SELECTION CRITERIA FOR SAFETY VALVE

CALCULATION OF THE DISCHARGE CAPACITY (Ref. EN 13136:2013)

The calculation of the minimum discharge capacity is linked to the system configuration on which the safety valve is installed, and to the cause of the safety valve opening, i.e.:

- **External heat sources** (Para. 6.2.1 - EN 13136:2013). The minimum required discharge capacity is determined by the following formula:

$$Q_{md} = \frac{3600 \times \varphi \times A_{surf}}{h_{vap}} \cdots [Kg/h]$$

where:
- φ = density of heat flow rate, assumed to be 10 [kW/m^2]
- A_{surf} = external surface area of the vessel [m^2]
- h_{vap} = latent heat of vaporization of liquid at p_o [kJ/kg]

- **Internal heat sources** (Para. 6.2.2 - EN 13136:2013). The minimum required discharge capacity is determined by the following formula:

$$Q_{md} = \frac{3600 \times Q_h}{h_{vap}} \cdots [Kg/h]$$

where Q_h = rate of heat production [kW]

- **Increased pressure caused by a positive displacement compressor** (Para. 6.3 - EN 13136:2013). The minimum required discharge capacity is determined by the following formula:

$$Q_{md} = 60 \times V \times n \times \rho_{10} \times \eta_v \cdots [Kg/h]$$

where:
- V = theoretical displacement of compressor [m^3]
- n = rotational frequency of compressor [min^{-1}]
- ρ_{10} = vapour density of refrigerant, from the saturation curve at a temperature of 10 °C [kg/m^3].
  Table 1 provides the values of ρ_{10} for:
  - traditional HCFC and HFC refrigerants most commonly used
  - new HFO and HFC/HFO blend refrigerants
  - natural HC fluids

  (for R744, the ρ_{-40} vapour density value for CO_2 is indicated, from the saturation curve at a temperature of -40 °C [kg/m^3]).
- η_v = volumetric efficiency of the compressor, estimated at suction pressure and discharge pressure equivalent to the safety valve setting.

SIZING OF THE SAFETY VALVE DESIGNED TO DISCHARGE GAS AT CRITICAL FLOW (Ref. EN ISO 4126-1: 2013 and EN 13136 :2013)

Critical flow occurs when the back-pressure p_b (the pressure existing immediately at the outlet of the valve) is lower than or equal to the critical pressure:

$$p_b \leq p_o \times \left|\frac{2}{k+1}\right|^{\left(\frac{k}{k-1}\right)} \cdots [\text{barabs}]$$

where:

- p_o = actual relieving pressure, upstream the valve. It's equal to the set pressure plus overpressure; that is, the pressure increase over the set pressure at which the shutter has its total lift [bar abs]
- k = isentropic exponent of gas or vapour, based on the actual temperature and pressure conditions upstream of the valve during the discharge phase under full glow.

If k is unknown or difficult to determine, it is possible to assume:

$$p_{critical} = 0{,}5 \times p_o \cdots [\text{barabs}]$$

A valve that discharges to the atmosphere, is in critical flow conditions.
The safety valves designed to discharge gas at critical flow must be sized using the following formula, shown in Paragraph 7.2.5.2 of the EN 13136:2013 standard.

$$A_c = 3{,}469 \times \frac{Q_{md}}{C \times 0{,}9 \times K_d} \times \sqrt{\frac{v_o}{p_o}} \cdots [\text{mm}^2]$$

where:

- A_c = minimum net cross-section area of the valve orifice [mm^2]
- Q_{md} = minimum required discharge capacity of safety valve [kg/h]
- K_d = certified discharge ratio of safety valve
- p_o = actual pressure upstream of the safety valve during discharge of the entire flow, see definition above. [bar abs]
- v_o = specific volume of gas or vapour at discharge conditions p_o and T_o, where T_o is the fluid temperature at valve inlet, defined by the user or by the designer [m^3/kg]
- C = expansion rate as a function of the k coefficient in the isentropic equation calculated with the following formula:

$$C = 3{,}948 \times \sqrt{k \times \left|\frac{2}{k+1}\right|^{\frac{(k+1)}{(k-1)}}}$$

  for this calculation, the value of k refers to a temperature of 25 °C. (Para. 7.2.3, EN 13136:2013 standard).

