



BSI Standards Publication

Gas Infrastructure — Gas installation pipework with an operating pressure greater than 0,5 bar for industrial installations and greater than 5 bar for industrial and non-industrial installations

Part 1: Detailed functional requirements for design,
materials, construction, inspection and testing

National foreword

This British Standard is the UK implementation of EN 15001-1:2023. It supersedes BS EN 15001-1:2009, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GSE/33, Gas supply.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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**Gas Infrastructure - Gas installation pipework with an
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requirements for design, materials, construction,
inspection and testing**

Infrastructures gazières - Canalisations d'installations
de gaz avec une pression de service supérieure à 0,5
bar pour les installations industrielles et supérieure à 5
bar pour les installations industrielles et non
industrielles (domestiques et commerciales) - Partie 1 :
Exigences fonctionnelles détaillées relatives à la
conception, aux matériaux, à la construction, à
l'inspection et aux essais

Gasinfrastruktur - Gas-Leitungsanlagen mit einem
Betriebsdruck größer 0,5 bar für industrielle
Installationen und größer 5 bar für industrielle und
nicht-industrielle Installationen - Teil 1: Detaillierte
funktionale Anforderungen an Planung, Material, Bau,
Inspektion und Prüfung

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European foreword

This document (EN 15001-1:2023) has been prepared by Technical Committee CEN/TC 234 “Gas Infrastructure”, 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of an identical text or by endorsement, at the latest by August 2023, and conflicting national standards shall be withdrawn at the latest by August 2023.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 15001-1:2009.

A list of the significant changes compared to EN 15001-1:2009 can be found in informative Annex E, Table E.1.

This document includes requirements concerning current design practice and reflects the state of the art at the time of publication. It provides clear solutions for users of the document. Other design solutions and construction materials, as well as new developments, may be used if equal or greater safety than that required by this document can be demonstrated or established.

The scope of this revised document is extended with biomethane and vaporized LNG gases. This document is not designed for various mixtures of natural gas and hydrogen which may be allowed in the different member states.

With respect to hydrogen there are proposals to inject hydrogen (H₂) from renewable sources into the natural gas network. Investigations have been conducted to evaluate the impact. According to EN 16726:2015+A1:2018 at present it is not possible to specify a limiting hydrogen value which would generally be valid for all parts of the European gas infrastructure.

There is a complete suite of functional standards prepared by CEN/TC 234 “Gas infrastructure” to cover all parts of the gas supply system from the input of gas to the transmission system up to the inlet connection of the gas appliances, whether for residential, commercial or industrial purposes.

In preparing this document, a basic understanding of gas supply by the user has been assumed.

Gas supply systems are complex and the importance on safety of their construction and use has led to the development of very detailed codes of practice and operating manuals in the member countries. These detailed statements embrace recognized standards of gas engineering and the specific requirements imposed by the legal structures of the member countries.

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

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

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

1 Scope

This document specifies detailed functional requirements for the design, selection of materials, construction, inspection and testing of:

- industrial gas installation pipework and assemblies with an operating pressure greater than 0,5 bar; and
- non-industrial gas installation pipework (residential and commercial) with an operating pressure greater than 5 bar in buildings;

starting from the outlet of the network operator's point of delivery up to the inlet connection to the gas appliance; normally the inlet isolation valve. This document also covers the pipework to the inlet connection of a gas appliance that is not included within the scope of the appliance standard.

Apart from the exceptions stated below, this document applies to gas installation pipework operating at ambient temperatures between $-20\text{ }^{\circ}\text{C}$ and $40\text{ }^{\circ}\text{C}$ and operating pressures up to and including 60 bar. For operating conditions outside these limitations, reference is additionally made to EN 13480 (all parts) for metallic pipework.

For industrial gas installation pipework up to and including 0,5 bar and for non-industrial (residential and commercial) gas installation pipework up to and including 5 bar in buildings, EN 1775 applies.

For gas installation pipework that do not fall within the scope of EN 1775 or other European Standards, this document applies.

In this document, the term "gas" refers to combustible gases, which are gaseous at $15\text{ }^{\circ}\text{C}$ and 1 013 mbar absolute atmospheric pressure (normal conditions). These gases are commonly referred to as manufactured gas, natural gas or Liquefied Petroleum Gas (LPG). They are also referred to as first, second or third family gases as classified in EN 437:2021, Table 1. The given values are considered as normal conditions for all volumes given in this document.

This document is applicable to gas installation pipework for the carriage of:

- processed, non-toxic and non-corrosive natural gas according to EN 437:2021 and EN 16726:2015+A1:2018 "Gas infrastructure — Quality of gas — Group H";
- biomethane, complying with EN 16723-1:2016;
- vaporized LNG.

NOTE The specification of vaporized LNG is equal to that of natural gas as classified in EN 437:2021.

This document does not cover pipework for hydrogen rich gases that fall outside the definitions within EN 437:2021.

LPG storage vessels (including all ancillaries fitted directly to storage vessels) are excluded. Also excluded are LPG installations and sections of LPG installations operating at vapour pressure or in the liquid state.

In this document, all pressures are gauge pressures unless otherwise stated.

This document has been harmonized to address the essential safety requirements of the Pressure Equipment Directive (PED, 2014/68/EU [formerly 97/23/EC]) relevant for the joining of gas installation pipework (assemblies) falling within the scope of the PED. These are listed in Annex ZA. "However, this Directive should not apply to the assembly of pressure equipment on the site and under the responsibility of a user who is not the manufacturer, as in the case of industrial installations." (PED, Preamble, 7th recital, last paragraph).

Although in this respect, the document takes into account the essential safety requirements of the PED, no inference can be drawn from this as to whether or not the installation pipework or parts of the installation pipework falls within the scope of the PED. Reference should therefore be made to the PED and relevant national legislation.

This document specifies common basic principles for gas supply systems. Users of this document are expected to be aware that more detailed national standards and/or code of practice may exist in the CEN member countries.

This document is intended to be applied in association with these national standards and/or codes of practice setting out the above-mentioned basic principles.

