



DPC: 25/30457731 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 14 February 2025

Origin: European

Latest date for receipt of comments: 09 April 2025

Project No. 2022/01420

Responsible committee: PVE/18 Cryogenic vessels

Interested committees:

Title: Draft BS EN ISO 21013-3 Cryogenic vessels - Pressure-relief accessories for cryogenic service. Part 3: Sizing and capacity determination.

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD. THIS DRAFT IS NOT CURRENT BEYOND 09 April 2025

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <https://standardsdevelopment.bsigroup.com/>.

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 21013-3

Cryogenic vessels — Pressure-relief accessories for cryogenic service —

Part 3: Sizing and capacity determination

*Réceptacles cryogéniques — Dispositifs de sécurité pour le service
cryogénique —*

Partie 3: Détermination de la taille et du volume

ICS: 23.020.40

ISO/TC 220

Secretariat: **AFNOR**

Voting begins on:
2025-02-14

Voting terminates on:
2025-05-09

This document is circulated as received from the committee secretariat.

ISO/CEN PARALLEL PROCESSING

THIS DOCUMENT IS A DRAFT CIRCULATED FOR COMMENTS AND APPROVAL. IT IS THEREFORE SUBJECT TO CHANGE AND MAY NOT BE REFERRED TO AS AN INTERNATIONAL STANDARD UNTIL PUBLISHED AS SUCH.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

Reference number
ISO/DIS 21013-3:2025(en)

Full document details: 25/30457731 DC

© ISO 2025



Documents

Document Sharing Hub



COPYRIGHT PROTECTED DOCUMENT

© ISO 2025

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword	v
1 Scope	1
2 Normative references	2
3 Symbols	2
4 Calculation of the total quantity of heat transferred per unit time from the hot wall (outer jacket) to the cold wall (inner vessel)	6
4.1 General	6
4.2 Under conditions other than fire	6
4.2.1 Vacuum-insulated vessels under normal vacuum	6
4.2.2 Pressure build-up device	7
4.2.3 Vacuum-insulated vessels in the case of loss of vacuum and non-vacuum insulated vessels	7
4.2.4 Supports and piping	8
4.3 Under fire conditions	9
4.3.1 Insulation system remains fully or partially in place during fire conditions	9
4.3.2 Insulation system does not remain in place during fire conditions	9
4.4 Air or Nitrogen condensation	10
4.4.1 General	10
4.4.2 Loss of vacuum with air and nitrogen	10
4.4.3 Fire with loss of vacuum with air or nitrogen	10
4.5 Heat transfer per unit time (watts)	11
4.5.1 General	11
4.5.2 Normal operation	11
4.5.3 Pressure build up regulator fully open	12
4.5.4 Loss of vacuum condition	12
4.5.5 Fire condition with loss of vacuum, vacuum jacket, and insulation fully or partially in place	12
4.5.6 Fire condition with loss of vacuum, insulation not in place	13
4.5.7 Total heat transfer rate	13
5 Calculation of the mass flow to be relieved by pressure relief devices	13
5.1 Relieving pressure, P , less than the critical pressure	13
5.2 Relieving pressure, P , equal to or greater than the critical pressure	14
5.3 Example	14
6 Piping for pressure relief devices	15
6.1 Pressure drop	15
6.1.1 General	15
6.1.2 Relief valves	15
6.1.3 Bursting discs	15
6.2 Back pressure consideration	15
6.3 Heat transfer	15
7 Sizing of pressure relief devices	17
7.1 General	17
7.2 Sizing of pressure relief valves	17
7.2.1 Discharge capacity	17
7.2.2 Determination of critical vs. subcritical flow for gases	17
7.2.3 Critical flow	17
7.2.4 Subcritical flow	19
7.2.5 Recommended analysis method	19
7.2.6 Example	21
7.3 Sizing of bursting discs	26
7.3.1 Discharge capacity	26
7.3.2 Determination of critical vs. subcritical flow for gases	26
7.3.3 Critical flow	27

ISO/DIS 21013-3:2025(en)

7.3.4	Subcritical flow.....	27
7.3.5	Recommended analysis method.....	27
7.3.6	Example	30
Annex A (informative) Cryostats.....		34
Annex ZA (informative) Relationship between this European Standard and the essential requirements of Directive 2014/68/UE (Pressure Equipment Directive) aimed to be covered.....		35
Bibliography.....		36

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 220, *Cryogenic Vessels*.

This third edition cancels and replaces the second edition (ISO 21013-3:2016), which has been technically revised.

