BRITISH STANDARD

BS ISO 14531-1:2002

Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications —

Part 1: Pipes

ICS 75.200; 83.140.30

British Standards

National foreword

This British Standard reproduces verbatim ISO 14531-1:2002 and implements it as the UK national standard.

The UK participation in its preparation was entrusted by Technical Committee PRI/88, Plastics piping systems, to Subcommittee PRI/88/2/Panel 6, Pressure piping-gas, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international publications referred to in this document may be found in the *BSI Catalogue* under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the *BSI Electronic Catalogue* or of British Standards Online.

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Summary of pages

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INTERNATIONAL STANDARD

ISO 14531-1

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Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications —

Part 1: **Pipes**

Tubes et raccords en matières plastiques — Systèmes de tubes en polyéthylène réticulé (PE-X) pour le transport de combustibles gazeux — Série métrique — Spécifications —

Partie 1: Tubes

Reference number
ISO 14531-1:2002(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 14531 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14531-1 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 4, *Plastics pipes and fittings for the supply of gaseous fuels*.

ISO 14531 consists of the following parts, under the general title *Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications*:

— *Part 1: Pipes*

— *Part 2: Fittings for heat-fusion jointing*

— *Part 3: Fittings for mechanical jointing (including PE-X/metal transitions)*

— *Part 4: System design and installation guidelines*

Annexes B, C and D form a normative part of this part of ISO 14531. Annexes A and E are for information only.

The inclusion of annex E is an interim measure. The content of annex E is also incorporated in ISO 14531-4, the system design and installation guide. Annex E will be deleted from this part of ISO 14531 as soon as ISO 14531-4 is available as a draft International Standard (DIS).

Introduction

Further to the publication of International Standards for crosslinked polyethylene (PE-X) hot-water pipes, it has become evident that the properties of PE-X, in particular its high fracture resistance and its socket and saddle fusion-jointing capability, render it suitable for use in high-performance gas-distribution systems. The philosophy of ISO 14531 is to provide the platform for the introduction of PE-X gas pipe systems by embracing a performance envelope beyond that covered by existing PE standards, whilst taking its application into regimes of higher operating pressure and extremes of operating temperature.

ISO 14531-1 is therefore one part of a four-part system standard covering pipes, fittings for heat-fusion jointing, fittings for mechanical jointing and design and installation guidelines. The content is suitable for use by procurement authorities and distribution engineers responsible for the design, installation and operation of pipeline systems.

Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications —

Part 1: **Pipes**

1 Scope

This part of ISO 14531 specifies the physical properties and mechanical-performance requirements for crosslinked polyethylene (PE-X) pipes intended for use in the supply of gaseous fuels. In addition, it lays down dimensional requirements and specifies some general material properties (including chemical resistance) together with a classification scheme for PE-X produced in the form of pipe.

This part of ISO 14531, when used in conjunction with the other parts of ISO 14531, is applicable as the basis for the design, manufacture and installation of PE-X piping systems (PE-X pipes, PE-X fusion fittings and mechanical fittings) for the supply of category D and category E hydrocarbon-based fuels (see ISO 13623) at

a) maximum operating pressures (MOPs) up to and including 16 bar[1)];

b) a maximum operating temperature of + 60 °C;

c) a minimum operating temperature of

   i) − 50 °C

   ii) − 35 °C

   iii) − 20 °C.

This part of ISO 14531 may also be used in conjunction with the restricted specification for PE heat-fusion fittings detailed in ISO 14531-2 to support the introduction of a hybrid PE-X pipe/PE fitting system for operation within a narrower temperature range (− 20 °C to + 40 °C) with a maximum pressure as determined by ISO 8085-3.

