SLOVENSKI STANDARD
SIST EN 13136:2014

01-februar-2014

Nadomešča:
SIST EN 13136:2002
SIST EN 13136:2002/A1:2005

Hladilni sistemi in toplotne črpalke - Tlačne varnostne naprave in njihove napeljave - Metode za izračun

Refrigerating systems and heat pumps - Pressure relief devices and their associated piping - Methods for calculation

Kälteanlagen und Wärmepumpen - Druckentlastungseinrichtungen und zugehörige Leitungen - Berechnungsverfahren

Systèmes de réfrigération et pompes à chaleur - Dispositifs limiteurs de pression et tuyauteries associées - Méthodes de calcul

Ta slovenski standard je istoveten z: **EN 13136:2013**

ICS:

27.080	Toplotne črpalke	Heat pumps
27.200	Hladilna tehnologija	Refrigerating technology

SIST EN 13136:2014 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13136

October 2013

ICS 27.080; 27.200

Supersedes EN 13136:2001

English Version

Refrigerating systems and heat pumps - Pressure relief devices and their associated piping - Methods for calculation

Systèmes frigorifiques et pompes à chaleur - Dispositifs de limitation de pression et tuyauteries associées - Méthodes de calcul

Kälteanlagen und Wärmepumpen - Druckentlastungseinrichtungen und zugehörige Leitungen - Berechnungsverfahren

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 13136:2013: E

Contents

Page

Foreword

This document (EN 13136:2013) has been prepared by Technical Committee CEN/TC 182 “Refrigerating systems, safety and environmental requirements”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2014, and conflicting national standards shall be withdrawn at the latest by April 2014.

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This document supersedes EN 13136:2001.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

Compared to EN 13136:2001, EN 13136:2013 takes into account the application of CO_2 and the amendment A1, published in 2005.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard is based on applicable parts of EN ISO 4126-1:2013, EN ISO 4126-2:2003 and EN 12284.

It is suited to the specific requirements, and includes the data, of refrigerating systems. It provides means of satisfying the pressure relief devices requirements of EN 378-2:2008+A2:2012.

1 Scope

1.1 This European Standard describes the calculation of mass flow for sizing pressure relief devices for components of refrigerating systems.

NOTE The term "refrigerating system" used in this European Standard includes heat pumps.

1.2 This European Standard describes the calculation of discharge capacities for pressure relief valves and other pressure relief devices in refrigerating systems including the necessary data for sizing these when relieving to atmosphere or to components within the system at lower pressure.

1.3 This European Standard specifies the requirements for selection of pressure relief devices to prevent excessive pressure due to internal and external heat sources, the sources of increasing pressure (e.g. compressor, heaters, etc.) and thermal expansion of trapped liquid.

1.4 This European Standard describes the calculation of the pressure loss in the upstream and downstream line of pressure relief valves and other pressure relief devices and includes the necessary data.

1.5 This European Standard refers to other relevant standards in Clause 5.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 378-1:2008+A2:2012, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Basic requirements, definitions, classification and selection criteria*

EN 378-2:2008+A2:2012, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 2: Design, construction, testing, marking and documentation*

EN 764-1:2004, *Pressure equipment — Part 1: Terminology — Pressure, temperature, volume, nominal size*

EN 764-2:2012, *Pressure equipment — Part 2: Quantities, symbols and units*

EN 12284:2003, *Refrigerating systems and heat pumps — Valves — Requirements, testing and marking*

EN ISO 4126-1:2013, *Safety devices for protection against excessive pressure — Part 1: Safety valves (ISO 4126-1:2013)*

EN ISO 4126-2:2003, *Safety devices for protection against excessive pressure — Part 2: Bursting disc safety devices (ISO 4126-2:2003)*

ISO 817, *Refrigerants — Designation system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 378-1:2008+A2:2012, EN 12284:2003, EN ISO 4126-1:2013, EN ISO 4126-2:2003 and EN 764-1:2004 apply.

4 Symbols

For the purposes of this document, the symbols given in EN 764-2:2012 and the following apply:

Symbol	Designation	Unit
A	Flow area of the pressure relief valve $A = \left[\frac{\pi \times d^2}{4}\right]$	mm^2
A_c	Calculated flow area	mm^2
A_{DN}	Valve cross section related to DN	mm^2
A_{in}	Inside area of inlet tube	mm^2
A_{liq}	Calculated flow area of liquid after expansion	mm^2
A_{out}	Inside area of outlet tube	mm^2
A_R	Inside area of tube	mm^2
A_{surf}	External surface area of the vessel	m^2
A_{vap}	Calculated flow area of vapour after expansion	mm^2
C	Function of the isentropic exponents (Table A.2)	–
DN	Nominal size (see EN ISO 6708:1995)	–
d	Actual most narrow flow diameter of the pressure relief valve	mm
d_c	Calculated flow diameter of the pressure relief valve	mm
d_{in}	Inside diameter of inlet tube	mm
d_{out}	Inside diameter of outlet tube	mm
D_R	Outside diameter of tube (Table A.4)	mm
d_R	Inside diameter of tube	mm
h_{vap}	Heat of vaporisation calculated at 1,1 times the set pressure of the pressure relief device (for super critical or superheated conditions see 6.1)	kJ/kg
K_b	Theoretical capacity correction factor for sub-critical flow (Table A.3)	–
K_d	Certified coefficient of discharge taking into account the backpressure ratio p_b/p_o and the possible reduced stroke of the pressure relief valve	–
K_{dr}	De-rated coefficient of discharge $[K_{dr} = K_d \times 0{,}9]$	–
K_{drl}	De-rated coefficient of discharge for liquid $[K_{drl} \approx K_{dr} \times 0{,}8]$	–
K_{vs}	Valve constant (the rate of water flow for a differential pressure Δp of 1 bar at the rated full opening)	m^3/h
K_v	Viscosity correction factor	–

