SLOVENSKI STANDARD
SIST EN 17527:2022

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Kriostati za helij - Zaščita pred prekoračitvijo tlaka

Helium cryostats - Protection against excessive pressure

Helium Kryostate - Schutz gegen Drucküberschreitung

Cryostats pour hélium - Protections contre les surpressions

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23.020.40	Proti mrazu odporne posode (kriogenske posode)	Cryogenic vessels

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Helium cryostats - Protection against excessive pressure

Cryostats pour hélium - Protection contre les surpressions

Helium Kryostate - Schutz gegen Drucküberschreitung

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COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (EN 17527:2021) has been prepared by Technical Committee CEN/TC 268 "Cryogenic vessels and specific hydrogen technologies applications", the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by June 2022, and conflicting national standards shall be withdrawn at the latest by June 2022.

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Introduction

Helium cryostats, other than cryogenic vessels used for storage of cryogenic liquids covered by EN ISO 21009-2 and EN 13458, include additional specific components such as superconducting magnets and cavities, electrical heaters, heat exchangers, bellows, circulation pumps and internal control valves. These components imply additional risks for sudden excessive pressure rise, which strongly influences the design of pressure relief systems and is not covered by existing standards. Helium cryostats are characterized by a variety of complex and individual design solutions, often exploiting small design margins for cutting-edge performance. Therefore, a common and specific technical solution for the protection against excessive pressure rise cannot be standardized. Rather, the approach on how to obtain the state-of-the-art protection can be standardized and therefore is covered by this document, specifying the procedure and minimum requirements for the various aspects in the main part of the document. Additional information, example solutions and exemplary measures are provided in the extensive Annex, which mirrors the structure of the main part.

This document covers the typical sources that can lead to excessive pressure rise in helium cryostats and the conditions, which are relevant for the protection against excessive pressure rise during system failures, in order to harmonize risk assessments and design best practices. The document uses common SI-based units.

The user of this document can refer to CEN/CENELEC Internal Regulations Part 3, which deals with the use of verbal forms for the formulation of provisions.

1 Scope

This document specifies the minimum requirements for the protection of helium cryostats against excessive pressure rise, including the specific risks associated with cryostats for superconducting magnets and cryostats for superconducting radio-frequency cavities, coldboxes of helium refrigerators and liquefiers as well as helium distribution systems including valve boxes. It includes information on risk assessment, protection concepts, dimensioning of pressure relief devices, types of pressure relief devices, substance release and operation of helium cryostats.

In order to fulfil the aim of this document, the characteristics of pressure relief devices are taken into account.

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.

EN 13445-2, *Unfired pressure vessels - Part 2: Materials*

EN 13445-3, *Unfired pressure vessels - Part 3: Design*

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

EN ISO 4126-3:2020, *Safety devices for protection against excessive pressure - Part 3: Safety valves and bursting disc safety devices in combination (ISO 4126-3:2020)*

EN ISO 4126-6:2014, *Safety devices for protection against excessive pressure - Part 6: Application, selection and installation of bursting disc safety devices (ISO 4126-6:2014)*

EN ISO 21013-3:2016, *Cryogenic vessels - Pressure-relief accessories for cryogenic service - Part 3: Sizing and capacity determination (ISO 21013-3:2016)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

3.1
relevant national third party
inspection body authorized by national regulations

3.2
back pressure
p_b
pressure existing at the outlet of a pressure relief device during discharge as a result of the pressure in the downstream system

Note 1 to entry: The back pressure is the sum of the superimposed and built-up back pressures.

[SOURCE: EN ISO 4126-1:2013, 3.11, modified]

3.3
bath cooling
cooling method in which the object to be cooled is submerged in a vessel filled with a liquid cooling medium

Note 1 to entry: The enthalpy of evaporation is used for cooling, with the phase change providing a nearly constant cooling temperature.

3.4
blowdown
Δp_{reseat}
difference between set and reseating pressure

[SOURCE: EN ISO 4126-1:2013, 3.15]

3.5
build up back pressure
Δp_{bb}
pressure existing at the outlet of a pressure relief device caused by flow through the device and the downstream system

[SOURCE: EN ISO 4126-1:2013, 3.12, modified]

3.6
bursting pressure
p_{burst}
value of the differential pressure between the upstream side and the downstream side of the bursting disc when it bursts

[SOURCE: EN ISO 4126-2:2019, 3.10]

3.7
chattering
unstable discharge of a pressure relief valve characterised by high frequency opening and closing

3.8
coincident temperature
temperature of the bursting disc associated with a bursting pressure

[SOURCE: EN ISO 4126-2:2019, 3.14, modified]

3.9
coldbox
cryostat of a helium refrigerator or liquefier, where the cooling power and the low temperatures are being generated

3.10
cryogenic fluid
fluid with a normal boiling point below 120 K respectively −153 °C

3.11
cryogenics
subject of technologies, procedures and equipment for temperatures below 120 K

3.12
cryostat
vacuum-insulated device for the operation of components at cryogenic temperatures using cryogenic fluids

Note 1 to entry: A cryostat is considered as an assembly.