Table 1 provides the k and C values for:
- traditional HCFC and HFC refrigerants most commonly used
- new HFO and HFC/HFO blend refrigerants
- natural HC fluids and R744

TABLE 1

Refrig.	R134a	R22	R32	R404A	R407C	R410A	R448A	R449A	R450A	R452A	R507	R1234yf	R1234ze	R290	R600	R600a	R744
PED Group	2	2	1	2	2	2	2	2	2	2	2	1	2	1	1	1	2
k	1,12	1,17	1,24	1,12	1,14	1,17	1,14	1,14	1,11	1,11	1,10	1,07	1,07	1,19	1,10	1,10	1,30
C	2,50	2,54	2,59	2,50	2,51	2,54	2,51	2,51	2,49	2,49	2,48	2,45	2,45	2,55	2,48	2,48	2,63
ϱ [kg/m^3] (1)	20,23	28,82	30,23	41,66	27,45	41,92	30,63	31,11	18,49	40,62	44,03	24,27	16,45	13,78	3,87	5,87	26,12

(1) ϱ_{10} [kg/m^3] for all refrigerant, excluded R744
ϱ_{-40} [kg/m^3] for R744

INSTALLATION OF A SAFETY VALVE (Ref. EN 13136:2013)

As far as the installation of safety valves is concerned, remember these basic points:

- The fitting between the valve and the equipment to be protected must be as short as possible. Furthermore, the cross-section of the piping must not be smaller than the valve inlet. In any case, EN 13136:2013 states that the pressure drop between the protected vessel and the safety valve, at discharge capacity**, shall not exceed 3% of actual relieving pressure p_o,** including any accessory on the line.

- The location selected for installation of the safety valve must consider that valve operation involves the discharge of the refrigerant fluid under pressure, sometimes at high temperature. Where there is the risk of causing injuries to people nearby, exhaust piping must be provided, sized so as to not compromise valve operation. EN 13136:2013 states that this piping **must not generate, at discharge capacity, a back-pressure exceeding 10% of actual relieving pressure p_o** , for unbalanced, conventional valves. In the event of multiple valves installed in parallel, it is highly recommended that each valve be fit with a dedicated exhaust line rather than a single manifold for all of the valves. The risk of the latter solution is to create an overpressure in the manifold determined when a valve discharges. This overpressure can modify the operating characteristics of all the other valves installed in parallel.

Pressure losses in the upstream line

To calculate the pressure losses in the upstream line (between vessel and safety valve) refer to Section 7.4 of EN 13136:2013.
The upstream pressure loss is given by:

$$\Delta p_{in} = 0{,}032 \times \left[\frac{A_c}{A_{in}} \times C \times K_{dr} \right]^2 \times \zeta \times p_o \cdots [\mathrm{bar}]$$

where:
- A_c = minimum calculated flow cross-section area [mm^2]
- A_{in} = cross-section area of inlet tube to valve [mm^2]
- $K_{dr} = K_d$ x 0.9 , reduced discharge coefficient
- C = expansion rate as a function of the k coefficient in the isentropic equation for the refrigerant fluid
- ξ = sum of the of pressure loss coefficients ξ_n of the individual components and piping

  The coefficients ξ_n refer to:
  - pipe element losses, such as fittings and elbows
  - valve losses
  - losses along the piping

  are listed in standard EN 13136:2013 (see Table 2).

To ensure correct operation of safety valve $\Delta p_{in} \leq 0{,}03 \times p_0 \cdots [bar]$

Pressure losses in the downstream line

To calculate the pressure losses in the downstream line (between safety valve and atmosphere) refer to Section 7.4 of EN 13136:2013.
The downstream pressure loss is given by:

$$\Delta p_{out} = p_1 - p_0 \cdots [bar]$$

$$p_1 = \sqrt{0{,}064 \times \zeta \times \left(\frac{A_c}{A_{out}} \times C \times K_{dr} \times p_o \right)^2 + {p_2}^2} \cdots [barabs]$$

where:
- P_1 = inlet pressure to discharge line [bar abs]
- P_2 = outlet pressure to discharge line, equal to atmospheric pressure [bar abs]
- A_c = minimum calculated flow cross-section area [mm^2]
- A_{out} = cross-section area of valve outlet pipe [mm^2]
- $K_{dr} = K_d$ x 0.9 , reduced discharge coefficient
- C = expansion rate as a function of the k coefficient in the isentropic equation for the refrigerant fluid
- p_o = actual pressure downstream of the safety valve during discharge of the entire flow [bar abs].
- ξ = sum of the of pressure loss coefficients ξ_n of the piping

  The coefficients ξ_n refer to:
  - pipe element losses, bends
  - losses along the piping

  are listed in standard EN 13136:2013 (see Table 2).

