SLOVENSKI STANDARD
oSIST prEN ISO 24664:2021

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Hladilni sistemi in toplotne črpalke - Tlačne varnostne naprave in njihove napeljave - Metode za izračun (ISO/DIS 24664:2021)

Refrigerating systems and heat pumps - Pressure relief devices and their associated piping - Methods for calculation (ISO/DIS 24664:2021)

Kälteanlagen und Wärmepumpen - Druckentlastungseinrichtungen und zugehörige Leitungen - Berechnungsverfahren (ISO/DIS 24664:2021)

Systèmes frigorifiques et pompes à chaleur - Dispositifs de limitation de pression et tuyauteries associées - Méthodes de calcul (ISO/DIS 24664:2021)

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ICS:

27.080	Toplotne črpalke	Heat pumps
27.200	Hladilna tehnologija	Refrigerating technology

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

Systèmes de réfrigeration et pompes à chaleur — Dispositifs de surpression et tuyauteries associèes — Méthodes de calcul

ICS: 27.200; 27.080

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Foreword

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This document was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 182, *Refrigerating systems, safety and environmental requirements*, in collaboration with ISO Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 1, *Safety and environmental requirements for refrigerating systems*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement). Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This first edition cancels and replaces EN 13136:2013+A1:2018, which has been technically revised.

Introduction

This International Standard is based on applicable parts of ISO 4126-1:2013, ISO 4126-2:2018 and ISO/FDIS 21922:2021.

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 378-2:2016 and ISO 5149-2:2014.

1 Scope

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

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

1.2 This International 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 part of the refrigerating system at lower pressure.

1.3 This International 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 International Standard describes the calculation of the pressure loss in the inlet and outlet lines of pressure relief valves and other pressure relief devices and includes the necessary data.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/FDIS 21922:2020, *Refrigerating systems and heat pumps — Valves — Requirements, testing and marking*

ISO 4126-1:2013+Amd 1:2016, *Safety devices for protection against excessive pressure — Part 1: Safety valves*

ISO 4126-2:2018, *Safety devices for protection against excessive pressure — Part 2: Bursting disc safety devices*

ISO 817, *Refrigerants — Designation system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/FDIS 21922:2020, ISO 4126-1:2013 and ISO 4126-2:2018 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
refrigerant
fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and rejects heat at a higher temperature and a higher pressure usually involving changes of the state of the fluid

3.2
part of the refrigerating system
several components assembled together and exposed to the same pressure in operation or pressure source, respectively, as determined by the manufacturer

3.3
pressure relief device
pressure relief valve or bursting disc device designed to relieve excessive pressure automatically

3.4
pressure relief valve
pressure actuated valve held shut by a spring or other means and designed to relieve excessive pressure automatically by starting to open at a set pressure and re-closing after the pressure has fallen below the set pressure

Note 1 to entry: For the purpose of this standard, the definition of a safety valve as given in ISO 4126-1 is regarded equivalent to a pressure relief valve.

3.5
pressure vessel
any refrigerant-containing component of a refrigerating system other than:

- coils (including their headers) consisting of pipes with air as secondary fluid;
- piping and its valves, joints and fittings;
- control devices;
- pressure switches, gauges, liquid indicators;
- safety valves, fusible plugs, bursting discs;
- equipment comprising casings or machinery where the dimensioning, choice of material and manufacturing rules are based primarily on requirements for sufficient strength, rigidity and stability to meet the static and dynamic operational effects or other operational characteristics and for which pressure is not a significant design factor. Such equipment may include: pumps and compressors.

Note 1 to entry: The semi-hermetic and open type compressors used in refrigerating systems may be subject to the exclusion article 1.2.j of the EU Directive 2014/68/EU by referring to the working party group guidelines WPG 1/11, 1/12 and

2/34. The compressor manufacturer has to decide on the basis of a case by case assessment, if the exclusion article 1.2.j of the EU Directive 2014/68/EU is applicable.