For installation, this standard provides for the jointing of PE-X fusion fittings and mechanical fittings to PE-X pipes within the temperature range − 5 °C to + 40 °C.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14531. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 14531 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3, *Preferred numbers — Series of preferred numbers*

ISO 161-1, *Thermoplastics pipes for the conveyance of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series*

1) 1 bar = 10^5 N/m^2 = 100 kPa

ISO 497, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers*

ISO 1167, *Thermoplastics pipes for the conveyance of fluids — Resistance to internal pressure — Test method*

ISO 2505-1, *Thermoplastics pipes — Longitudinal reversion — Part 1: Determination methods*

ISO 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 4065, *Thermoplastics pipes — Universal wall thickness table*

ISO 4437, *Buried polyethylene (PE) pipes for the supply of gaseous fuels — Metric series — Specifications*

ISO 6259-1, *Thermoplastics pipes — Determination of tensile properties — Part 1: General test method*

ISO 6259-3, *Thermoplastics pipes — Determination of tensile properties — Part 3: Polyolefin pipes*

ISO 6964, *Polyolefin pipes and fittings — Determination of carbon black content by calcination and pyrolysis — Test method and basic specification*

ISO 8085-3, *Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels — Metric series — Specifications — Part 3: Electrofusion fittings*

ISO 9080:—[1], *Plastics piping and ducting systems — Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation*

ISO 10147, *Pipes and fittings made of crosslinked polyethylene (PE-X) — Estimation of the degree of crosslinking by determination of the gel content*

ISO/TR 10837, *Determination of the thermal stability of polyethylene (PE) for use in gas pipes and fittings*

ISO 11922-1:1997, *Thermoplastics pipes for the conveyance of fluids — Dimensions and tolerances — Part 1: Metric series*

ISO 12162, *Thermoplastics materials for pipes and fittings for pressure applications — Classification and designation — Overall service (design) coefficient*

ISO 13477, *Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Small-scale steady-state test (S4 test)*

ISO 13479, *Polyolefin pipes for the conveyance of fluids — Determination of resistance to crack propagation — Test method for slow crack growth on notched pipes (notch test)*

ISO 13623, *Petroleum and natural gas industries — Pipeline transportation systems*

ISO 13760, *Plastics pipes for the conveyance of fluids under pressure — Miner's rule — Calculation method for cumulative damage*

ISO 14531-2:—[2], *Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications — Part 2: Fittings for heat-fusion jointing*

ISO 16871:—[3], *Plastics piping and ducting systems — Plastics pipes and fittings — Method for exposure to direct (natural) weathering*

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1) To be published. (Revision of ISO/TR 9080:1992)

2) To be published.

3) To be published.

ISO 18553, *Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds*

3 Terms and definitions

For the purposes of this part of ISO 14531, the following terms and definitions apply.

3.1 Geometrical terms

3.1.1
nominal outside diameter
d_n
numerical designation of size which is common to all components in a thermoplastics piping system other than flanges and components designated by thread size

NOTE 1 It is a convenient round number for reference purposes.

NOTE 2 The nominal outside diameter expressed in millimetres is the minimum mean outside diameter $d_{em,min}$ defined in 3.1.3.

3.1.2
mean outside diameter
d_{em}
value of the outer circumference of the pipe at any cross-section divided by π[1)] and rounded up to the nearest 0,1 mm

3.1.3
minimum mean outside diameter
$d_{em,min}$
minimum value of the mean outside diameter of the pipe specified for a given nominal outside diameter

3.1.4
maximum mean outside diameter
$d_{e,max}$
maximum value of the mean outside diameter of the pipe specified for a given nominal outside diameter

3.1.5
outside diameter at any point
d_{ey}
value of the outside diameter through the pipe cross-section at any point along the pipe

3.1.6
absolute out-of-roundness
ovality
difference between the measured maximum mean outside diameter $d_{em,max}$, and the measured minimum mean outside diameter $d_{em,min}$ at any point in the same cross-section of the pipe

3.1.7
nominal wall thickness
e_n
wall thickness, in millimetres, tabulated in ISO 4065, corresponding to the minimum wall thickness at any point $e_{y,min}$

3.1.8
wall thickness at any point
e_y
value of the wall thickness at any point around the circumference of the pipe

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1) The value of π is taken to be 3,141 6.