To ensure correct operation of safety valve $\Delta p_{out} \leq 0{,}10 \times p_0 \cdots [bar]$

EXAMPLE 1: Calculation of the flow rate (Q_{md}) and selection of the safety valve (Increased pressure caused by a positive displacement compressor)

1 Data for the Compressor

- Bore: 82.5 mm
- Stroke: 69.8 mm
- Number of cylinders 4
- Rotational frequency 1450 rpm
- Clearance 4%
- Refrigerant fluid R407C

The theoretical displacement of the compressor is:

$$V = \frac{\pi}{4} \times 0{,}0825^2 \times 0{,}0698 \times 4 = 0{,}00149 \cdots [m^3]$$

2 Maximum allowable pressure of the liquid condenser / receiver: PS = 25 bar

3 Set pressure of the safety valve that must be installed on the upper crown of the condenser housing: p_{set} = 25 bar

Calculation of the valve discharge pressure under full flow exhaust conditions: using a safety valve in series 3065 with an overpressure of 10%:

$$p_0 = p_{set} \times \left(1 + \frac{10}{100}\right) + 1 = 28{,}5 \cdots [barabs]$$

Operating conditions of compressor at the safety valve discharge:
Condensation temperature: +65.2 °C (28.5 bar abs)
Evaporation temperature: +10 °C (6.33 bar abs)
These conditions, defined by the designer, are assumed to be the most critical for the safety valve due to operating faults such as:

- Manoeuver errors
- Failure of automatic protection systems to operate before the safety valve

Calculation of minimum full discharge capacity: for cautionary reasons, ignoring the vapour overheating at the outlet of the evaporator, the volumetric efficiency of compressor is:

$$\eta_v = 1 - 0{,}04 \times \frac{p_{discharge}}{p_{suction}} = 1 - 0{,}04 \times \frac{28{,}5}{6{,}33} = 0{,}82$$

and so the minimum required full discharge capacity:

$$Q_{md} = 60 \times V \times n \times \rho_{10} \times \eta_v = 60 \times 0{,}00149 \times 1450 \times 27{,}45 \times 0{,}82 = 2918 \cdots [Kg/h]$$

where ρ_{10} = 27.45 [kg/m^3] , saturated vapour density of R407C at a temperature of 10 °C (see Table 1).

Sizing of minimum flow cross-section area of the safety valve: the safety valves to discharge gas or vapour at critical flow must be sized using the following formula.

$$A_c = 3{,}469 \times \frac{Q_{md}}{C \times 0{,}9 \times K_d} \times \sqrt{\frac{v_o}{p_o}} = 3{,}469 \times \frac{2918}{2{,}51 \times 0{,}9 \times 0{,}87} \times \sqrt{\frac{0{,}0069}{28{,}5}} = 80{,}3 \cdots \left[mm^2\right]$$

where:

- C = 2.51, corresponding to k exponent for R407C, equal to 1.14 (see Table 1)
- K_d = 0.87, certified discharge ratio of safety valve 3065/4
- v_o = 0.0069 [m^3/kg] , specific volume of the saturated vapour upstream of the safety valve during operation.
  This value refers to the following operating conditions upstream of the valve:
  - Pressure, p_o = 28.5 [bar abs]
  - Temperature, T_o = 65.2 [°C]

Conclusion: the selected safety valve is model 3065/4 with the following characteristics:

- certified discharge ratio, Kd = 0.87
- nozzle cross-section area, A = 132.73 [mm^2]
- set pressure, p_{set} = 25 bar

Verification of the system upstream the safety valve

Assuming the valve installed is 3065/4C250, using a steel fitting with the following characteristics:

- d_{in} = 17 [mm] , fitting inside diameter
- A_{in} = 227 [mm^2] fitting inside cross-section area
- L = 60 [mm] , fitting length
- Condenser connection: Flush with the housing and with a broken edge

The following information is taken from Table 2:

- $\xi_{1\ (inlet)}$ = 0.25
- $\xi_{2\ (length)} = \lambda \times L / d_{in}$ = 0.02 x 60/17 = 0.07
  with λ = 0.02 for steel pipe
- $\xi_T = \xi_1 + \xi_2$ = 0.25 + 0.07 = 0.32

