

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

The European Standard EN 13136:2001, with the incorporation of amendment A1:2005, has the status of a British Standard

ICS 27.080; 27.200

National foreword

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English version

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

(includes amendment A1:2005)

Systèmes de réfrigération et pompes à chaleur - Dispositifs
de surpression et tuyauteries associées - Méthodes de
calcul
(inclut l'amendement A1:2005)

Kälteanlagen und Wärmepumpen -
Druckentlastungseinrichtungen und zugehörige Leitungen -
Berechnungsverfahren
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Foreword

This European Standard 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of an identical text or by endorsement, at the latest by November 2001, and conflicting national standards shall be withdrawn at the latest by November 2001.

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

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

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A1

This document (EN 13136:2001/A1:2005) has been prepared by the Technical Committee CEN/TC 182 "Refrigerating systems, safety and environmental requirements" the Secretariat of which is held by DIN.

This Amendment to the European Standard EN 13136:2001 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2005, and conflicting national standards shall be withdrawn at the latest by December 2005.

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Introduction

A1 This European Standard is based on applicable parts of EN ISO 4126-1:2004, 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. **A1**

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 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 A1 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. A1

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.

A1 **1.5** This European Standard refers to other relevant standards in clause 5 *General*. A1

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

A1 EN ISO 4126-1, *Safety devices for protection against excessive pressure — Part 1: Safety valves (ISO 4126-1:2004)*.

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

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

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

EN 764-2, *Pressure equipment — Part 2: Quantities, symbols and units* A1

3 Terms and definitions

A1 For the purposes of this European Standard the definitions given in EN 378-1, EN 12284, EN ISO 4126-1, EN 4126-2 and EN 764-1 apply. A1

4 Symbols

For the purposes of this standard the following symbols are used:

Symbol	Designation	Unit
A	Flow area of the pressure relief valve $\left(A = \frac{\pi \times d^2}{4} \right)$	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 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 vaporization calculated at 1,1 times the set pressure of the pressure relief device	kJ/kg
K_b	Theoretical capacity correction factor for sub-critical flow (table A.3)	—
K_d	$\left[A_1 \right]$ Certified coefficient of discharge taking into account the backpressure ratio p_b/p_0 and the possibly reduced stroke of the pressure relief valve $\left[A_1 \right]$	—
K_{dr}	Derated coefficient of discharge $(K_{dr} = K_d \times 0,9)$	—
K_{drl}	Derated 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 at the relieving inlet	—
L	Length of tube	mm
L_{in}	Length of inlet tube	mm
L_{out}	Length of outlet tube	mm
n	Rotational frequency	min ⁻¹

(continued)

Symbol	Designation	Unit
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 $p_{\text{o}} = 1,1 p_{\text{set}} + p_{\text{atm}}$	bar
p_{s}	Maximum allowable pressure of a component, gauge ^a	bar
p_{set}	Set pressure, gauge (The predetermined 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}	$\left[\frac{\text{A}_1}{\text{A}_1} \right]$ Calculated mass flow rate of refrigerant of the pressure relief device $\left[\frac{\text{A}_1}{\text{A}_1} \right]$	kg/h
q_{m}	Theoretical discharge capacity	kg/h · mm ²
q'_{m}	Actual discharge capacity determined by tests	kg/h · mm ²
Q_{md}	Minimum required discharge capacity, of refrigerant, of the pressure relief device	kg/h
Q_{vap}	Flow of vapour after expansion	kg/h
R	Bending radius of tube (table A.4)	mm
Re	Reynolds number	—
$\left[\frac{\text{A}_1}{\text{A}_1} \right] s$	Thickness of insulation	m $\left[\frac{\text{A}_1}{\text{A}_1} \right]$
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	—
(continued)		

Symbol	Designation	Unit
λ	Friction loss coefficient of tube (plain steel tube $\mu \mu 0,02$)	—
ν	Kinematic viscosity	m ² /s
ρ	Density of vapour or liquid ($\rho = 1/\nu_0$)	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 φ_{red}

^a The Pressure Equipment Directive 97/23/EC identifies the maximum allowable pressure by the symbol "PS".