The main changes are as follows:

- Precision added on the total outer surface area of the pipe network containing flow of fluid,
- Inclusion of the coefficient of discharge symbol,
- Precision added on the overall convective heat transfer coefficient of the ambient air vaporizer,
- Additional information added on the fire case and PBU conditions,
- Correction of the molar mass in kg/kmol and modification of [formulas 32](#) and [43](#),
- Supplementary information added on cryostats mentioned in this standard.

A list of all parts in the ISO 21013 series can be found on the ISO website.

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.

Cryogenic vessels — Pressure-relief accessories for cryogenic service —

Part 3:
Sizing and capacity determination

1 Scope

This part of ISO 21013 provides separate calculation methods for determining the required mass flow to be relieved for each specified conditions described in the following table:

Condition	Type of insulation system:	Vacuum status:	Inner ves-sel temper-ature:	Insulation system (outer jacket + insulating material) condition:	Ambient conditions:	Pressure buildup system con-dition:	Use clauses including any sub-clauses
1	non-vacu-um	N/A	temperature of the con-tents at the specified relieving pressure	intact	normal (ambient tempera-ture)	normal con-dition	4.2.3/4.2.4/4.5.1/4.5.2/4.5.7/5/6/7
2				fully or partially in place	fire (922 K)		4.3.1/4.5.1/4.5.7/5/6/7
3	intact	normal (ambient tempera-ture)		full open	4.2.1/4.2.4/4.5.1/4.5.2/4.5.7/5/6/7		
4					4.2.1/4.2.2/4.2.4/4.5.1/4.5.3/4.5.7/5/6/7		
5	loss of vacuum	fire (922 K)		normal con-dition	4.2.3/4.2.4/4.5.1/4.5.4/4.5.7/5/6/7		
6					fully or partially in place	4.3.1/4.4.3/4.5.1/4.5.5/4.5.7/5/6/7	
7	intact	normal (ambient tempera-ture)	normal con-dition		4.4.2/4.5.1/4.5.4/4.5.7/5/6/7		
8					4.4.3/4.5.1/4.5.5/4.5.7/5/6/7		
9	vacu-um and non-vacu-um	loss of vacuum with air or nitrogen in the vacu-um space	contents with reliev-ing temper-ature below 75 K		totally lost	fire (922 K)	4.5.1/4.5.6/4.5.7/5/6/7

Good engineering practice based on well-established theoretical physical science needs to be adopted to determine the required mass flow where an appropriate calculation method is not provided for an applicable condition.

Recommendations for pressure relief devices for cryostats are given in [Annex A](#).

2 Normative references

There are no normative references in this document.

3 Symbols

A	arithmetic mean of inner and outer surface areas of vessel insulating material	m^2
A_B	actual flow area of a pipe element	m^2
A_e	is the total outer surface area of the pipe network containing flow of fluid, from the outer jacket up to the flow temperature location x under consideration, in m^2 ; Applicable only when length > than 0,6 m (See 6.1.1)	m^2
A_F	minimum flow area (reference area) in a pipe network	m^2
A_{Fd}	minimum flow area (reference area) in the pipe network, downstream of relief valve	m^2
A_{Fu}	minimum flow area (reference area) in the pipe network, upstream of relief valve	m^2
A_i	total outside surface area of inner vessel	m^2
A_j	total outer surface area of pipe network between the inner and outer jackets (inter-space)	m^2
A_L	larger flow area of a pipe element containing two different flow area sizes	m^2
A_n	cross-sectional area, support, or pipe material	m^2
A_R	area ratio, A_S/A_L	—
A_S	smaller flow area of a pipe element containing two different flow area sizes	m^2
A_V	actual flow (orifice) area of a pressure relief valve	mm^2
A_{Va}	actual flow (orifice) area of pressure relief valve selected for final analysis	mm^2
A_{V1}	minimum required relief valve flow (orifice) area	mm^2
A_2	external heat transfer surface area of ambient air vaporizer	m^2
c_p	constant pressure specific heat capacity at the average of T_n and T_e	$\text{kJ}/(\text{kg}\cdot\text{K})$
C_V	experimentally determined flow rate through a pipe element or device	$\text{gal}/\text{min}/\text{psi}$
e_1	nominal insulating material thickness, normal vacuum, non-fire condition	m
e_3	minimum insulating material thickness, considering loss of vacuum, non-fire condition	m
e_5	insulating material thickness remaining in place during fire conditions	m
f_T	pipe flow friction coefficient	—
h	enthalpy of fluid at conditions of v	kJ/kg
h_r	specific enthalpy at relief valve inlet and outlet	kJ/kg
K_A	flow resistance coefficient of a pipe element in terms of A_F	—
K_B	flow resistance coefficient of a pipe element in terms of A_B	—