Note 2 to entry: This definition is aligned to EU Directive 2014/68 EU.

4 Symbols

For the purposes of this document, the following apply:

Symbol	Designation	Unit
A_{actual}	Actual flow area of the pressure relief device. The flow area at the most narrow cross section when the pressure relief device is fully open	mm²
$A_{effective}$	Effective area of the pressure relief device	mm²
A_{liq}	Calculated flow area of liquid after expansion	mm²
A_R	Inside area of tube	mm²
A_{surf}	External surface area of the vessel	m²
A_{vap}	Calculated flow area of vapour after expansion	mm²
DN	Nominal size (see ISO 6708:1995)	–
d	Actual most narrow flow diameter of the pressure relief device	mm
d_R	Inside diameter of tube	mm
f	Darcy friction factor	-
Δh_{vap}	Heat of vaporisation	kJ/kg
K_{cap}	Capacity correction factor	–
K_d	Certified coefficient of discharge considering the backpressure ratio p_b/p_0 and the possible reduced stroke of the pressure relief valve	–
K_{dr}	De-rated coefficient of discharge	–
K_{drl}	De-rated coefficient of discharge for liquid	–
K_{vs}	Valve constant (the rate of water flow for a pressure loss of 1 bar at the rated full opening)	m^3/h
K_{visc}	Viscosity correction factor	–
L	Length of pipe	mm
n	Rotational frequency	min^{-1}
p_{atm}	Atmospheric pressure (1,01325 bar)	bar
p_b	Back pressure at outlet of pressure relief device, absolute	bar
p_c	Critical absolute pressure	bar
$p_{connection}$	Pressure in connection point	bar
p_0	Actual absolute relieving pressure	bar
p_1	Absolute pressure at the inlet to the outlet line of the pressure relief device	bar

Symbol	Designation	Unit
$p_{r,choked}$	Choked pressure ratio	–
p_{set}	Set pressure, gauge (the pre-determined pressure at which a pressure relief device under operation starts to open)	bar
Δp	Pressure loss	bar
Δp_{common}	Pressure loss in common outlet line	bar
Δp_{in}	Pressure loss in the inlet line to the pressure relief device	bar
Δp_{out}	Pressure loss in the outlet line from the pressure relief device	bar
Q_h	Rate of heat production, internal heat source	kW
q_m	Theoretical discharge capacity	kg/h · mm²
q'_m	Actual discharge capacity determined by tests	kg/h · mm²
$Q_{m, adjusted}$	Adjusted discharge capacity, of the pressure relief device. Used for pressure drop calculation in piping	kg/h
$Q_{m, common}$	Mass flow in common outlet pipe	kg/h
$Q_{m, liq}$	Flow of liquid after expansion	kg/h
$Q_{m, relief}$	Calculated refrigerant mass flow rate of the pressure relief device	kg/h
$Q_{m, required}$	Minimum required discharge capacity, of refrigerant, of the pressure relief device	kg/h
$Q_{m, vap}$	Flow of vapour after expansion	kg/h
R	Bending radius of bend	mm
Re	Reynolds number	–
s	Thickness of insulation	m
u	Velocity in pipe	m/s
V	Theoretical displacement	m³
v	Specific volume of vapour or liquid	m³/kg
v_0	Specific volume of vapour in inlet line	m³/kg
v_1	Specific volume at the inlet to the outlet line of the pressure relief device	m³/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 outlet line	m/s
x	Vapour fraction of refrigerant at p_b	–
α	Flush connection angle	°
γ	Heat capacity ratio	–
ε_R	Pipe roughness	mm
ζ	Pressure loss coefficient	–

Symbol	Designation	Unit
ζ_{DN}	Pressure loss coefficient related to DN	–
$\zeta_{fittings}$	Pressure loss coefficient of fittings	–
ζ_{pipes}	Pressure loss coefficient of pipes in outlet line	–
ζ_{total}	Total pressure loss coefficient in outlet line	–
η_v	Volumetric efficiency estimated at suction pressure and discharge pressure equivalent to the pressure relief device setting	–
ν	Kinematic viscosity	m^2/s
ρ	Density of vapour or liquid	kg/m^3
ρ_0	Density of vapour in inlet line	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

5 General

This international standard describes the calculation of:

- The required discharge capacity of a pressure relief device.
- The actual capacity of a pressure relief device.
- Pressure losses in inlet and outlet lines from the pressure relief device.