In the event of conflicts in terms of more restrictive requirements in national legislation/regulation with the requirements of this document, the national legislation/regulation takes precedence as illustrated in CEN/TR 13737-1 and CEN/TR 13737-2.

This provision does not apply to requirements that are harmonized to directive 2014/68/EU (see Annex ZA).

CEN/TR 13737-1 and CEN/TR 13737-2 give:

- clarification of all legislations/regulations applicable in a country;
- if appropriate, more restrictive national requirements thereof;
- a national contact point for the latest information.

Functional requirements for commissioning, operation and maintenance of industrial gas installation pipework with an operating pressure greater than 0,5 bar and of gas installation pipework greater than 5 bar in buildings and areas intended for non-industrial installation pipework are described in EN 15001-2:2023.

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 331:2015, *Manually operated ball valves and closed bottom taper plug valves for gas installations for buildings*

EN 334:2005+A1:2009, *Gas pressure regulators for inlet pressure up to 10 MPa (100 bar)*

EN 751-1:1996, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water - Part 1: Anaerobic jointing compounds*

EN 751-2:1996, *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water - Part 2: Non-hardening jointing compounds*

EN 751-3:1996,¹ *Sealing materials for metallic threaded joints in contact with 1st, 2nd and 3rd family gases and hot water — Part 3: Unsintered PTFE tapes*

EN 764-5:2014, *Pressure equipment - Part 5: Inspection documentation of metallic materials and compliance with the material specification*

¹ As impacted by EN 751-3:1996/AC:1997.

EN 1057:2006+A1:2010, *Copper and copper alloys - Seamless, round copper tubes for water and gas in sanitary and heating applications*

EN 1092-1:2018, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 1: Steel flanges*

EN 1092-2:1997, *Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated - Part 2: Cast iron flanges*

EN 1092-3:2003,² *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 3: Copper alloy flanges*

EN 1254-1:2021, *Copper and copper alloys - Plumbing fittings - Part 1: Capillary fittings for soldering or brazing to copper tubes*

EN 1254-2:2021, *Copper and copper alloys - Plumbing fittings - Part 2: Compression fittings for use with copper tubes*

EN 1254-3:2021, *Copper and copper alloys - Plumbing fittings - Part 3: Compression fittings for use with plastics and multilayer pipes*

EN 1254-4:2021, *Copper and copper alloys - Plumbing fittings - Part 4: Threaded fittings*

EN 1254-5:2021, *Copper and copper alloys - Plumbing fittings - Part 5: Capillary fittings with short ends for brazing to copper tubes*

EN 1254-6:2021, *Copper and copper alloys - Plumbing fittings - Part 6: Push-fit fittings for use with metallic tubes, plastics and multilayer pipes*

EN 1254-7:2021, *Copper and copper alloys - Plumbing fittings - Part 7: Press fittings for use with metallic tubes*

EN 1254-8:2021, *Copper and copper alloys - Plumbing fittings - Part 8: Press fittings for use with plastics and multilayer pipes*

EN 1514-1:1997, *Flanges and their joints - Dimensions of gaskets for PN-designated flanges - Part 1: Non-metallic flat gaskets with or without inserts*

EN 1514-2:2014+A1:2021, *Flanges and their joints - Gaskets for PN-designated flanges - Part 2: Spiral wound gaskets for use with steel flanges*

EN 1515-4:2021, *Flanges and their joints - Bolting - Part 4: Selection of bolting for equipment subject to the Pressure Equipment Directive 2014/68/EU*

EN 1555-2:2021, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 2: Pipes*

EN 1555-3:2021, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 3: Fittings*

EN 1555-4:2021, *Plastics piping systems for the supply of gaseous fuels - Polyethylene (PE) - Part 4: Valves*

² As impacted by EN 1092-3:2003/AC:2007.

EN 1594:2013, *Gas infrastructure - Pipelines for maximum operating pressure over 16 bar - Functional requirements*

EN 1775:2007, *Gas supply - Gas pipework for buildings - Maximum operating pressure less than or equal to 5 bar - Functional recommendations*

EN ISO 683-4:2018, *Heat-treatable steels, alloy steels and free-cutting steels - Part 4: Free-cutting steels (ISO 683-4:2016)*

EN 10088-1:2014, *Stainless steels - Part 1: List of stainless steels*

EN 10088-3:2014, *Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes*

EN 10204:2004, *Metallic products - Types of inspection documents*

EN 10216-1:2013, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 1: Non-alloy steel tubes with specified room temperature properties*

EN 10216-2:2013, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 2: Non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10216-3:2013, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 3: Alloy fine grain steel tubes*

EN 10216-5:2021, *Seamless steel tubes for pressure purposes - Technical delivery conditions - Part 5: Stainless steel tubes*

EN 10217-1:2019, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 1: Electric welded and submerged arc welded non-alloy steel tubes with specified room temperature properties*

EN 10217-2:2019, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10217-3:2019, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 3: Electric welded and submerged arc welded alloy fine grain steel tubes with specified room, elevated and low temperature properties*

EN 10217-5:2019, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 5: Submerged arc welded non-alloy and alloy steel tubes with specified elevated temperature properties*

EN 10217-7:2021, *Welded steel tubes for pressure purposes - Technical delivery conditions - Part 7: Stainless steel tubes*

EN 10220:2002, *Seamless and welded steel tubes - Dimensions and masses per unit length*

EN 10222-5:2017, *Steel forgings for pressure purposes - Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels*

EN 10226-1:2004, *Pipe threads where pressure tight joints are made on the threads - Part 1: Taper external threads and parallel internal threads - Dimensions, tolerances and designation*

EN 10226-2:2005, *Pipe threads where pressure tight joints are made on the threads - Part 2: Taper external threads and taper internal threads - Dimensions, tolerances and designation*

EN 10241:2000, *Steel threaded pipe fittings*

EN 10242:1994, *Threaded pipe fitting in malleable cast iron*

EN 10253-2:2007, *Butt-welding pipe fittings — Part 2: Non alloy and ferritic alloy steels with specific inspection requirements*

EN 10253-4:2008,³ *Butt-welding pipe fittings — Part 4: Wrought austenitic and austenitic-ferritic (duplex) stainless steels with specific inspection requirements*