K_b	subcritical flow coefficient	—
K_d	coefficient of discharge	—
K_{dr}	derated coefficient of discharge	—
$K_{dr,a}$	derated coefficient of discharge of next largest available valve orifice area greater than A_{V1}	—
$K_{dr,1}$	derated coefficient of discharge of initially analyzed valve	—
k_n	mean thermal conductivity of an individual support or pipe, between T and T_a	W/(m·K)
K_R	flow resistance coefficient of complete pipe network in terms of reference area, A_F	—
K_{RC}	flow resistance coefficient at the transition between critical and subcritical flow	—
K_{Rd}	overall flow resistance coefficient of pipe network, downstream of pressure relief valve	—
K_{Ru}	overall flow resistance coefficient of pipe network, upstream of pressure relief valve	—
K_{SUM}	total flow resistance coefficient of a series or parallel pipe network	—
K_V	experimentally determined flow rate through a pipe element or device	m ³ /h/bar
k_1	mean thermal conductivity of insulating material, normal vacuum, non-fire condition	W/(m·K)
k_3	mean thermal conductivity of insulating material with air or gaseous lading, non-fire condition	W/(m·K)
L	latent heat of vaporization of cryogenic liquid at relieving conditions	kJ/kg
l	length, pipe element	m
L_a	latent heat of vaporization of cryogenic liquid at a pressure of 1,013 bar	kJ/kg
l_n	length of support or pipe in vacuum interspace	m
L'	enthalpy-to-volume expansion ratio for critical or all-gas fluid flow conditions	kJ/kg
M	molar mass	kg/kmol
m_{max}	maximum mass capacity of vessel	kg
N	normal evaporation rate (NER)	%/day
P	relieving pressure, inner vessel in absolute pressure	bar
P_b	pressure, safety relief valve outlet in absolute pressure	bar
P_{b10}	pressure at relief valve outlet for a downstream built-up backpressure of 10 %	bar
P_{exit}	pressure at pipe network exit in absolute pressure	bar
P_i	pressure, safety relief valve inlet in absolute pressure	bar
P_S	pressure relief valve set pressure in absolute pressure	bar
Q_m	mass flow rate	kg/h

Q_{ma}	mass flow rate of a relief valve within a given pipe network	kg/h
Q_{mNER}	mass flow rate due to the normal evaporation rate	kg/h
R	universal gas constant	J/(mol·K)
r	pipe elbow transition radius	m
T	relieving temperature, inner vessel	K
T_a	maximum external ambient temperature, non-fire condition	K
$T_{b,Pb}$	temperature at relief valve outlet	K
T_{b10}	temperature at relief valve outlet for a downstream built-up backpressure of 10 %	K
T_e	external temperature for a given condition	K
$T_{exit,Pb}$	temperature at pipe network exit	K
T_f	external temperature, fire condition	K
T_i	temperature, safety relief valve inlet	K
T_n	temperature of fluid at a given flow start location along the pipe network	K
T_{sat}	saturation temperature of fluid at a pressure of 1 bar	K
T_x	temperature of fluid at a given location x along the pipe network	K
U_p	overall heat transfer coefficient of a pipe network for given temperature conditions	W/ (m ² ·K)
U_1	heat transfer coefficient of insulating material, normal vacuum, non-fire condition	W/ (m ² ·K)
U_2	overall convective heat transfer coefficient of ambient air vaporizer	W/ (m ² ·K)
U_3	heat transfer coefficient of insulating material with air or gaseous lading, non-fire condition	W/ (m ² ·K)
U_{3a}	heat transfer coefficient, air or nitrogen condensation, loss of vacuum, non-fire condition	W/m ²
U_5	heat transfer coefficient of insulating material with air or gaseous lading, fire condition	W/ (m ² ·K)
U_{5a}	heat transfer coefficient, air or nitrogen condensation, loss of vacuum, fire condition	W/m ²
w_n	heat leak from an individual support or pipe	W/K
W_T	total heat transfer rate for specified conditions	Watt [W]
W_{T1}	total heat transfer rate under normal operation	Watt [W]
W_{T1NER}	total NER heat transfer rate under normal operation	Watt [W]
W_{T2}	total heat transfer rate under normal operation, including pressure build-up device	Watt [W]
W_{T2NER}	total NER heat transfer rate under normal operation, including pressure build-up device	Watt [W]
W_{T3}	total heat transfer rate, loss of vacuum, insulation in place, non-fire condition, $T_{sat} > 75$ K	Watt [W]