3.1.9
minimum wall thickness at any point
$e_{y,min}$
minimum permissible value of the wall thickness e_y at any point around the circumference of the pipe

3.1.10
standard dimension ratio
SDR
ratio of the nominal outside diameter of a pipe to its nominal wall thickness

$$SDR = \frac{d_n}{e_n}$$

3.2 Terms relating to materials

3.2.1
crosslinked polyethylene
PE-X
polyethylene structure within which the polymer chains are interconnected by chemical bonds to create a three-dimensional polymer network

NOTE The properties of the three-dimensional structure ensure that it is not possible to melt or dissolve the polymer. The extent of crosslinking is related to the mass of insoluble material remaining following solvent extraction and can be determined by measurement of the gel content.

3.2.2
base material
physical blend of non-crosslinked polyethylene(s) and additives formulated to facilitate conversion to PE-X during the production of pipe to meet the requirements of this part of ISO 14531

3.2.3
lower confidence limit of the predicted hydrostatic strength
σ_{LPL}
quantity, with the dimensions of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength at a temperature θ and time t in water

NOTE It is denoted as $\sigma_{LPL} = \sigma_{(\theta, t,\ 0{,}975)}$.

3.2.4
long-term hydrostatic strength
σ_{LTHS}
quantity, with the dimensions of stress, which represents the predicted mean strength at a temperature θ and time t in water

3.2.5
minimum required strength
MRS
value of σ_{LPL} at a temperature of 20 °C and a time of 50 years ($\sigma_{(20,\ 50\ years,\ 0{,}975)}$) rounded down to the nearest lower value in the R10 or R20 series as specified in ISO 3 and ISO 497, depending on the value of σ_{LPL}

3.2.6
overall service (design) coefficient
C
overall coefficient, with a value greater than 1, that takes into consideration service conditions as well as properties of the components of a piping system other than those represented in σ_{LPL}

NOTE See annex E and ISO 12162 for information regarding the minimum permissible service (design) coefficient for PE-X pipes.

3.3 Terms related to service conditions

3.3.1
gaseous fuel
any fuel which is in the gaseous state at a temperature of + 15 °C and a pressure of 1 bar

3.3.2
category D gaseous fuel
natural gas

NOTE Categories of gaseous and liquid fuel are defined in detail in ISO 13623.

3.3.3
category E gaseous fuel
LPG vapour or natural gas conveyed in association with liquid condensate

NOTE Categories of gaseous and liquid fuel are defined in detail in ISO 13623.

3.3.4
maximum operating pressure
MOP
highest effective pressure, in bars, of the gas in the piping system which is allowed in continuous use

3.3.5
operating temperature(s)
assumed temperature(s) of a pipe/fitting component at its intended service location

NOTE Such temperatures are used in designing a pipeline for operation at its MOP.

3.3.6
ancillary pipe
pipe used within buildings to facilitate the supply of gas from the distribution service pipe to the gas appliance(s)

3.3.7
pipeline operator
private or public organization authorized to design, construct and/or operate and maintain the gas supply

4 Materials

4.1 General

Base material used in the manufacture of pipes meeting the performance requirements described in clause 5 shall be crosslinked by the peroxide (PE-Xa), silane (PE-Xb) or electron beam (PE-Xc) crosslinking process or, subject to consultation with the pipeline operator, by another process.

Base material shall contain only those additives necessary for the manufacture and end use of pipes conforming to this specification including fusion jointing using socket and saddle fittings that meet the requirements of ISO 14531-2 and ISO 8085-3.

Other materials (plastics and metals) utilized in the manufacture of pipes to this part of ISO 14531 shall be supplied in accordance with a relevant ISO standard (e.g. ISO 4437 for PE 80 and PE 100 material).

The manufacturer of the pipes shall maintain the availability of a technical file (generally confidential) with all relevant material data to prove the conformity of pipes to this part of ISO 14531. It shall include all the results of type testing. Any change in the materials used that is likely to affect product quality and performance shall require a re-assessment of material performance against the requirements of this part of ISO 14531.