Between the safety valve and the steel fitting, a shut-off valve type 3064/44 is installed.
The main characteristics of this valve are:

- d_R = 13 [mm] , inside valve diameter
- A_R = 132.7 [mm^2], inside valve cross-section area
- kv = 10 [m^3/h] , valve kv coefficient

The pressure loss coefficient ξ_R of the shut-off valve is given by:

$$\zeta_R = 2{,}592 \times \left[\frac{132{,}7}{10}\right]^2 \times 10^{-3} = 0{,}45$$

Total loss coefficient: $\xi_T + \xi_R = 0.77$

Recalling the previously calculated cross-section, the characteristics of safety valve 3065/4 and refrigerant fluid R407C:

- A_c = 78.4 [mm^2]
- K_{dr} = 0.87 x 0.9 =0.783
- C = 2.51

The pressure loss is given by:

$$\frac{\Delta p_{in}}{p_o} = 0{,}032 \times \left[\frac{80{,}3}{227} \times 2{,}51 \times 0{,}783 \right]^2 \times 0{,}77 = 0{,}012$$

The pressure loss value obtained is admissible because it is lower than the value of 0.03 indicated in standard EN 13136:2013.

Verification of system downstream the safety valve

It is supposed to be necessary to build a discharge pipe on safety valve 3065/4C250, using 1" gas pipe with the following characteristics:

- d_{out} = 30 [mm] , inside pipe diameter
- A_{out} = 707 [mm^2] , inside pipe cross-section area
- L = 3000 [mm] , pipe length
- 90° elbow with bending radius, R, equal to three times external diameter of pipe

The following information is taken from Table 2:

- $\xi_{1\ (elbow)}$ = 0.25
- $\xi_{2\ (length)} = \lambda$ x L/ d_{out} = 0.02 x 3000/30 = 2 where λ = 0.02 for steel pipe
- $\xi_T = \xi_1 + \xi_2$ = 0,25 + 2 = 2,25

The pressure loss is given by:

$$p_1 = \sqrt{0{,}064 \times 2{,}25 \times \left(\frac{80{,}3}{707} \times 2{,}51 \times 0{,}783 \times 28{,}5 \right)^2 + 1^2} = 2{,}61 \quad \text{[bar]}$$

$$= \frac{\Delta p_{out}}{p_o} = \frac{2{,}61 - 1}{28{,}5} = 0{,}056$$

The pressure loss obtained is admissible because it is lower than the value of 0.10 indicated in standard EN 13136:2013.

EXAMPLE 2: Calculation of the flow rate (Q_{md}) and selection of the safety valve (Increase in pressure caused by internal heat source)

1 **Data for the liquid receiver**
   - Refrigerant fluid R404A
   - Pressure equipment 300 l liquid receiver
   - External surface area of the vessel 3.2 m^2

2 **Maximum allowable pressure of the liquid receiver: PS = 28 bar**

3 **Set pressure of the safety valve that must be installed on the upper crown of the liquid receiver housing: p_{set} = 28 bar**

Calculation of the valve discharge pressure under full flow exhaust conditions: using a safety valve in series 3061 with an overpressure of 10%:

$$p_0 = (p_{set} \times 1{,}1) + 1 = (28 \times 1{,}1) + 1 = 31{,}8 \cdots [barabs]$$

Calculation of minimum discharge capacity: calculation of the flow rate for the external heat source considering that there are flammable substances in such quantities as to feed a fire near the vessel to be protected.

$$Q_{md} = \frac{3600 \times \varphi \times A_{surf}}{h_{vap}} = \frac{3600 \times 10 \times 3{,}2}{67{,}28} = 1712 \cdots [Kg/h]$$

where:
- φ = density of heat flow rate, assumed to be 10 [kW/m^2]
- A_{surf} = external surface area of the vessel [m^2]
- h_{vap} = latent heat of vaporization of R404A at pressure, p_o [kJ/kg]

Sizing of minimum flow cross-section area of the safety valve: the safety valves to discharge gas or vapour at critical flow must be sized using the following formula.