W_{T3a}	total heat transfer rate, loss of vacuum, insulation in place, non-fire condition, $T_{sat} \leq 75$ K	Watt [W]
W_{T5}	total heat transfer rate, loss of vacuum, insulation in place, fire condition, $T_{sat} > 75$ K	Watt [W]
W_{T5a}	total heat transfer rate, loss of vacuum, insulation in place, fire condition, $T_{sat} \leq 75$ K	Watt [W]
W_{T6}	total heat transfer rate, loss of vacuum, insulation not in place, fire condition	Watt [W]
W_1	heat transfer rate through insulation system, normal vacuum, non-fire condition	Watt [W]
W_2	heat transfer rate through pressure build-up device, fully open regulator	Watt [W]
W_3	heat transfer rate through insulation system, loss of vacuum, non-fire condition	Watt [W]
W_{3a}	heat transfer rate through air or nitrogen condensation, loss of vacuum, non-fire condition	Watt [W]
W_4	heat transfer rate through interspace supports and piping	Watt [W]
W_5	heat transfer rate through vessel walls, insulation in place, fire condition	Watt [W]
W_{5a}	heat transfer rate through air or nitrogen condensation, loss of vacuum, fire condition	Watt [W]
W_6	heat transfer rate through vessel walls, insulation not in place, fire condition	Watt [W]
x	lengthwise location along a pipe network	m
X	number of insulation layers	—
Y	heat transfer rate U_{3a} or U_{5a}	—
Z_i	compressibility factor at pressure, P_i , and temperature, T_i	—
φ	pressure ratio P_{exit}/P	—
κ	isentropic exponent	—
λ_1	subcritical flow coefficient	—
λ_2	subcritical flow coefficient	—
ν	specific volume of critical or all-gas fluid at a given temperature at pressure, P	m ³ /kg
ν_{b10}	specific volume at relief valve outlet for a downstream built-up backpressure of 10 %	m ³ /kg
$\nu_{b,Pb}$	specific volume at pressure relief valve outlet, evaluated at h_r and a trial value of P_b	m ³ /kg
ν_{dmax}	maximum average downstream specific volume, as per desired backpressure limit	m ³ /kg
ν_{d10}	average downstream specific volume, for a downstream built-up backpressure of 10 %	m ³ /kg
$\nu_{exit,Pb}$	specific volume at pipe network exit, evaluated at P_{exit} and $T_{exit,Pb}$	m ³ /kg
ν_{exit10}	specific volume at pipe network exit for a downstream built-up backpressure of 10 %	m ³ /kg
ν_g	specific volume of saturated gas at relieving pressure, P	m ³ /kg
ν_{ga}	specific volume of saturated gas at a pressure of 1,013 bar	m ³ /kg

v_i	specific volume, safety relief valve inlet	m^3/kg
v_l	specific volume of saturated liquid at relieving pressure, P	m^3/kg
v_{la}	specific volume of saturated liquid at a pressure of 1,013 bar	m^3/kg
v_u	average specific volume of flowing fluid upstream of pressure relief valve inlet	m^3/kg
ψ	expression for determining Q_m and T for critical or gas-full-vessel fluid flow conditions	$\text{m}^{3/2} \cdot \text{kg}^{1/2} / \text{kJ}$

4 Calculation of the total quantity of heat transferred per unit time from the hot wall (outer jacket) to the cold wall (inner vessel)

4.1 General

P (in bar abs) is the actual relieving pressure inside the vessel which is used for calculating the required mass flow through pressure relief devices.

T_a (in K) is the maximum ambient temperature for conditions other than fire (as specified, for example, by a regulation or standard).

T_f (in K) is the external environment temperature under fire conditions which is taken to be 922 K in this part of ISO 21013.

T (in K) is the relieving temperature in the vessel to be taken into account.

- a) For subcritical fluids, T is the saturation temperature of the liquid at pressure, P .
- b) For critical or supercritical fluids, T is calculated from [5.2](#).

4.2 Under conditions other than fire

4.2.1 Vacuum-insulated vessels under normal vacuum

W_1 is the quantity of heat transferred per unit time (in watts) by heat leak through the insulation system.

$$W_1 = (U_1 \cdot A)(T_a - T) \quad (1)$$

where

U_1 is the overall heat transfer coefficient of the insulating material under normal vacuum, in $\text{W}/(\text{m}^2 \cdot \text{K})$;

$$U_1 = \frac{k_1}{e_1} ;$$

k_1 is the mean thermal conductivity of the insulating material under normal vacuum, between T and T_a , in $\text{W}/(\text{m} \cdot \text{K})$;

e_1 is the nominal insulating material thickness, in metres;

A is the arithmetic mean of the inner and outer surface areas of the vessel insulating material, in m^2 .