EN 10255:2004+A1:2007, *Non-Alloy steel tubes suitable for welding and threading - Technical delivery conditions*

EN 10269:2013, *Steels and nickel alloys for fasteners with specified elevated and/or low temperature properties*

prEN 10344:2006,⁴ *Malleable cast iron fittings with compression ends for steel pipes*

EN 12007-2:2012, *Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 2: Specific functional requirements for polyethylene (MOP up to and including 10 bar)*

EN 12007-3:2015, *Gas infrastructure - Pipelines for maximum operating pressure up to and including 16 bar - Part 3: Specific functional requirements for steel*

EN 12068:1998, *Cathodic protection - External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection - Tapes and shrinkable materials*

EN 12186:2014, *Gas infrastructure - Gas pressure regulating stations for transmission and distribution - Functional requirements*

EN 12266-1:2012, *Industrial valves - Testing of metallic valves - Part 1: Pressure tests, test procedures and acceptance criteria - Mandatory requirements*

EN 12266-2:2012, *Industrial valves - Testing of metallic valves - Part 2: Tests, test procedures and acceptance criteria - Supplementary requirements*

EN 12279:2000,⁵ *Gas supply systems — Gas pressure regulating installations on service lines — Functional requirements*

EN 12560-1:2001, *Flanges and their joints - Gaskets for Class-designated flanges - Part 1: Non-metallic flat gaskets with or without inserts*

EN 12560-2:2013, *Flanges and their joints - Dimensions of gaskets for Class-designated flanges - Part 2: Spiral wound gaskets for use with steel flanges*

EN 12732:2021, *Gas infrastructure - Welding steel pipework - Functional requirements*

EN 12799:2000,⁶ *Brazing — Non-destructive examination of brazed joints*

³ As impacted by EN 10253-4:2008/AC:2009.

⁴ At draft stage.

⁵ As impacted by EN 12279:2000/A1:2005.

⁶ As impacted by EN 12799:2000/A1:2003.

EN 12954:2019, *General principles of cathodic protection of buried or immersed onshore metallic structures*

EN 13100-1:2017, *Non destructive testing of welded joints of thermoplastics semi-finished products - Part 1: Visual examination*

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EN 13480-3:2017,⁸ *Metallic industrial piping — Part 3: Design and calculation*

EN 13480-4:2012,⁹ *Metallic industrial piping - Part 4: Fabrication and installation*

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⁷ As impacted by EN 13480-2:2017/A7:2020

⁸ As impacted by EN 13480-3:2017/A1:2020, EN 13480-3:2017/A2:2020 and EN 13480-3:2017/A3:2021.

⁹ As impacted by EN 13480-4:2012/A1:2013 and EN 13480-4:2012/A2:2015

¹⁰ As impacted by EN 14382:2005+A1:2009 and EN 14382:2005+A1:2009/AC:2009.

¹¹ As impacted by EN 60079-14:2014/AC:2016.

¹² As impacted by EN 60529:1991/A1:2000, EN 60529:1991/A2:2013, EN 60529:1991/corrigendum May 1993 and EN 60529:1991/AC:2016-12.

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¹³ As impacted by EN ISO 898-1:2013/AC:2013.

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EN ISO 15626:2018, *Non-destructive testing of welds - Time-of-flight diffraction technique (TOFD) - Acceptance levels (ISO 15626:2018)*

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EN ISO 17640:2018, *Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment (ISO 17640:2018)*

EN ISO 17672:2016, *Brazing - Filler metals (ISO 17672:2016)*

EN ISO 19285:2017, *Non-destructive testing of welds - Phased array ultrasonic testing (PAUT) - Acceptance levels (ISO 19285:2017)*

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EN ISO 23278:2015, *Non-destructive testing of welds - Magnetic particle testing - Acceptance levels (ISO 23278:2015)*

EN ISO 23279:2017, *Non-destructive testing of welds - Ultrasonic testing - Characterization of discontinuities in welds (ISO 23279:2017)*

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

3.1 Definitions relating to pressure

3.1.1

pressure

gauge pressure of the fluid inside the system, measured under static conditions

3.1.2

maximum allowable pressure

PS

maximum pressure for which pipework is designed in accordance with the strength requirements in this document

Note 1 to entry: For this standard, PS is equivalent to the design pressure (DP).

Note 2 to entry: $PS \geq \frac{MIP}{1,1}$

3.1.3

maximum incidental pressure

MIP

maximum pressure which a system can experience during a short time, limited by the safety devices

3.1.4

operating pressure

OP

pressure which occurs within a system under normal operating conditions

3.1.5

maximum operating pressure

MOP

maximum pressure at which a system can be operated continuously under normal operating conditions

Note 1 to entry: Normal conditions are: no fault in any device or stream.

3.1.6

tightness test pressure

TTP

pressure applied to a system during tightness testing

3.1.7

strength test pressure

STP

pressure applied to a system during strength testing

Note 1 to entry: Strength test pressure is equivalent to proof test as defined in the PED Annex I 3.2.2.

3.1.8

combined test pressure

CTP

pressure applied to a system during combined testing

3.2 Definitions relating to the gas installation

3.2.1

component

item from which a gas supply system or installation is constructed and for which a distinction is drawn between the following groups of components:

- ancillaries (for example: pressure regulators, valves, safety devices, expansion joints and insulating joints);
- pipes, including bends made from pipe;
- instrumentation pipework;
- fittings (for example: reducers, tees, factory-made elbows, flanges, dome ends, welding stubs and mechanical joints)

Note 1 to entry: This definition includes items that have their own individual definitions in the PED.

3.2.2

flexible appliance connector

fitting of flexible pipe to be fitted between the end of fixed pipework and the appliance inlet connection

3.2.3

point of delivery

point where the gas is transferred to the user

Note 1 to entry: This can be at a means of isolation or at the meter outlet connection and is normally at the point of transfer of ownership.

3.2.4

user

person responsible for the safety of the gas installation and associated risks on a site

Note 1 to entry: Normally the user will be the site occupier, operator or owner. It is assumed that every user has a responsibility for work performed on their site, whether or not the work is performed directly for the user or not. This does not mean that they cannot take advice from an independent specialist.