$$A_c = 3{,}469 \times \frac{Q_{md}}{C \times 0{,}9 \times K_d} \times \sqrt{\frac{v_o}{p_o}} = 3{,}469 \times \frac{1712}{2{,}5 \times 0{,}9 \times 0{,}89} \sqrt{\frac{0{,}004231}{31{,}8}} = 34{,}2 \cdots [mm^2]$$

where:
- A_c = minimum net cross-section area of the valve orifice [mm^2]
- Q_{md} = minimum required discharge capacity of safety valve [kg/h]
- C = expansion rate as a function of the k coefficient in the isentropic equation for the R404A refrigerant fluid
- K_d = certified discharge ratio of safety valve 3061/4
- p_o = pressure downstream of the valve during operation [bar abs]

  v_o = specific volume of the saturated vapour upstream of the safety valve during operation. This value refers to the following operating conditions upstream of the valve:
  - Pressure, p_o = 31.8 [bar abs]
  - Temperature, T_o = 64.7 [°C] (saturation temperature)

Conclusion: the selected safety valve is model 3061/4 with the following characteristics:
- certified discharge ratio, Kd = 0.89
- nozzle cross-section area, A = 44.2 [mm^2]
- set pressure, p_{set} = 28 bar

Verification of the system upstream the safety valve

Assuming the valve installed is 3061/4C280, using a steel fitting with the following characteristics:
- d_{in} = 17 [mm] , fitting inside diameter
- A_{in} = 227 [mm^2] fitting inside cross-section area
- L = 60 [mm] , fitting length
- Receiver connection: Flush with the housing and with a sharp edge

The following data is taken from Table 2:
- $\xi_{1\ (inlet)} = 0,25$
- $\xi_{2\ (length)} = \lambda \times L/\ d_{in} = 0,02 \times 60/17 = 0,07$
  with λ = 0.02 for steel pipe
- $\xi_T = \xi_1 + \xi_2 = 0,25 + 0,07 = 0,32$

Between the valve and the fitting, an exchange valve (type 3032/44) has been installed.
The main characteristics of this valve are:
- d_R = 13 [mm] , inside valve diameter
- A_R = 132.7 [mm^2], inside valve cross-section area
- kv = 3.3 [m^3/h] , valve kv coefficient

The pressure loss coefficient ξ_R of the exchange valve is given by:

$$\zeta_R = 2,592 \times \left[\frac{132,7}{3,3}\right]^2 \times 10^{-3} = 4,19$$

Total loss coefficient: $\xi_T + \xi_R = 4.51$

Recalling the previously calculated cross-section, the characteristics of safety valve 3061/4 and refrigerant fluid R404A are:
- A_c = 34.2 [mm^2]
- K_{dr} = 0,89 x 0,9 =0,801
- C = 2,50

The pressure loss is given by:

$$\frac{\Delta p_{in}}{p_o} = 0,032 \times \left[\frac{34,2}{227} \times 2,50 \times 0,801\right]^2 \times 4,51 = 0,013$$

The pressure loss value obtained is admissible because it is lower than the value of 0.03 indicated in standard EN 13136:2013.

The calculations shown in the previous examples 1 / 2 and the results obtained are:

- The minimum discharge capacity
- The minimum cross-sectional area of the valve orifice
- The pressure loss in the upstream line
- The pressure loss in the downstream line

can be performed using the selection software.

EXAMPLE 1

PART A: Calculation of minimum flow area Ac for sizing pressure relief valve, according to EN 13136:2013 Standard

POINT A.1: Choose the refrigerant used in the system from the drop down menu

A.1

Selection of refrigerant	R407C ▾	*Choose the refrigerant from the drop down menu*
Fluid group, according to Art. 13 , Directive 2014/68/EU	2	*This datum is a function of the selected refrigerant*
Isoentropic exponent of the refrigerant , as measured at 25 °C and 1,013 bar - k	1,14	*This datum is a function of the selected refrigerant*
Function of the isoentropic exponent - C	2,51	*This datum is a function of the selected refrigerant*
Vapour density at refrigerant saturation pressure/dew point at 10 °C - ϱ10 (- 40 °C for R23 and R744)	27,45 [kg/m³]	*This datum is a function of the selected refrigerant*

The software returns you the data for the choosen refrigerant.

POINT A.2: Choose the set pressure of the safety valve from the drop down menu. It must be lower or at least equal to the PS of the system to be protected.

A.2

Selection of set pressure - Pset (NB: Pset ≤ PS of equipment to be protected)	25,0 [bar] ▾	*Choose the Pset from the drop down menu*
Actual relieving pressure - Po	28,5	*Calculated datum*
Actual back pressure - Pb	1,013 [bar ass]	*Atmospheric pressure*
Saturated temperature at Po - To	65,2 [°C]	*This datum is a function of the selected refrigerant and the selected Pset*
Specific volume of vapour at Po - Vo	0,00694 [m³/kg]	*This datum is a function of the selected refrigerant and the selected Pset*

The software returns you the data for the choosen refrigerant and set pressure.