4.2 PE-X

4.2.1 Performance

PE-X shall conform to the performance requirements given in Tables 1 and 2 when tested in the form of pipe. Conformity shall be demonstrated by the pipe manufacturer and shall relate to one source of base material and associated pipe manufacturing method.

Table 1 — Chemical and fracture characteristics of PE-X (tested in the form of extruded pipe)

Characteristic	Units	Requirements	Test parameters	Test method
Resistance to gas constituents	h	No failure when tested to 1 000 h	Temperature: 80 °C Stress: 2 MPa	Annex B Pipe test piece $d_n = 32$ mm, SDR 11
Slow crack growth[a]	h	No failure when tested to 5 000 h	Temperature: 80 °C Pressure: PE-X 80: 8,0 bar PE-X 100: 9,2 bar PE-X 125: 10,8 bar	ISO 13479 Pipe test piece $d_n = 110$ mm or 125 mm, SDR 11
RCP arrest temperature[b, c]	°C	$\leqslant -50$[d]	Stress: PE-X 80: 6,4 MPa PE-X 100: 8,0 MPa PE-X 125: 10,0 MPa	ISO 13477 Pipe test piece $d_n \geqslant 90$ mm
Long-term stability	h	No failure when tested to 8 760 h	Temperature: 110 °C Stress: 2,5 MPa	ISO 1167 Type A end caps Water-in-air Pipe test piece $d_n = 32$ mm, SDR 11
Degree of crosslinking	%	$\geqslant 60$ but $\leqslant 90$ at any point through the wall thickness		ISO 10147 Pipe test pieces $d_n = 32$ mm, SDR 11 and $d_n = 110$ mm or 125 mm, SDR 11

[a] For materials intended for pipes with $e_{y,min} > 5$ mm.

[b] All materials to be evaluated with extruded pipe test pieces having diameter and wall thickness conforming to Table 5 (see also footnote b to Table 7).

[c] RCP evaluation of materials intended for pipes of $d_n < 90$ mm is unnecessary.

[d] Alternative temperature limits of -20 °C or -35 °C may be used to qualify material for minimum operating temperatures higher than -50 °C (see clause 1).

Table 2 — Classification of PE-X

Designation	σ_{LPL}(20 °C, 50 years, 97,5 %) MPa	MRS MPa
PE-X 80	$8,00 \leqslant \sigma_{LPL} \leqslant 9,99$	8,0
PE-X 100	$10,00 \leqslant \sigma_{LPL} \leqslant 12,49$	10,0
PE-X 125	$12,50 \leqslant \sigma_{LPL} \leqslant 13,99$	12,5

4.2.2 Classification

PE-X intended for use in the manufacture of pipes conforming to this part of ISO 14531, when tested in the form of pipe, shall be classified in accordance with ISO 12162. The MRS classification and material designation requirements given in Table 2 shall apply.

Classification testing and evaluation shall be undertaken in accordance with ISO 1167, ISO 12162 and ISO 9080.

In addition, the test data generated (pipe stress applied and failure time) covering the temperature range 10 °C to 100 °C shall be used to derive the following predictive relationship between the long-term hydrostatic strength σ_{LTHS}, failure time and temperature:

$$\log t = A + \frac{B \times \log \sigma_{LTHS}}{\theta} + \frac{C}{\theta} + D \times \log \sigma_{LTHS}$$

where

θ is the temperature, expressed in kelvins;

t is the time, expressed in hours;

σ_{LTHS} is the long-term hydrostatic strength, expressed in megapascals;

A, B, C and D are coefficients determined from experimental data.

4.2.3 Chemical resistance and fracture characteristics

The chemical resistance and fracture characteristics of PE-X shall conform to the requirements given in Table 1.

4.3 Reprocessable material

PE-X shall not be reprocessed and used in the manufacture of pipes intended to conform to this part of ISO 14531.

Non-crosslinked base material pipes, produced in the course of manufacturing PE-Xc pipes to meet the requirements of this part of ISO 14531, may be reprocessed if derived from the same non-crosslinked material grade used in the production of PE-Xc pipes by the same manufacturing process. Products containing reprocessed material shall conform to the requirements of this part of ISO 14531.