3.2.5**pipework**

assembly of pipes and fittings

Note 1 to entry: This definition is considered to be equivalent to piping in the PED.

3.2.6**installation pipework**

pipework including components and stations downstream of the point of delivery terminating at the appliance inlet connection

Note 1 to entry: This pipework is normally the property of the customer rather than the supplier.

3.2.7**ventilated space**

space where the air is continuously changed by natural or mechanical means

3.2.8**safety zone**

area around the pipework from which persons who are not involved in the strength test are excluded during testing

3.2.9**equipotential bond**

means of ensuring that metallic gas pipework and other metallic parts of the building are at the same electrical potential

Note 1 to entry: For safety reasons, this equipotential bonding is connected to earth.

3.2.10**ventilation duct**

duct forming part of the structure of the building and intended exclusively for ventilation purposes

3.3 Definition relating to means of isolation**3.3.1****means of isolation**

device which is intended to interrupt the gas flow in pipework

EXAMPLE Manually operable valve.

3.4 Definitions relating to jointing methods**3.4.1****joint**

means of connecting elements of a gas installation

3.4.2**flanged joint**

joint in which gas tightness is achieved by compression of a gasket between the faces of two flanges

3.4.3

threaded joint

joint in which gas tightness is achieved by metal-to-metal contact within threads with the assistance of a sealant

3.4.4

mechanical joint

joint in which gas tightness is achieved by compression, with or without a seal and which can be disassembled and reassembled

Note 1 to entry: This definition includes twin ferrule type joints.

3.4.5

pressed joint

joint in which tightness is achieved by using a specific tool for either compressing a fitting to form the joint or expanding a pipe to enable forming the joint

3.4.6

brazed joint

joint formed by brazing

Note 1 to entry: See 3.8.2.

3.4.7

welded joint

joint formed by welding

Note 1 to entry: See 3.8.1.

3.4.8

electro fusion joint

joint formed between polyethylene components using fittings which have an integrated electric heating element

3.4.9

butt fusion joint

joint formed between polyethylene components where the two pipe ends are heated and brought together to be fused directly without the use of a separate fitting or filler material

3.4.10

compression joint

type of joint in which gas tightness is achieved by compression within a socket with or without a seal

3.5 Definitions relating to components

3.5.1

regulator

device which reduces the gas pressure to a set value and maintains it within prescribed limits

3.5.2

appliance connection

flexible pipe or length of rigid pipework connecting an appliance's means of isolation with the appliance inlet connection

3.5.3**insulating joint**

fitting installed to insulate electrically one section of pipework from another

3.5.4**sleeve**

protective pipe through which a gas pipe passes

3.5.5**vent pipe**

pipework connected to a safety or control device to release gas at a safe location

3.5.6**creep relief valve**

device designed to release a limited flow of gas in the event of an unacceptable pressure being detected within the system it protects

3.5.7**safety slam-shut device**

device designed to quickly shut off the gas flow in the event of an unacceptable pressure being detected within the system it protects

3.5.8**safety system**

system which ensures, independent of the pressure regulating system, that the outlet pressure of that system does not exceed the safety limits

3.5.9**instrumentation pipework**

pipework required for the proper functioning of the ancillaries installed within the pressure regulating installation

EXAMPLE Sensing, measuring, auxiliary and sampling lines.

3.5.10**DN**

alphanumeric designation of size for components of a pipework system, which is used for reference purposes and which comprises the letters DN followed by a dimensionless whole number, that is directly related to the physical size, in millimetres, of the bore or outside diameter of the end connections

Note 1 to entry: The number following the letters DN does not represent a measurable value and should not be used for calculation purposes except where specified.

Note 2 to entry: Where DN designation is used, any relationship between DN and component dimensions are given, e.g. DN/OD or DN/ID.

3.6 Definitions relating to tests**3.6.1****strength test**

specific procedure intended to verify that the pipework meets the requirements for mechanical strength

3.6.2

tightness test

specific procedure intended to verify that the pipework meets the requirements for tightness

3.6.3

combined test

specific procedure to verify that the pipework and/or installation meets the requirements for mechanical strength and tightness

3.6.4

leak detection fluid

specially formulated fluid and foaming product that gives a clear indication that a leak exists when applied to an element of pipework

3.7 Definition relating to testing and inspection

3.7.1

competent person

person who is trained, experienced and approved to perform activities relating to gas pipework

Note 1 to entry: Means of approval are determined within each country.

3.8 Definitions relating to assembly processes for metallic materials

3.8.1

welding

permanent joining (union) of two or more parts by heat or pressure or a combination of both (fusion, arc or oxy-acetylene), such that the materials form a continuity

Note 1 to entry: A filler metal having a melting point similar to that of the materials to be welded may be used.

3.8.2

brazing

operation in which metal parts are permanently joined by means of capillary action of a filler metal in the liquid state with a melting temperature, higher than 450 °C, lower than that of the parts to be joined and wetting the parent metal(s), which does not participate in the making of the joint

Note 1 to entry: This is often referred to as hard soldering.

3.8.3

hot tapping

procedure involving the safe use of heat, e.g. welding or fusion, to affix an attachment to a section of pipework containing gas at pressure

3.9 Definitions relating to pressure regulating and metering

3.9.1

compressor

complete unit for raising the gas pressure within installation pipework

Note 1 to entry: Centrifugal compressors may also be referred to as Boosters.

3.9.2**station**

gas pressure regulating and/or metering system including (where applicable) the housing, the odorization facilities and the fenced site

3.9.3**gas pressure control and metering system**

system comprising all equipment, together with inlet and outlet pipework up to and including the isolating valves, which together performs the functions of pressure regulation, pressure safety and/or quantitative gas measurement, whether or not including pressure boosting and/or gas mixing facilities

3.9.4**monitor**

second regulator used as a safety device in series with the active regulator which assumes control of the pressure at a higher set value in the event of the active regulator failing open

4 General**4.1 Quality system and competence**

The life of a gas installation can be divided into four phases:

- design;
- construction and testing;
- commissioning;
- operation and maintenance.