POINT A.3: Choose a Castel safety valve

(see technical handbook for the maximum discharge capacities of Castel valve models).

A.3

Selection of Castel safety valve	3065/4	Choose the safety valve model from the drop down menu NB: if you use a fluid Group 1, you can only choose from the 3061 and 3065 valves
Flow area - A	132,7 [mm²]	This datum is a function of the selected safety valve model
Certified coefficient of discharge - Kd	0,87	This datum is a function of the selected safety valve model

The software returns you the data for the choosen safety valve.

POINT A.4: Calculations shall be based on known or assumed processes which result in increased in pressure. The processes you can choose, considered in EN 13136 Standard, are the following:

- **External heat sources**
- **Internal heat sources**
- **Increased pressure caused by a positive displacement compressor**

Depending on the process selected, the software will ask you to enter the data for the calculation of minimum required discharge capacity.

A.4

Select an option:	Excessive pressure caused by compressor (par. 6.3 of EN 13136:201	
Theoretical displacement - V [m³]	0,00149 [m³]	Enter datum
Rotational frequency - n [min-¹]	1450 [min-¹]	Enter datum
"Volumetric efficiency estimated at suction pressure and discharge pressure equivalent to the pressure relief valve setting - ηv"	0,82	Enter datum
Minimum required discharge capacity for excessive pressure caused by compressor - Qmd	2917,5 [kg/h]	Calculated datum
Calculation of minimum flow area - Ac (par. 7.2.5 of EN 13136:2013)	80,4 [mm²]	Calculated datum
Flow area-A > Flow area-Ac?	YES	Calculated datum

The selection of safety valve (point 3) is correct.

The software returns you if the choosen safety valve at point A.3 is correct or not.

PART B: Calculation of pressure loss Δp_{in} in upstream line, according to EN 13136:2013 Standard

POINT B.1: enter all the data about the upstream line: pipe dimensions, type of connection on the equipment to be protected, isolating valve model

B.1

Inside diameter of inlet tube - Din [mm]	17 [mm]	Enter datum
Length of inlet tube - Lin [mm]	60 [mm]	Enter datum
Inside area of inlet tube - Ain	227 [mm²]	Calculated datum
Connection of inlet tube *(see Table 2 on instructions)*	Flush connection broken edged	Choose the connection from the drop down menu
Pressure loss coefficient for inlet connection - ξC	0,25	This datum is a function of the selected connection
Pressure loss coefficient for inlet length - ξL	0,071	Calculated datum
Shut-off valve	3064/44	Choose the shut-off valve model from the drop down menu
Inside diameter of valve - Dvalve	13 [mm]	This datum is a function of the selected shut-off valve model
Kv factor of valve	10 [m³/h]	This datum is a function of the selected shut-off valve model
Inside area of valve - Avalve	132,7 [mm²]	Calculated datum
Pressure loss coefficient for shut-off valve - ξV	0,457	Calculated datum
Total pressure loss coefficient - ξT	0,777	Calculated datum

The software returns you the total loss coefficient in upstream line.

POINT B.2: no data entering.

B.2

Calculation of pressure loss - ΔPin (par. 7.4.3 of EN 13136:2013)	0,343 [bar]	Calculated datum
Maximum pressure loss in upstream line 0,03 x Po (par 7.4.1 of EN 13136:2013)	0,855 [bar]	Calculated datum
ΔPin < 0,03 x Po?	YES	Calculated datum

The entered data is correct.

The software returns you if the dimensioning of upstream line is correct or not.

PART C: Calculation of pressure loss Δp_{out} in downstream line, according to EN 13136:2013 Standard

POINT C.1: enter all the data about the downstream line: pipe dimensions, type of bends

C.1

Inside diameter of outlet tube - Dout [mm]	30 [mm]	*Enter datum*
Length of outlet tube - Lout [mm]	3000 [mm]	*Enter datum*
Inside area of outlet tube - Aout	706,9 [mm²]	*Calculated datum*
First bend of outlet tube *(see Table 2 on instructions)*	Pipe bend 90° Rcurve = 3 x Dpipe ▾	*Choose the pipe bend from the drop down menu*
Second bend of outlet tube (optional)	No additional bend ▾	*Choose the pipe bend from the drop down menu*
Third bend of outlet tube (optional)	No additional bend ▾	*Choose the pipe bend from the drop down menu*
Pressure loss coefficient for outlet bends - ξB	0,25	*This datum is a function of the selected pipe bends*
Pressure loss coefficient for oulet length - ξL	2	*Calculated datum*
Total pressure loss coefficient - ξT	2,25	*Calculated datum*

The software returns you the total loss coefficient in upstream line.