4.4 Surface coatings and stripes

Materials used for external surface coatings/stripes, e.g. for colour-coded end use identification systems, shall not have a detrimental effect on the ability of the product to conform to the performance requirements of this part of ISO 14531 or to withstand normal handling and installation.

5 Pipes

5.1 Pipe SDR and wall thickness

It is recommended that the pipe SDR series and wall thickness for the defined design conditions be determined by the pipeline operator in accordance with annex E.

5.2 Appearance

5.2.1 Condition

When viewed without magnification, the internal and external surfaces shall be smooth, clean and free from scoring, cavities or other defects likely to prevent the pipe from conforming to this part of ISO 14531. The pipe ends shall be cut cleanly and square to the axis of the pipe.

5.2.2 Identification

Pipe identification features (e.g. marking and surface colouring) shall be incorporated in a permanent form to enable PE-X pipes to be visually distinctive among adjacent buried pipework. Marking shall be in accordance with clause 6.

5.3 Dimensions and tolerances

5.3.1 General

The dimensions of the pipes shall be measured not less than 24 h after manufacture in accordance with ISO 3126, after conditioning for at least 4 h.

The outside diameters and wall thicknesses specified in Tables 3 to 6 apply to the basic pipe and do not take into account the presence of any external coatings.

NOTE The dimensions of ancillary PE-X pipes in the size range $8 \geqslant d_n \geqslant 20$ are indicated in annex A. This information is offered as guidance to assist in the development of pipe systems in accordance with national requirements.

5.3.2 Mean outside diameter, out-of-roundness (ovality) and associated tolerances

The mean outside diameter d_{em} and the out-of-roundness (ovality) shall conform to Table 3.

NOTE The minimum and maximum values of the mean outside diameter and the maximum out-of-roundness specified in Table 3 conform to the tolerance limits specified in ISO 11922-1.

5.3.3 Minimum wall thickness $e_{y,min}$ and associated tolerance

Minimum wall thicknesses $e_{y,min}$ are specified in Tables 4 and 5. They have been derived from ISO 4065 assuming $e_{y,min} = e_n$.

For pipes of $d_n \leqslant 25$, the specification of a constant value of $e_{y,min}$ in Table 4 follows the requirements given in ISO 4437.

In Table 5, $e_{y,min}$ values are given for each of a range of preferred SDR values (9, 11, 13,6 and 17,6) for convenience in the selection of pipe wall thickness in accordance with the pipe design guidelines to be given in ISO 14531-4. Other SDR values may be utilized provided they are in accordance with ISO 4065 and ISO 161-1.

5.3.4 Tolerance on minimum wall thickness $e_{y,min}$

The tolerances on the minimum wall thickness $e_{y,min}$ shall conform to Table 6, which is derived from grade V as specified in ISO 11922-1:1997 for $e_{y,min} \leqslant 46$ mm. The maximum variation between e_y and $e_{y,min}$ is determined by the tolerance specified in Table 6.

Table 3 — Mean outside diameter and out-of-roundness

Dimensions in millimetres

Nominal outside diameter d_n	Minimum mean outside diameter $d_{em,min}$	Maximum mean outside diameter $d_{em,max}$		Maximum absolute out-of-roundness (ovality)[a,b]
		Grade A	Grade B	Grade N
16	16,0	—	16,3	1,2
20	20,0	—	20,3	1,2
25	25,0	—	25,3	1,2
32	32,0	—	32,3	1,3
40	40,0	—	40,4	1,4
50	50,0	—	50,4	1,4
63	63,0	—	63,4	1,5
75	75,0	—	75,5	1,6
90	90,0	—	90,6	1,8
110	110,0	—	110,7	2,2
125	125,0	—	125,8	2,5
140	140,0	—	140,9	2,8
160	160,0	—	161,0	3,2
180	180,0	—	181,1	3,6
200	200,0	—	201,2	4,0
225	225,0	—	226,4	4,5
250	250,0	—	251,5	5,0
280	280,0	282,6	281,7	9,8
315	315,0	317,9	316,9	11,1
355	355,0	358,2	357,2	12,5
400	400,0	403,6	402,4	14,0
450	450,0	454,1	452,7	15,6

[a] Measurement of out-of-roundness shall be made at the point of manufacture in accordance with ISO 3126.