5 General

φ_{red} Requirements for protection against excessive pressure in refrigeration systems and heat pumps are given in EN 378-2:2000. Devices selected in accordance with this standard shall be designed and manufactured in accordance with prEN 12284:1996, ISO/DIS 4126-1:1995 and prEN ISO 4126-2:1998. φ_{red}

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.

φ_{red} For design and manufacturing of bodies, bonnets and bolts for pressure relief device — safety valves and bursting discs — with view of strength pressure test EN 12284 applies. For other aspects the requirements of EN ISO 4126-1:2004 Safety Valves, clauses 3 Terms and definitions, 5 Design, 7 Type tests and 10 Marking and sealing and EN ISP 4126-2:2003 Bursting Disc Safety Devices, clauses 17 Marking, 17.2 Bursting discs/bursting disc assemblies and 17.3 Bursting disc holders apply. φ_{red}

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 purposes of this standard h_{vap} is calculated at 1,1 times the set pressure of the pressure relief device.

6.2 Excessive pressure caused by heat sources

6.2.1 External heat sources

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

$$Q_{md} = \frac{3\,600 \times \varphi \times A_{surf}}{h_{rap}} \text{ [hg/h]} \quad (1)$$

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

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

but a higher value shall be used if necessary. φ_{red}

[A1] For pressure vessels the total external surface area of the vessel shall be taken as A_{surf} . For fin and tube heat exchangers the sum of the face areas of all sides shall be taken as A_{surf} .

NOTE 1 Higher values for density of heat flow rate than 10 kW/m^2 may be assumed where in case of fire full engulfment for the pressure vessel is to except and/or in the case the pressure vessel is insulated a flammable insulation is used.

NOTE 2 Where pressure vessels of a refrigerating system are protected against excessive pressure according to prEN 378-2:2003, clause 7.2 and monitored according to prEN 378-3:2003, clause 7 and installed in machinery rooms as specified in prEN 378-3:2003, clause 5, none 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 (prEN 378-2:2003, clause 6.2.6.3).

NOTE 3 Combustion heat potential of insulations in case of fire is none part of calculations in this 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.

NOTE 4 Where the thickness of the insulation of the pressure vessel is bigger than $s = 0,04 \text{ m}$ 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:

$$\varphi_{\text{red}} = \varphi \times \frac{0,04}{s} [\text{kW/m}^2] \quad \text{[A1]}$$

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

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:

$$Q_{\text{md}} = 3600 \times \frac{Q_{\text{h}}}{h_{\text{vap}}} \quad [\text{kg/h}] \quad (2)$$

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

6.3 Excessive pressure caused by compressors

The minimum required discharge capacity of the pressure relief device for excessive pressure caused by compressors shall be determined by the following:

$$Q_{\text{md}} = 60 \times V \times n \times \varphi_{10} \times \eta_v \quad \text{kg/h} \quad (3)$$

NOTE 1 In cases where discharge shut-off valves are not fitted, a high pressure relief device will suffice, providing there are no intermediate shut-off valves.

NOTE 2 Non-positive displacement compressors need not have a pressure relief device providing it is not possible to exceed the maximum allowable pressure.

NOTE 3 Relieving to the low pressure side may cause compressor overheating.

NOTE 4 The setting of a compressor pressure limiter will be above the maximum allowable pressure of the system and does therefore not serve as protection of the entire system.

NOTE 5 prEN 12693:1996 covers compressors which can run against a closed discharge valve. prEN 12693:1996 should, therefore, be considered, especially the requirement covering conditions under which the allowable evaporating temperature exceeds the value of $10 \text{ }^\circ\text{C}$ by more than 5 K .

The sizing of the pressure relief device and the calculation of the pressure loss shall be carried out in accordance with clause 7.