A quality system shall be applied to the design, construction, and testing activities in accordance with this standard also considering the requirements for commissioning, operation and maintenance in EN 15001-2:2023. Reference may be made to the EN ISO 9001:2015 or to equivalent quality management systems.

After the gas installation has been put into service, the integrity should be maintained by the programme of operation, maintenance and condition monitoring in accordance with EN 15001-2:2023.

Any person who designs or constructs gas pipework shall be a competent person.

4.2 Selection of materials**4.2.1 Specification of materials and components**

Whenever possible, materials and components, see Clause 5, specified for pressure containment applications shall be selected from standards harmonized under the Pressure Equipment Directive (2014/68/EU). Materials shall be compatible with each other and with anticipated fabrication procedures and suitable for the internal fluid and external environment involved. Both normal operating conditions and transient conditions occurring during fabrication, transport, testing, commissioning and decommissioning shall be taken into account when specifying the materials.

4.2.2 Compliance with EU Directive 2014/68/EU**4.2.2.1 Tensile test elongation**

Steels intended for pipework shall have a specified minimum elongation value of 14 %, when tensile tested in accordance with EN ISO 6892-1:2019.

4.2.2.2 Ageing

Steels shall be used that are not affected by ageing in service.

4.2.3 Certification of materials and components

Appropriate inspection documentation for materials and components shall be supplied in accordance with EN 764-5. Ideally the material manufacturer or supplier has an appropriate quality assurance system concerning the materials that are supplied. There should be suitable procedures in place to identify the materials for pressure equipment from receipt through to final test.

Only materials supplied with a 3.1 or 3.2 inspection certificate in accordance with EN 10204:2004 shall be used for main pressure bearing parts in pressure equipment categories II, III.

An inspection report 2.2 in accordance with EN 10204:2004 is acceptable for category I pressure equipment and for carbon steel pipe and pipe fittings intended for use at PS less than or equal to 5 bar.

NOTE Attention is drawn to Directive 2014/68/EU and related CE marking requirements for items of pressure equipment and assemblies.

4.3 Protection against hazards

4.3.1 Resistance to fire

Pipework, including, supports shall be designed and constructed to limit the likelihood of gas being released in the event of a fire; so as to minimize the possibility of an explosion or a significant increase in the ferocity of the fire.

4.3.2 Resistance to corrosive substances and atmosphere

Pipework, including supports, in contact with soil or building materials which can be expected to contain corrosive substances, or operating in corrosive atmospheres shall either be resistant to or suitably protected against these substances.

4.3.3 Protection against variations in the operating pressure

The specifiers and designers of pipework shall ensure that the supply pressure conditions are suitable for the safe operation of the appliances.

4.3.4 Protection against gas hazards

4.3.4.1 General

Gas escaping through apertures in ancillaries can result in a flammable mixture in an enclosed space or in small building areas.

To avoid this, the following provisions can be used:

- any apertures are fitted with vent pipes terminating in a safe location;
- restrictions in breather connections are fitted, provided that the operational performance is not impaired;
- extra ventilation to the room is provided.

The above apertures also include breather holes serving diaphragms in pressure regulators and safety devices.

Suitable consideration should also be given to the heavier than air properties of LPG.

Additional safety precautions should be considered where non-odorized gas is used.

For non-industrial purposes, the gas should be odorized.

4.3.4.2 Zone classification

A risk assessment shall be performed to verify if a hazardous area classification shall be established.

NOTE See Directive 1999/92/EC of the European Parliament and of the Council of 16 December 1999 on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC). All mechanical and electrical equipment will need to conform with 2014/34/EU ATEX when within the scope of this Directive. Reference can also be made to EN 60079-10-1:2015.

Normally, pipework designed and constructed to this standard and subsequently maintained in accordance with EN 15001-2:2023, should not leak during its service life.

However, where gas detection systems are to be installed, they shall not be considered as an alternative to good ventilation.

Gas detection systems should be in compliance with EN 60079-29-1:2016.

4.3.5 Electrical installation

4.3.5.1 Power Supplies

The safety of the gas installation shall not be impaired by the failure or restoration of electric power or by a voltage fluctuation or by overload (flash of lightning).

4.3.5.2 Installation in hazardous area

Electrical installations in hazardous areas shall comply with EN 60079-14:2014.

4.4 Accommodation and location of gas pressure control and metering systems, gas pressure compressors and gas mixing systems

4.4.1 Requirements for the enclosure of installations

If a gas pressure control and metering system for PS upstream greater than 5 bar or a gas mixing system is installed in an isolated enclosed space, the enclosure shall comply with the relevant requirements of EN 12186:2014.

The information contained within EN 12186:2014 may be considered for compressors in the absence of specific recognized standards or information from the manufacturer.

Compressor installations should comply with the manufacturer's indications and/or the national legislation/regulation.

The layout of the installation and installation security can be in compliance with the relevant requirements in EN 12186:2014.

4.4.2 Installation in an appliance room

A gas pressure control and metering system for one or more gas appliances may be installed in the same room as the appliance(s) provided there is adequate ventilation and a PS upstream is equal to or less than 16 bar. In this case, the construction, layout, facilities and location of the room shall be subject to the requirements applicable to the gas appliances concerned.

Where compressors and/or gas mixing systems are installed, additional safety precautions may be necessary.

4.4.3 Protection against adverse influences

Gas pressure control and metering systems, gas pressure compressors and/or gas mixing systems in appliance rooms as referred to in 4.4.2 shall, where necessary, be protected against adverse influences such as corrosion, heat and vibration.

5 Materials

5.1 Standards and specifications for pipes and pipe fittings

5.1.1 General

Pipes and fittings shall be selected in accordance with Annex D.

Materials not harmonized with the PED, in accordance with Table D.6, may be used providing that the technical data for the materials meets the specified design requirements and an equivalent overall level of safety can be demonstrated for the pressure equipment.

5.1.2 Carbon steel pipes

5.1.2.1 General

Pipes shall either be selected from the standards and grades specified in Table D.1 or Table D.6. Alternatively, materials in accordance with EN 13480-2:2017 may be used.

5.1.2.2 Product form

Either seamless, high frequency longitudinally welded (HFW) or longitudinally or helically welded submerged arc welded (SAWL/SAWH) pipes may be employed.