[b] For straight pipes (and coiled pipes after uncoiling and conditioning) in accordance with requirements agreed between the manufacturer and pipeline operator.

Table 4 — Minimum wall thickness $e_{y,min}$ for nominal pipe diameters $d_n \leqslant 25$

Dimensions in millimetres

Nominal outside diameter d_n	Minimum wall thickness $e_{y,min}$
16	2,3[a]
20	2,3[a]
25	2,3[a]

[a] The optional specification of a minimum wall thickess of 2,9 mm for special applications is not precluded by this part of ISO 14531.

Table 5 — Minimum wall thickness $e_{y,min}$ for pipe diameters $d_n \geqslant 32$

Dimensions in millimetres

Nominal outside diameter d_n	**Minimum wall thickness** $e_{y,min}$			
	SDR 17,6	SDR 13,6	SDR 11	SDR 9
32		2,4	2,9	3,6
40		3,0	3,7	4,5
50		3,7	4,6	5,6
63	3,6	4,7	5,8	7,1
75	4,3	5,6	6,8	8,4
90	5,2	6,7	8,2	10,1
110	6,3	8,1	10,0	12,3
125	7,1	9,2	11,4	14,0
140	8,0	10,3	12,7	15,7
160	9,1	11,8	14,6	17,9
180	10,2	13,3	16,4	20,1
200	11,4	14,7	18,2	22,4
225	12,8	16,6	20,5	25,2
250	14,2	18,4	22,7	27,9
280	15,9	20,6	25,4	31,3
315	17,9	23,2	28,6	35,2
355	20,1	26,1	32,2	39,7
400	22,7	29,4	36,3	44,7
450	25,5	33,1	40,9	50,3