POINT C.2: no data entering.

C.2

Calculation of pressure loss - ΔPout (par. 7.4.4 of EN 13136:2013)	2,62 [bar]	*Calculated datum*
Maximum pressure loss in downstream line 0,10 x Po (par 7.4.1 of EN 13136:2013)	2,85 [bar]	*Calculated datum*
ΔPout < 0,10 x Po?	YES	*Calculated datum*

The entered data is correct.

The software returns you if the dimensioning of downstream line is correct or not.

Now you can download the PDF of the calculation sheets: Part A , Part B and Part C.

EXAMPLE 2

PART A: Calculation of minimum flow area Ac for sizing pressure relief valve, according to EN 13136:2013 Standard

POINT A.1: Choose the refrigerant used in the system from the drop down menu

A.1

Selection of refrigerant	R404A	Choose the refrigerant from the drop down menu
Fluid group, according to Art. 13 , Directive 2014/68/EU	2	This datum is a function of the selected refrigerant
Isoentropic exponent of the refrigerant , as measured at 25 °C and 1,013 bar - k	1,12	This datum is a function of the selected refrigerant
Function of the isoentropic exponent - C	2,5	This datum is a function of the selected refrigerant
Vapour density at refrigerant saturation pressure/dew point at 10 °C - ϱ_{10} (- 40 °C for R23 and R744)	41,66 [kg/m^3]	This datum is a function of the selected refrigerant

The software returns you the data for the choosen refrigerant.

POINT A.2: Choose the set pressure of the safety valve from the drop down menu.
It must be lower or at least equal to the PS of the system to be protected.

A.2

Selection of set pressure - Pset (NB: Pset ≤ PS of equipment to be protected)	28,0 [bar]	Choose the Pset from the drop down menu
Actual relieving pressure - Po	31,8	Calculated datum
Actual back pressure - Pb	1,013 [bar ass]	Atmospheric pressure
Saturated temperature at Po - To	64,7 [°C]	This datum is a function of the selected refrigerant and the selected Pset
Specific volume of vapour at Po - Vo	0,00423 [m^3/kg]	This datum is a function of the selected refrigerant and the selected Pset

The software returns you the data for the choosen refrigerant and set pressure.

POINT A.3: Choose a Castel safety valve

(see technical handbook for the maximum discharge capacities of Castel valve models).

A.3

Selection of Castel safety valve	3061/4	Choose the safety valve model from the drop down menu NB: if you use a fluid Group 1, you can only choose from the 3061 and 3065 valves
Flow area - A	44,2 [mm²]	This datum is a function of the selected safety valve model
Certified coefficient of discharge - Kd	0,89	This datum is a function of the selected safety valve model

The software returns you the data for the choosen safety valve.

POINT A.4: Calculations shall be based on known or assumed processes which result in increased in pressure. The processes you can choose, considered in EN 13136 Standard, are the following:

- **External heat sources**
- **Internal heat sources**
- **Increased pressure caused by a positive displacement compressor**

Depending on the process selected, the software will ask you to enter the needed data for the calculation of minimum required discharge capacity.

A.4

Select an option:	External heat source (par. 6.2.1 of EN 13136:2013)	
External surface of vessel to be protected - Asurf [m²]	3,2 [m²]	Enter datum
Density of flow rate - ϕ	10 [kW/m²]	Value defined in EN 13136 Standard
Heat of vaporisation - hvap	67,28 [kJ/kg]	This datum is a function of the selected refrigerant and the selected Pset
Minimum required discharge capacity for external heat source - Qmd	1712,2 [kg/h]	Calculated datum
Calculation of minimum flow area - Ac (par. 7.2.5 of EN 13136:2013)	34,2 [mm²]	Calculated datum
Flow area-A > Flow area-Ac?	YES	Calculated datum

The selection of safety valve (point 3) is correct.