5.1.2.3 Welding and forming restrictions

Where pipe materials not listed in Table D.1 are used, the chemical composition of steels intended for welding or forming shall not exceed the following values:

$C = 0,21 \text{ \% max. ladle analysis (0,23 \% max. product analysis)}$

$P = 0,035 \text{ \% max.}$

$S = 0,030 \text{ \% max.}$

$P + S \text{ ladle analysis} = 0,050 \text{ \% max.}$

$CEV \text{ ladle analysis (carbon equivalent)} = 0,45 \text{ \% max.}$

Carbon equivalent is given by the formula:

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$$

where

- CE is the carbon equivalent;
- C is the weight percentage of carbon content;
- Mn is the weight percentage of manganese content;
- Cr is the weight percentage of chromium content;
- Mo is the weight percentage of molybdenum content;
- V is the weight percentage of vanadium content;
- Cu is the weight percentage of copper content;
- Ni is the weight percentage of nickel content.

Any exceptions shall be technically justified (e.g. by previous weldability/formability data or by carrying out a weldability test) and shall be agreed between the parties involved.

5.1.2.4 Pipe dimensions

With the exception of tubes to EN 10255:2004+A1:2007 where the size range is specified in the standard, pipe dimensions shall be selected from EN 10220:2002 with nominal external diameter greater than or equal to 21,3 mm OD.

5.1.2.5 Pressure limits

For details of pressure limits and minimum wall thickness for steel pipes, see 6.4.2.1.

Steel threaded pipes in accordance with EN 10255:2004+A1:2007 shall be medium or heavy wall and only employed for PS less than or equal to 5 bar and in diameters less than or equal to DN 50.

5.1.2.6 Impact testing

Steels shall have a specified minimum impact energy measured on a Charpy V-notch impact test specimen (EN ISO 148-1:2016) as follows:

27 J for ferritic and 1,5 % to 5 % Ni alloyed steels;

40 J for austenitic steel, nickel alloyed steel with Ni $\leq 10\%$ and austenitic ferritic stainless steels stainless steel (duplex) at a test temperature in accordance with EN 13480-2:2017, Annex B, but not higher than 20 °C. The other requirements of EN 13480-2:2017, Annex B shall also apply.

If standard 10 mm × 10 mm Charpy test pieces cannot be obtained, then sub-size specimens (either 10 mm × 7,5 mm or 10 mm × 5 mm) shall be used and the above values modified as follows:

— 27 J (10 × 10) = 20 J (10 × 7,5)/14 J (10 × 5)

— 40 J (10 × 10) = 30 J (10 × 7,5)/20 J (10 × 5).

Either longitudinal or transverse test pieces may be taken at the discretion of the material supplier. Samples shall not be flattened before test piece machining. Where 10 mm × 5 mm test pieces cannot be obtained from the material or component, it need not be subjected to impact testing. Standards for carbon steel pipes are listed in Table D.1 and stainless pipes in Table D.4.

5.1.3 Carbon steel and iron fittings

5.1.3.1 General

Appropriate carbon steel and iron pipe fittings shall be selected from the standards and grades specified in Table 1 and Table D.2 or alternatively materials in accordance with EN 13480-2:2017 may be used.

5.1.3.2 Flange types, dimensions and drilling patterns

The appropriate pressure class of flange to use depends on the type of material, the maximum allowable pressure, and the operating temperature as defined in EN 1092-1:2018 and EN 1092-2:1997.

For the application of flanged joints see 6.6.4.2.

5.1.3.3 Threaded fittings

Threaded joints shall be made in accordance with either EN 10226-1:2004 or EN 10226-2:2005. Male and female threads shall be compatible to ensure adequate sealing on the threads and it is recommended that suitable thread sealing compound in accordance with EN 751-1:1996, EN 751-2:1996 or EN 751-3:1996 be used to ensure this.

Where equipment is to be connected to a component with a parallel thread in accordance with EN ISO 228-1:2003, care shall be taken to ensure an adequate seal. A suitable thread sealant in accordance with EN 751-1:1996, EN 751-2:1996 or EN 751-3:1996 shall be used to ensure this.

Table 1 — Standards and steel grades for pipe fittings

Component	Dimensions defined in	Steel grade (defined in)
Tee, Bend or elbow Reducer Cap	EN 10253-2:2007	P235TR2, P235GH (EN 10253-2:2007)
		P265TR2, P265GH (EN 10253-2:2007)
		P355N and P355NH
Flange	EN 1092-1:2018	Table 9, Groups 3E0 and 8E3

5.1.4 Stainless steel pipes and pipe fittings (including flanges and valves)

Stainless steel pipes and fittings shall be selected from the standards and grades specified in Table 2 and Table D.4.

For stainless steel products that are to be machined, a controlled sulphur content of 0,015 % to 0,030 % may be permitted by agreement provided the resistance to corrosion is satisfied for the intended purpose.

For details of pressure limits and minimum wall thickness for stainless steel pipes, see 6.4.2.1.

Table 2 — Standards and EN material numbers for stainless steel

Component	Standard dimensional requirements	Standard mechanical requirements	EN material number (EN 10088-3:2014, EN 13480-2:2017)
Welded pipe	EN 10217-7:2021	EN 10217-7:2021	1.4301
Seamless pipe	EN 10216-5:2021	EN 10216-5:2021	1.4306
Elbow, Tee, Reducer, Cap	EN 10253-4:2008	EN 10253-4:2008	1.4311
Branch outlet fitting	a	b	1.4401
			1.4404
			1.4571
Flange	EN 1092-1:2018	EN 10222-5:2017	
a No EN standard available yet, tentatively standard MSS SP-97 can be used. b No EN standard available yet, tentatively standard ASTM A403 can be used, supported by Particular Material Appraisal (PMA) in case of PED (2014/68/EU) Category I, II or III.			

5.1.5 Copper

Copper pipes and copper/copper alloy pipe fittings, intended for use with copper pipes, shall be selected from the standards and grades specified Table D.5.

For pressure limits and wall thickness of copper pipes, see 6.4.2.2.