K	Isentropic exponent of the refrigerant; for calculation, the value of K shall be as measured at 25 °C and 1,013 bar	–
L	Length of tube	mm
L_{in}	Length of inlet tube	mm
L_{out}	Length of outlet tube	mm
n	Rotational frequency	min^{-1}
p_{atm}	Atmospheric pressure (1 bar)	bar
p_b	Back pressure at outlet of pressure relief device, absolute	bar
p_c	Critical absolute pressure	bar
p_o	Actual relieving pressure $p_o = 1{,}1\ p_{set} + p_{atm}$	bar
p_s	Maximum allowable pressure of a component, gauge[a]	bar
p_{set}	Set pressure, gauge (the pre-determined pressure at which a pressure relief valve under operation starts to open)	bar
P_1	Pressure at the inlet to downstream line absolute (in practice = p_b)	bar
P_2	Pressure at the outlet of downstream line absolute	bar
Δp	Differential pressure	bar
Δp_{in}	Pressure loss in the upstream line of pressure relief valve	bar
Δp_{out}	Pressure loss in the downstream line of pressure relief valve	bar
Q_h	Rate of heat production, internal heat source	kW
Q_{liq}	Flow of liquid after expansion	kg/h
Q_m	Calculated refrigerant mass flow rate of the pressure relief device	kg/h
q_m	Theoretical discharge capacity	$kg/h \cdot mm^2$
q'_m	Actual discharge capacity determined by tests	$kg/h \cdot mm^2$
Q_{md}	Minimum required discharge capacity, of refrigerant, of the pressure relief device	kg/h
$Q_{md'}$	Adjusted discharge capacity of refrigerant, of the pressure relief device, used for pressure drop calculation	kg/h
Q_{vap}	Flow of vapour after expansion	kg/h
R	Bending radius of tube (Table A.4)	mm
Re	Reynolds number	–
s	Thickness of insulation	m
V	Theoretical displacement	m^3
v_o	Specific volume of vapour or liquid	m^3/kg
w_0	Actual flow speed of liquid in the smallest section of pressure relief valve	m/s
w_1	Speed at the inlet into the downstream line	m/s
x	Vapour fraction of refrigerant at p_C	–

α	Flush connection angle (Table A.4)	°
ζ	Pressure loss coefficient $\zeta = \sum_{n=1}^{n} \zeta_n$	–
ζ_{DN}	Pressure loss coefficient related to DN	–
ζ_n	Pressure loss coefficient of a single component	–
η_v	Volumetric efficiency estimated at suction pressure and discharge pressure equivalent to the pressure relief device setting	–
λ	Friction loss coefficient of tube (plain steel tube $\lambda \approx 0{,}02$)	–
ν	Kinematic viscosity	m^2/s
ρ	Density of vapour or liquid ($\rho = {}^1/v_o$)	kg/m^3
ρ_{10}	Vapour density at refrigerant saturation pressure/dew point at 10 °C	kg/m^3
φ	Density of heat flow rate	kW/m^2
φ_{red}	Reduced density of heat flow rate	kW/m^2
[a] The Pressure Equipment Directive 97/23/EC identifies the maximum allowable pressure by the symbol "PS".		

5 General

Requirements for protection against excessive pressure in refrigeration systems and heat pumps are given in EN 378-2.

For design and manufacturing of bodies, bonnets and bolts for pressure relief devices — safety valves and bursting discs — specification of strength pressure test, EN 12284 applies.

For other aspects, the requirements of EN ISO 4126-1:2013 Safety Valves, Clause 3, Terms and definitions, Clause 5, Design, Clause 7, Type tests and Clause 10, Marking and sealing and EN ISO 4126-2:2003 Bursting Disc Safety Devices, Clause 17 Marking, 17.2 Bursting discs/bursting disc assemblies and 17.3 Bursting disc holders apply.

NOTE Calculations for flow areas for non-evaporating and evaporating liquids are given in Annex B. Calculations for a pressure relief device with the corresponding pipes are given in Annex C.