The capacity of the pressure relief device (calculated in Clause 7), shall be larger than the required capacity (calculated in Clause 6), and the pressure losses (calculated in Clause 8) shall be within given limits for the pressure relief device to operate correctly.

The equations in Clause 7 are only valid for discharge of refrigerant gas or vapour.

NOTE 1 Calculations of flow areas for pressure relief devices for non-flashing and flashing liquids are given in Annex B. Example calculations with corresponding piping are given in Annex C.

NOTE 2 Requirements for protection against excessive pressure in refrigerating systems and heat pumps are given in EN 378-2 and ISO 5149-2.

For design and manufacturing of bodies, bonnets and bolts for pressure relief devices — safety valves and bursting discs — specification of strength pressure test, ISO/FDIS 21922:2020 applies.

For other aspects, the requirements of ISO 4126-1:2013, Clause 3, Terms and definitions, Clause 5, Design, Clause 7, Type tests and Clause 10, Marking and sealing and ISO 4126-2:2018 Bursting Disc Safety Devices, Clause 17 Marking, 17.2 Bursting discs/bursting disc assemblies and 17.3 Bursting disc holders apply.

5.1 Refrigerant properties used in calculations

The actual absolute relieving pressure of a pressure relief device is calculated as:

$$p_0 = 1{,}1 \cdot p_{set} + p_{atm} \quad \text{[bar]} \tag{1}$$

For calculation of the required discharge capacity of a pressure relief device, knowledge of the heat of vaporisation Δh_{vap} of the refrigerant is required.

For calculation of the actual discharge capacity of a pressure relief device, knowledge of the density ρ_0 (or specific volume v_0) and the heat capacity ratio γ of the refrigerant is required.

For calculation of pressure losses in inlet and outlet piping, knowledge of the density ρ_0 (or specific volume v_0) is required.

The values are found at the following conditions:

- If the pressure p_0 is less than the critical pressure of the refrigerant:
  - If the saturated gas temperature corresponding to p_0 is higher than the critical temperature minus 5 K, then ρ_0, v_0 and Δh_{vap} are found at saturated gas at critical temperature minus 5 K.
  - Else ρ_0, v_0 and Δh_{vap} are found at saturated gas at pressure p_0. If the inlet temperature is given (superheated gas), then ρ_0, v_0 and Δh_{vap} are found at pressure p_0 and the inlet temperature.
- If the pressure p_0 is higher than the critical pressure of the refrigerant, then ρ_0, v_0 and Δh_{vap} are found at saturated gas at critical temperature minus 5 K.

The value of the heat capacity ratio γ shall be found at 25 °C and 1,01325 bar. Values of γ for different refrigerants can be found in Table A.1.

6 Minimum required discharge capacity for protection of parts of a refrigerating system

6.1 General

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

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

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 safe operation.

Even if a vessel contains only gas, it might in some situations contain liquid and should therefore for the purpose of this standard be treated as a vessel containing both liquid and gas.

6.2 Excessive pressure caused by heat sources

6.2.1 External heat sources

The minimum required discharge capacity of the pressure relief device for pressure vessels is calculated as:

$$Q_{m,required} = \frac{3600 \cdot \phi \cdot A_{surf}}{\Delta h_{vap}} \text{ [kg/h]} \qquad (2)$$

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

$$\phi = 10 \text{ kW/m}^2 \qquad (3)$$

but a higher value shall be used if necessary.