3.13
current lead
electrical connection between an ambient temperature power supply unit and a low temperature superconducting magnet for charging, operating and discharging the magnet

Note 1 to entry: In larger systems, current leads are actively cooled due to the high thermal conduction and the large temperature gradient. The current lead consists of e.g. a copper part as electrical conductor and a heat exchanger for cooling.

3.14
dewar
vacuum-insulated storage and transport container for cryogenic fluids

3.15
driven mode
<superconducting magnet> operation of a magnet by a power supply unit, where the magnet is always connected to the power supply unit or, in the event of quench, to an external protective circuit or a discharge resistor

3.16
full-lift pressure relief valve
PRV
PRV that opens instantaneously within 5 % of the pressure increase up to the design limited lift

Note 1 to entry: The proportion of the lift up to the instantaneous opening (proportional range) may not exceed 20 % of the total lift.

3.17
helium guard
barrier gas volume to avoid atmospheric gas leaks into sub-atmospheric helium systems

3.18
leak rate
pV throughput of a specific fluid which flows through a leak under specific conditions

Note 1 to entry: In vacuum technology and cryogenics, a leak rate is commonly expressed in the unit mbar l/s.

[SOURCE: EN ISO 20484:2017, 4.3.5]

3.19
maximum allowable pressure
p_s
maximum gauge pressure for which the equipment is designed, as specified by the manufacturer

[SOURCE: EN ISO 4126-1:2013, 3.6, modified]

3.20
maximum credible incident
MCI
worst incident within the realm of possibility that has a propensity to cause significant damage

Note 1 to entry: The MCI is the design basis for the dimensioning of the primary pressure relief device (PRD).

3.21
multi-layer insulation
MLI
very effective thermal insulation method used in cryogenics, which significantly reduces the heat transport caused by thermal radiation

Note 1 to entry: MLI consists of multiple layers of highly reflective films enclosing the cryogenic components. MLI is used along with vacuum insulation.

3.22
nominal operating pressure
$p_{operate}$
pressure expected during nominal operation

3.23
overpressure
Δp_{over}
pressure increase over the set pressure

[SOURCE: EN ISO 4126-1:2013, 3.7]

3.24
performance tolerance
Δp_{burst}
range of pressure between the specified minimum bursting pressure and the specified maximum bursting pressure, or the range of pressure in positive and negative percentages or quantities which is related to the specified bursting pressure

[SOURCE: EN ISO 4126-2:2019, 3.15]

3.25
persistent mode
<superconducting magnet> magnet operation without connection to a power supply unit, where the power supply unit is disconnected after charging the magnet and the superconducting magnet operates in short-circuit mode

3.26
pV throughput
rate at which a volume of gas at specified pressure passes a given cross-section of the system

Note 1 to entry: The pV throughput is expressed in mbar l/s.

[SOURCE: EN ISO 20484:2017, 4.2.3, modified]

3.27
quench
<superconducting magnet> spontaneous transition of a superconductor from the superconducting state to the normal conducting state

3.28
relieving pressure
p_0
pressure used for the sizing of pressure relief devices

Note 1 to entry: For a pressure relief valve the relieving pressure is greater than or equal to the set pressure plus overpressure.

[SOURCE: EN ISO 4126-1:2013, 3.10, modified]

3.29
reseating pressure
p_{reseat}
value of the inlet static pressure at which the disc re-establishes contact with the seat or at which the lift becomes zero

[SOURCE: EN ISO 4126-1:2013, 3.8, modified]

3.30
set pressure
p_{set}
predetermined gauge pressure at which the pressure relief valve commences to open

Note 1 to entry: It is the gauge pressure measured at the valve inlet at which the pressure forces tending to open the valve for the specific service conditions are in equilibrium with the forces retaining the valve disc on its seat.

[SOURCE: EN ISO 4126-1:2013, 3.5, modified]

3.31
specified bursting pressure

$p_{burst,sp}$

bursting pressure quoted with a fixed coincident temperature when defining the bursting disc requirements, used in conjunction with a performance tolerance

[SOURCE: EN ISO 4126-2:2019, 3.11, modified]

3.32
specified maximum bursting pressure

$p_{burst,max}$

maximum pressure quoted with a fixed coincident temperature when defining the bursting disc requirements (used in conjunction with minimum bursting pressure)

[SOURCE: EN ISO 4126-2:2019, 3.12, modified]

3.33
specified minimum bursting pressure

$p_{burst,min}$

minimum pressure quoted with a fixed coincident temperature when defining the bursting disc requirements (used in conjunction with maximum bursting pressure)

[SOURCE: EN ISO 4126-2:2019, 3.13, modified]

3.34
superconducting magnet

magnet whose coils are cooled to a temperature at which the conductor becomes superconducting, effectively removing electrical resistance

3.35
superimposed back pressure

p_{bs}

initial pressure existing at the outlet of a pressure relief device in the absence of flow at the time when the device is required to operate

[SOURCE: EN ISO 4126-1:2013, 3.13, modified]

3.36
test pressure

p_{test}

pressure to which the equipment is subjected for test purposes

[SOURCE: EN 764-1:2015+A1:2016]

3.37
thermal acoustic oscillation

resonant gas oscillation building up spontaneously within a connecting tube between high and low temperature levels