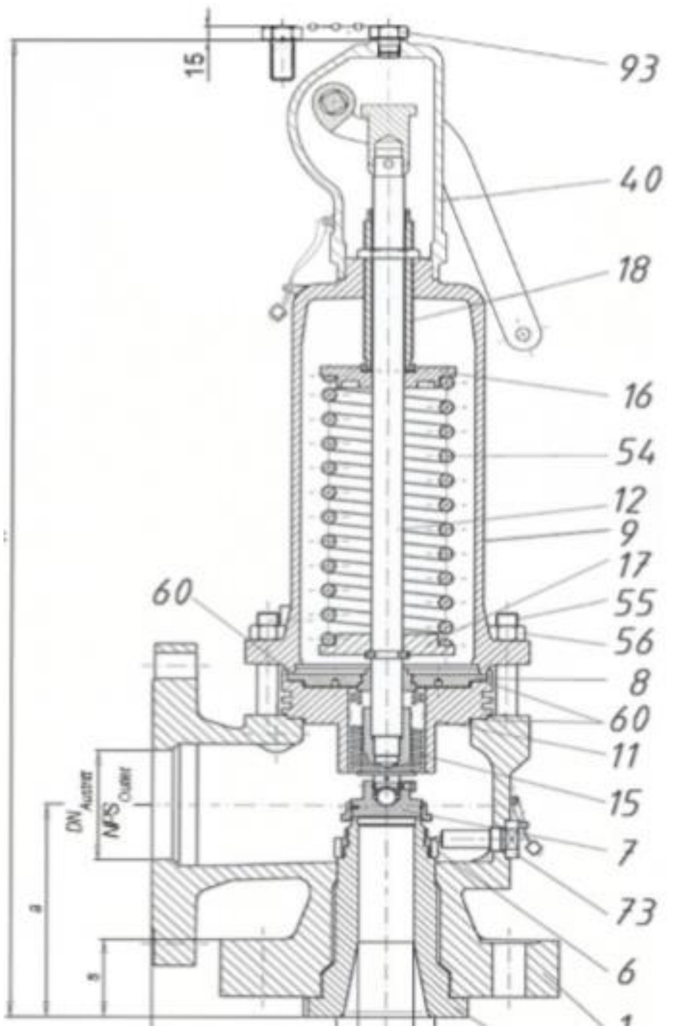
superimposed	Build-up	Total
1.5 barg	18.5 barg	20 barg
2.7%	33.6%	36%

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 NG, A216 WCB could be used 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.	40
4	Type	5262.0324
5	Orifice	F
6	Inlet size	NPS 1 1/2"
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]	18,00
13	Set pressure	55,00
14	Pressure unit	bar-g
15	CDTP [bar-g]	55,60
16	Dimension a [mm]	124,00
17	Dimension b [mm]	152,00
18	Dimension s [mm]	85,00
19	Dimension H [mm]	559,00
20	Weight [kg]	35,00
21	Tag No. 1 + 2	PSV-1031
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	1	1.4401/ 1.4404/ 316/ 316L
9	Bonnet	1	1.0619/ WCB/ WCC
11	Spacer	1	1.0460/ SA-105
12	Spindle	1	1.4021/ Chrome Steel
15	Bellow AS	1	1.4401/ 1.4404/ 316/ 316L + 2.4856/ N06626
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
40	Cap/ Lifting Device AS	1	0.7040/ 60-40-18
54	Compession Spring	1	2.4669 (Inconel X750)
55	Stud	4	1.4401 / Stainless Steel
56	Hexagon Nut	4	1.4401 / Stainless Steel
60	Gasket	3	Graphit/ 1.4401 / Stainless Steel
73	Lock screw	1	1.4401/ 1.4404/ 316/ 316L
93	Test Gag AS	1	1.4401 / Stainless Steel

Discussion

The selected PSV in site is 11/2F2 but calculation shows that it should be 1E2, then what is the cause?

Topsoe has calculated 1200 kg/hr for its relief loading but my calculation and that of TCC show otherwise.

Remember that according to API526 1E2 should be selected but TOPSOE has selected 11/2F2