5.1.6 Polyethylene

Polyethylene (PE) pipes and fittings shall be selected from the standards and grades specified in Table D.6.

For pressure ratings and wall thickness of PE pipes, see 6.4.2.3.

5.1.7 Ancillaries

Minimum material requirements for ancillaries not otherwise specified in this standard shall be as follows:

Instrumentation pipes shall be either copper in accordance with EN 1057:2006+A1:2010 or stainless steel in accordance with EN 10088-1:2014 (see Tables D.4 and D.5).

Materials for fasteners shall be in accordance with Table D.2 or D.3 as appropriate.

Gas pressure regulators shall meet the requirements of EN 334:2005+A1:2009 for natural and manufactured gas and EN 16129:2013 for LPG.

Safety slam shut devices shall meet the requirements of EN 14382:2005.

Creep relief valves shall meet the requirements of Annex E of EN 334:2005+A1:2009.

All other metallic materials for pipes, fittings and joints in regulating and metering systems shall be in accordance with the requirements of Clause 5 of this document.

5.1.8 Valves

Valves, if applicable, shall meet the requirements of EN 331:2015, EN 1555-4:2021, EN 12266-1:2012, EN 13774:2013 and/or EN 14141:2013 (see Annex D). Valves in gaseous systems shall be suitable for the application.

6 Design of pipework

6.1 General

6.1.1 Installation drawings and technical file

The user shall ensure that a technical file is available and that it contains the following information (with parts lists where appropriate):

- the MIP and minimum operational pressure (OPmin) at the point of delivery, provided by the network operator;
- the manufacturer's technical file;
- the location (route) of the installation pipework;
- the pipe diameters, materials and coatings;
- the location and design of supports;
- the location and design of wall and floor transits, points where pipework crosses or runs parallel with other systems, etc.;
- location of ancillaries, stating the make, type, connection sizes and type of material;
- joints, gaskets, bolts, etc.;
- location and layout of internal gas pressure regulating systems, stating the required settings for regulators and safety devices;
- the location and sizes of valved points for testing and purging;
- maximum flow in pipework sections including any extension, expressed in m³/h under normal conditions of gas;
- cathodic protection system, where fitted.

The gas appliances to be connected to the system shall be specified separately, stating:

- supplier/make and type;
- maximum flow, in m³/h under normal conditions of gas;
- minimum and maximum operating pressure.

6.1.2 Measuring and test instruments

Gas installations shall incorporate such measuring instruments and test points as are necessary for its safe operation.

Valves or other facilities shall be provided at an accessible and appropriate point of the pipework for pressure measurement, sampling, commissioning and decommissioning.

6.1.3 Properties of gas

If a gas is toxic, corrosive, contains moisture or condensate then this shall be taken into account.

NOTE Some manufactured or process gases can be toxic, corrosive or 'wet'. Higher hydrocarbon gases can be heavier than air.

Where condensation from the fuel gas can occur, consideration shall be given to the use of drainage, collection, pre- heating the gas or trace heating the pipework.

6.2 Layout

6.2.1 Limits of the pipework location

Pipework shall be laid, if possible, within the property for which the gas installation is intended.

6.2.2 Above-ground pipework

Whether installed in a building or above ground within the site, gas pipework shall:

- be able to absorb expansion;
- be well supported;
- not be exposed to mechanical damage;
- not be of PE-pipe unless encased in a steel sleeve, see 6.6.4.1.

The design shall also take into account the adverse effects of stray currents, lightning and differing electrical potentials between nearby metallic components.

6.2.3 Buried pipework

The pipework design shall take account of any future requirements for inspection and repair.

Buried pipework shall not impair the building's construction and shall be protected against movement of the building (such as through the use of a protective sleeve), see 8.3.1. Above 5 bar, buried pipework below buildings is not permitted. For systems up to 5 bar, it may be permissible to locate pipework under buildings on the completion of a risk assessment to determine any additional safety precautions or constructional requirements.

NOTE Attention is drawn to 8.8.3.

6.2.4 Distance between buried pipework and buildings

Except at the point where the pipe enters a building, pipework should be located at least 1 m away from any building or structure.

6.2.5 Unacceptable locations for gas pipework in buildings

Pipework shall not be laid:

- in wall cavities, walls or ceilings except for pipe transits employing a pipe sleeve;
- in chimneys, flue ducts or ventilation ducts and ducts forming part of an air conditioning system;
- in garbage chutes, fuel chutes or lift shafts;
- immediately adjacent to hot or refrigerated services or high voltage cables unless taken into account in the design.

NOTE In fire protected escape routes, national legislation can prohibit gas pipework.

6.3 Dimensioning

6.3.1 Pressure loss

At maximum flow, the pressure drop shall not exceed 10 % of the OP in the case of gas appliances without pressure regulators.

In the case of appliances with pressure regulators, the pressure shall not be outside that specified for the safe operation of all connected appliances under all operating and flow conditions.

6.3.2 Gas velocity

In the metering and regulating systems, the design shall be limited to 20 m/s to prevent erosion and flow-induced pulsation, the velocity of the gas in the pipe should not exceed 25 m/s. For higher velocities flow-induced pulsation calculations shall be considered and noise and erosion aspects should be taken into account.

NOTE VDI 3733 can be consulted for designs based on noise criteria.

6.4 Pressure and wall thickness

6.4.1 PS and test pressure

The PS of the gas installation shall be at least equal to $\frac{MIP}{1,1}$. The user shall request the network operator for the value of MIP. Components shall be chosen in such a way that they are leak tight at a pressure at least equal to the MIP. The required STP/CTP in relation to PS are given in Table 3.

Table 3 — Required STP/CTP in relation to PS

PS bar	STP/CTP bar
> 40	≥ 1,43 PS
16 < PS ≤ 40	≥ 1,43 PS
5 < PS ≤ 16	≥ 1,43 PS
2 < PS ≤ 5	≥ 1,43 PS
0,5 < PS ≤ 2	> 1,75 PS

6.4.2 Pipe wall thickness

6.4.2.1 Steel pipe

6.4.2.1.1 General

The wall thickness of steel pipes shall be at least equal to the relevant values given in Table 4. These have been calculated on the basis of the minimum thickness required for pressure containment plus the absolute value of the negative tolerance taken either from the material standard, or as provided by the pipe manufacturer.