Table 6 — Tolerance on minimum wall thickness at any point $e_{y,min}$

Dimensions in millimetres

Minimum wall thickness $e_{y,min}$	Tolerance	Minimum wall thickness $e_{y,min}$	Tolerance
$2,0 < e_{y,min} \leqslant 3,0$	$^{+0,4}_{0}$	$27,0 < e_{y,min} \leqslant 28,0$	$^{+2,9}_{0}$
$3,0 < e_{y,min} \leqslant 4,0$	$^{+0,5}_{0}$	$28,0 < e_{y,min} \leqslant 29,0$	$^{+3}_{0}$
$4,0 < e_{y,min} \leqslant 5,0$	$^{+0,6}_{0}$	$29,0 < e_{y,min} \leqslant 30,0$	$^{+3,1}_{0}$
$5,0 < e_{y,min} \leqslant 6,0$	$^{+0,7}_{0}$	$30,0 < e_{y,min} \leqslant 31,0$	$^{+3,2}_{0}$
$6,0 < e_{y,min} \leqslant 7,0$	$^{+0,8}_{0}$	$31,0 < e_{y,min} \leqslant 32,0$	$^{+3,3}_{0}$
$7,0 < e_{y,min} \leqslant 8,0$	$^{+0,9}_{0}$	$32,0 < e_{y,min} \leqslant 33,0$	$^{+3,4}_{0}$
$8,0 < e_{y,min} \leqslant 9,0$	$^{+1}_{0}$	$33,0 < e_{y,min} \leqslant 34,0$	$^{+3,5}_{0}$
$9,0 < e_{y,min} \leqslant 10,0$	$^{+1,1}_{0}$	$34,0 < e_{y,min} \leqslant 35,0$	$^{+3,6}_{0}$
$10,0 < e_{y,min} \leqslant 11,0$	$^{+1,2}_{0}$	$35,0 < e_{y,min} \leqslant 36,0$	$^{+3,7}_{0}$
$11,0 < e_{y,min} \leqslant 12,0$	$^{+1,3}_{0}$	$36,0 < e_{y,min} \leqslant 37,0$	$^{+3,8}_{0}$
$12,0 < e_{y,min} \leqslant 13,0$	$^{+1,4}_{0}$	$37,0 < e_{y,min} \leqslant 38,0$	$^{+3,9}_{0}$
$13,0 < e_{y,min} \leqslant 14,0$	$^{+1,5}_{0}$	$38,0 < e_{y,min} \leqslant 39,0$	$^{+4}_{0}$
$14,0 < e_{y,min} \leqslant 15,0$	$^{+1,6}_{0}$	$39,0 < e_{y,min} \leqslant 40,0$	$^{+4,1}_{0}$
$15,0 < e_{y,min} \leqslant 16,0$	$^{+1,7}_{0}$	$40,0 < e_{y,min} \leqslant 41,0$	$^{+4,2}_{0}$
$16,0 < e_{y,min} \leqslant 17,0$	$^{+1,8}_{0}$	$41,0 < e_{y,min} \leqslant 42,0$	$^{+4,3}_{0}$
$17,0 < e_{y,min} \leqslant 18,0$	$^{+1,9}_{0}$	$42,0 < e_{y,min} \leqslant 43,0$	$^{+4,4}_{0}$
$18,0 < e_{y,min} \leqslant 19,0$	$^{+2}_{0}$	$43,0 < e_{y,min} \leqslant 44,0$	$^{+4,5}_{0}$
$19,0 < e_{y,min} \leqslant 20,0$	$^{+2,1}_{0}$	$44,0 < e_{y,min} \leqslant 45,0$	$^{+4,6}_{0}$
$20,0 < e_{y,min} \leqslant 21,0$	$^{+2,2}_{0}$	$45,0 < e_{y,min} \leqslant 46,0$	$^{+4,7}_{0}$
$21,0 < e_{y,min} \leqslant 22,0$	$^{+2,3}_{0}$	$46,0 < e_{y,min} \leqslant 47,0$	$^{+4,8}_{0}$
$22,0 < e_{y,min} \leqslant 23,0$	$^{+2,4}_{0}$	$47,0 < e_{y,min} \leqslant 48,0$	$^{+4,9}_{0}$
$23,0 < e_{y,min} \leqslant 24,0$	$^{+2,5}_{0}$	$48,0 < e_{y,min} \leqslant 49,0$	$^{+5}_{0}$
$24,0 < e_{y,min} \leqslant 25,0$	$^{+2,6}_{0}$	$49,0 < e_{y,min} \leqslant 50,0$	$^{+5,1}_{0}$
$25,0 < e_{y,min} \leqslant 26,0$	$^{+2,7}_{0}$	$50,0 < e_{y,min} \leqslant 51,0$	$^{+5,2}_{0}$
$26,0 < e_{y,min} \leqslant 27,0$	$^{+2,8}_{0}$	—	—

5.4 Coiled pipe

The minimum internal diameter, maximum external diameter and width of pipe coils shall be specified by agreement between the manufacturer and pipeline operator.

5.5 Mechanical characteristics

Pipes shall conform to the mechanical-performance requirements given in Table 7.

Table 7 — Mechanical characteristics of pipes

Characteristic	Units	Requirements	Test parameters	Test method
Hydrostatic strength	h	No failure when tested to 1 000 h[a]	Temperature: 20 °C Stress: PE-X 80: 8,3 MPa PE-X 100: 10,4 MPa PE-X 125: 13,0 MPa	ISO 1167 Type A end caps Water-in-water
		No failure when tested to 165 h	Temperature: 95 °C Stress: PE-X 80: 3,8 MPa PE-X 100: 4,8 MPa PE-X 125: 6,0 MPa	
		No failure when tested to 1 000 h	Temperature: 95 °C Stress: PE-X 80: 3,7 MPa PE-X 100: 4,7 MPa PE-X 125: 5,9 MPa	
Elongation at break	%	$\leqslant$ 350		ISO 6259-1, ISO 6259-3
RCP arrest temperature[b]	°C	$\leqslant -50$[c]	Stress: PE-X 80: 6,4 MPa PE-X 100: 8,0 MPa PE-X 125: 10,0 MPa	ISO 13477
Slow crack growth[d]	h	No failure when tested to 5 000 h	Temperature: 80 °C Pressure:[e] PE-X 80: 8,0 bar PE-X 100: 9,2 bar PE-X 125: 10,8 bar	ISO 13479
Squeeze-off properties	h	No failure when tested to 1 000 h	Temperature: 95 °C Stress: PE-X 80: 3,7 MPa PE-X 100: 4,7 MPa PE-X 125: 5,9 MPa	Annex C Preferred squeeze-off temperature −50 °C (lower temperatures may also be used)