6 Pressure relief devices for protection of system components

6.1 General

Calculations shall be based on known or assumed processes which result in increases in pressure. All foreseeable processes shall be considered including those covered in 6.2, 6.3 and 6.4.

For the general purposes of this European Standard, h_{vap} is calculated at 1,1 times the set pressure of the pressure relief device.

If the set pressure of the pressure relief valve times 1,1, is higher than the saturated pressure of the refrigerant at (critical temperature minus 5 [K]) then h_{vap} and v_o shall be taken at critical temperature minus 5 [K].

If the temperature, at 1,1 times the set pressure of the pressure relief device, is higher than the saturated temperature (superheated gas), then h_{vap} shall be taken at saturated condition.

In case of relieving CO_2 to a pressure below the triple point (e.g. atmospheric pressure), there is a possibility to create solid CO_2. Necessary precautions shall be taken to ensure a safe operation.

Vessels operating normally in the gas phase may however contain liquid refrigerant, which may evaporate under an external heat impact.

NOTE Vessels only containing refrigerant in the gas phase do not produce a continuous mass flow under an external heat impact.

In case of supercritical pressure, the valve shall be suitable for both gas and liquid.

6.2 Excessive pressure caused by heat sources

6.2.1 External heat sources

Where necessary the minimum required discharge capacity of the pressure relief device for pressure vessels shall be determined by the following:

$$Q_{\text{md}} = \frac{3600 \times \varphi \times A_{\text{surf}}}{h_{\text{vap}}} \quad \text{[kg/h]} \tag{1}$$

For those pressure vessels in this European Standard, the density of heat flow rate is assumed to be

$$\varphi = 10\ \text{kW/m}^2 \tag{2}$$

but a higher value shall be used if necessary.

Where the thickness(s) of the insulation of the pressure vessel is bigger than 0,04 [m] and the insulation is tested according to reaction of fire as described in EN 13501-1 and classified better than class C, a reduced density of heat flow rate can be used and determined as follows:

$$\varphi_{\text{red}} = \varphi \times \frac{0{,}04}{s}\ [\text{kW/m}^2] \tag{3}$$

The sizing of the pressure relief device and calculating of pressure loss are carried out in accordance with Clause 7.

For pressure vessels the total external surface area of the vessel shall be taken as A_{surf}.

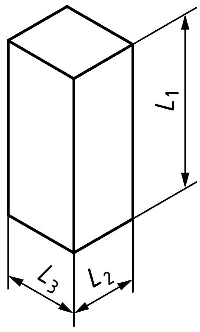

Figure 1 — Plate Heat Exchanger (PHE)

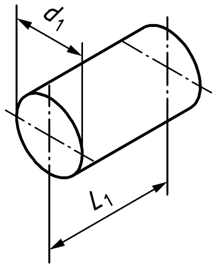

Figure 2 — Plate and Shell Heat Exchanger (PSHE)

A_{surf} of Plate Heat Exchanger will be calculated as follows:

$$A_{\text{surf}} = 2 \times (L_1 \times L_2 + L_2 \times L_3 + L_1 \times L_3) \text{ [m}^2\text{]} \quad (4)$$

A_{surf} for Plate and Shell Heat Exchanger will be calculated as follows:

$$A_{\text{surf}} = 2 \times (\pi / 4 \times d_1^{\,2}) + (\pi \times d_1 \times L_1) \text{ [m}^2\text{]} \quad (5)$$

Heat exchangers are generally considered to be vessels. Due to its unique design, some fin and tube heat exchangers in refrigeration systems may be classified according to Article 1 paragraph 2.1.2 last sentence. For further details, see guideline 2/4 of PED 97/23/EC.

Higher values for density of heat flow rate than 10 kW/m^2 may be necessary where in case of fire full engulfment for the pressure vessel is to be expected and/or in the case the pressure vessel is insulated with a flammable insulation. Other calculation methods could be necessary in case of heat radiation with a higher heat flow directed to one side of the vessel.

Where pressure vessels of a refrigerating system are protected against excessive pressure according to EN 378-2:2008+A2:2012, 6.2 and monitored according to EN 378-3:2008+A1:2012, Clause 7 and installed in special machinery rooms as specified in EN 378-3:2008+A1:2012, Clause 5, no external heat sources for sizing the pressure relief devices used for those vessels themselves may be considered. But, nevertheless, for the sizing of those pressure relief devices on the low pressure side of the refrigerating system all connected pressure vessels, compressors and pumps should be taken into account (EN 378-2:2008+A2:2012, 6.2.6.3).

Combustion heat potential of insulations in case of fire is not part of the calculations in this European Standard. Care should be taken at welding activities near insulated vessels and pipes. Electric equipment inside of the flammable insulation should be carried out according to EN 60204-1.

6.2.2 Internal heat sources

The minimum required discharge capacity of the pressure relief device for conditions which arise due to an internal source of excessive heat shall be determined by the following:

$$Q_{\text{md}} = \frac{3600 \times Q_{\text{h}}}{h_{\text{vap}}} \quad \text{[kg/h]} \quad (6)$$