The minimum pipe wall thickness used shall not be less than the values given in Table 4. These have been calculated, in accordance with 6.4.2.1.2, on the basis of the minimum thickness required for pressure containment.

NOTE 1 As the calculated thickness values do not take account of any negative manufacturing tolerances, those in Table 4 have been adjusted, either from the material standard or from data provided by the pipe manufacturer, and rounded off to match standard pipe (average wall) dimensions, after also taking into account handling and weldability factors.

As steel pipes can corrode, both internally and externally, appropriate corrosion protection should be applied where site or operating conditions are such that corrosion is likely. In such cases, an additional minimum corrosion allowance of 2 mm shall also be added to the minimum wall thickness values given in Table 4.

NOTE 2 It is not normally necessary to add a corrosion allowance for stainless steel pipes.

Table 4 — Minimum wall thickness of steel pipes as a function of diameter and PS

		Minimum wall thickness mm											
		PS bar											
Nominal pipe diameter (DN)	Outside diameter mm	≤ 1	≤ 10	≤ 16	≤ 25	≤ 40	≤ 50	≤ 60	≤ 16	≤ 25	≤ 40	≤ 50	≤ 60
		Material											
		Carbon steel welded and seamless											
		Smooth (threaded)	Smooth (threaded ≤ 5 bar)	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
		Stainless steel welded and seamless											
15	21,3	2,6 (3,2)	2,6 (3,2)	2,6	3,6	3,6	3,6	3,7	2,6	2,6	2,6	2,6	2,6
20	26,9	2,6 (3,2)	2,6 (3,2)	2,6	3,6	3,6	3,6	3,9	2,6	2,6	2,6	2,9	2,9
25	33,7	2,6 (3,2)	2,6 (3,2)	2,6	3,6	3,6	3,6	4,5	2,6	2,6	2,6	3,2	3,2
40	48,3	2,6 (3,2)	2,6 (3,2)	2,6	3,6	3,6	3,6	5,0	2,6	3,6	3,6	3,6	3,6
50	60,3	2,9 (3,6)	2,9 (3,6)	2,9	3,6	3,6	3,6	5,6	2,9	3,6	3,6	4,0	4,0
65	76,1	2,9	2,9	2,9	3,6	3,6	3,6	5,6	2,9	3,6	3,6	5,0	5,0
80	88,9	3,2	3,2	3,2	3,6	4,0	3,6	5,6	3,2	3,6	3,6	5,6	5,6
100	114,3	3,6	3,6	3,6	3,6	4,5	3,6	6,3	3,2	3,6	3,6	6,3	6,3

		Minimum wall thickness mm											
		PS bar											
Nominal pipe diameter (DN)	Outside diameter mm	≤ 1	≤ 10	≤ 16	≤ 25	≤ 40	≤ 50	≤ 60	≤ 16	≤ 25	≤ 40	≤ 50	≤ 60
		Material											
		Carbon steel welded and seamless								Stainless steel welded and seamless			
		Smooth (threaded)	Smooth (threaded ≤ 5 bar)	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth			
125	139,7	4,0	4,0	4,0	4,0	5,6	6,6	6,6	3,6	4,0	4,0	6,3	6,3
150	168,3	4,5	4,5	4,5	4,5	5,6	7,1	7,1	4	4,5	5,0	7,1	7,1
200	219,1	5,9	5,9	6,3	6,3	7,1	8,0		4,5	6,0	6,3	8,0	
250	273,0	6,3	6,3	7,1	7,1	8,0	10,0		5	6,3	8,2	10,0	
300	323,9	7,1	7,1	8,0	8,0	8,8	-		5,6	6,3	9,5	-	
350	355,6	7,1	7,1	8,0	8,0	10,0	-		-	-	-	-	
400	406,4	7,1	7,1	8,8	8,8	-	-		-	-	-	-	
450	457,2	7,1	7,1	10,0	-	-	-		-	-	-	-	
500	508,0	7,1	7,1	10,0	-	-	-		-	-	-	-	

6.4.2.1.2 Straight pipe wall thickness determination

If no additional requirements are imposed, for straight pipe the minimum wall thickness to withstand the internal pressure is calculated as follows:

$$T_{\min} = \frac{PS \times D}{20 \sigma_p \times z}$$

with the requirement that:

$$\sigma_p \leq f_0 \times R_{t0,5}(\theta)$$

where

$T_{\min}$	is the calculated minimum wall thickness, in millimetres (mm);
PS	is the maximum allowable pressure, in bar;
D	is the outside diameter of the pipe, in millimetres (mm);
if D_i is preset, D shall equal $D_i + 2 T_{\min}$, D_i being the inside diameter in millimetres (mm);	
σ_p	is the hoop stress, in Mega Pascal (MPa);
f_0	is the design factor;
$R_{t0,5}(\theta)$	is the specified minimum yield strength at the design temperature, in Mega Pascal (MPa);
$R_{t0,5}$	is the specified minimum yield strength at ambient temperature, in Mega Pascal (MPa) (see EN ISO 6892-1:2019);
z	joint coefficient.

If the design temperature is ≤ 60 °C, $R_{t0,5}(\theta) = R_{t0,5}$. If the design temperature is > 60 °C, the value of the specified minimum yield strength shall be corrected for the temperature accordingly.

6.4.2.1.3 Calculation conditions for Table 4

Wall thickness calculations for Table 4 are based on the lowest grade of materials permitted in Table D.1 and Table D.4

The wall thicknesses shown in the Table are calculated using the following:

- the design factor f_0 shall be 0,45;
- z is taken as 1 for materials or components subject to destructive and non-destructive testing which confirm that the whole series of joints show no significant defects;
 - 1) for materials or components subject to random non-destructive testing, z is taken as 0,85;
 - 2) for materials or components not subject to non-destructive testing other than visual inspection, z is taken as 0,7;
- $R_{t0,5}$ is taken from material specification, with suitable correction for the design temperature if necessary.
- external corrosion allowance taken as:
 - 1) carbon steel 2 mm;