The software returns you if the choosen safety valve at point A.3 is correct or not.

PART B: Calculation of pressure loss Δp_{in} in upstream line, according to EN 13136:2013 Standard

POINT B.1: enter all the data about the upstream line: pipe dimensions, type of connection on the equipment to be protected, isolating valve model

B.1

Inside diameter of inlet tube - Din [mm]	17 [mm]	*Enter datum*
Length of inlet tube - Lin [mm]	60 [mm]	*Enter datum*
Inside area of inlet tube - Ain	227 [mm²]	*Calculated datum*
Connection of inlet tube *(see Table 2 on instructions)*	Flush connection broken edged ▼	*Choose the connection from the drop down menu*
Pressure loss coefficient for inlet connection - ξC	0,25	*This datum is a function of the selected connection*
Pressure loss coefficient for inlet length - ξL	0,071	*Calculated datum*
Shut-off valve	3032/44 ▼	*Choose the shut-off valve model from the drop down menu*
Inside diameter of valve - Dvalve	13 [mm]	*This datum is a function of the selected shut-off valve model*
Kv factor of valve	3,3 [m³/h]	*This datum is a function of the selected shut-off valve model*
Inside area of valve - Avalve	132,7 [mm²]	*Calculated datum*
Pressure loss coefficient for shut-off valve - ξV	4,193	*Calculated datum*
Total pressure loss coefficient - ξT	4,514	*Calculated datum*

The software returns you the total loss coefficient in upstream line.

POINT B.2: no data entering.

B.2

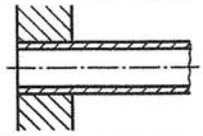
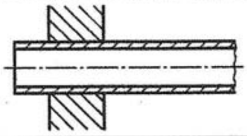
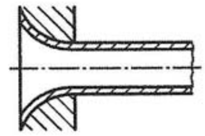
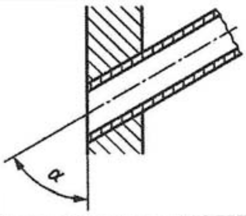
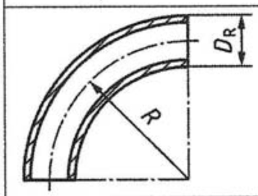
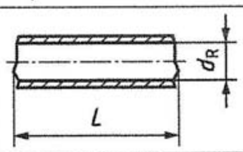
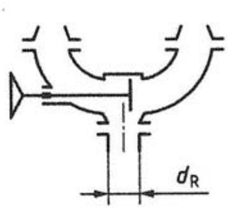
Calculation of pressure loss - ΔPin (par. 7.4.3 of EN 13136:2013)	0,418 [bar]	*Calculated datum*
Maximum pressure loss in upstream line 0,03 x Po (par 7.4.1 of EN 13136:2013)	0,954 [bar]	*Calculated datum*
ΔPin < 0,03 x Po?	YES	*Calculated datum*

The entered data is correct.

The software returns you if the dimensioning of upstream line is correct or not.

Now you can download the PDF of the calculation sheets: Part A and Part B.

TABLE 2 – Pressure loss coefficients of a single component ζ_n

Pipe elements		Flush connection	Very sharp edged $\zeta_n = 0{,}5$ Broken edge $\zeta_n = 0{,}25$
		Inserted connection	Very sharp edged $\zeta_n = 1$ Broken edge $\zeta_n = 0{,}56$
		Flared connection	According to the radius: Between $\zeta_n = 0{,}005$ and $\zeta_n = 0{,}06$ normally $\zeta_n = 0{,}05$ is used
		Angled flush connection	$\zeta_n = 0{,}5 + 0{,}3\cos\alpha + 0{,}2\cos^2\alpha$
		Pipe bend 90°	$R = 2D_R$ $\zeta_n = 0{,}3$ $R = 3D_R$ $\zeta_n = 0{,}25$ $R = 4D_R$ $\zeta_n = 0{,}23$ $R = 5D_R$. $\zeta_n = 0{,}18$
		Straight pipe	$\zeta_n = \lambda \times \frac{L}{d_R}$ Steel pipe $\lambda = 0{,}02$
		Valves and changeover valves	$\zeta = 2{,}592 \times \left[\frac{A_R}{K_{VS}}\right]^2 \times 10^{-3}$ $Ar = \frac{\pi \times d_R^{\ 2}}{4}$ K_{vs} or ζ shall be indicated by the manufacturer