[a] Conducting tests at 20 °C for 100 h at a stress level agreed between the manufacturer and pipeline operator is permissible if correlation with 1 000 h data can be demonstrated.

[b] For pipes of $d_n \geqslant 90$ mm. Testing is only required when the wall thickness of the pipe is greater than the wall thickness of the pipe used in the rapid crack propagation test on the PE-X compound (see footnote b to Table 1). Tests shall be carried out on the thickest-walled pipe in the manufacturer's range. For large-diameter thick-walled pipe, ISO 13478 may be used.

[c] Alternative temperatures of −20 °C or −35 °C may be used to qualify material for minimum operating temperatures higher than −50 °C (see clause 1).

[d] For pipes of $e_n > 5$ mm. For quality control, conducting tests for 165 h at 95 °C and a pressure agreed between the manufacturer and pipeline operator is permissible if correlation with 80 °C data can be demonstrated.

[e] The test pressures stated are for SDR 11 pipes. Guidance regarding test pressures for pipes of other SDR values is given in ISO 13479.

Test pieces shall be subjected to the hydrostatic strength, RCP arrest and squeeze-off tests using an internal pressure determined from the following equation:

$$p = \frac{20\sigma}{\frac{d_{em}}{e_{y,min}} - 1}$$

where

p is the internal pressure, in bars;

σ is the value of the hydrostatic stress, expressed in megapascals, corresponding to the test duration and test temperature given in Table 7.

d_{em} is the mean outside diameter;

$e_{y,min}$ is the minimum wall thickness of the test piece.

NOTE The test parameters given for hydrostatic-strength testing in Table 7 were derived using experimental data supplemented by theoretical calculations. As experience is gained in the implementation of this part of ISO 14531, ISO/TC 138/SC 4 may review the values specified.

5.6 Physical characteristics

When tested in accordance with the methods given in Table 8 using the parameters specified, pipes shall conform to the requirements given in Table 8.

Table 8 — Physical characteristics of pipes

Characteristic	Units	Requirements	Test parameters	Test method
Degree of crosslinking	%	Manufacturer's declared value[a] ($\geqslant$ 60 but $\leqslant$ 90)		ISO 10147[b]
Pigment dispersion		$\leqslant$ grade 3		ISO 18553
Carbon black dispersion		$\leqslant$ grade 3		ISO 18553
Thermal stability	min	$\geqslant$ 20	200 °C[c]	ISO/TR 10837
Resistance to weathering[d]		As indicated by change in a) thermal stability[e] b) 95 °C hydrostatic strength[f] c) elongation at break[f]	$E \geqslant$ 3,5 GJ/m^2	Annex C
Longitudinal reversion	%	$\leqslant$ 3 No change in appearance	110 °C	ISO 2505-1

[a] A tolerance of ± 5 % shall apply to the manufacturer's declared value at any point in the body of the pipe.

[b] Test pieces of radial thickness 0,1 mm shall be used for measurement of degree of crosslinking. They shall be taken from the outer and inner pipe surfaces and the mid-wall position.

[c] Testing at 210 °C is permissible if correlation with 200 °C data can be demonstrated. In cases of dispute, testing shall be carried out at 200 °C.

[d] Not applicable to carbon black pigmented pipes where the carbon content is greater than 2 % as determined in accordance with ISO 6964.

[e] Test pieces shall be taken from the outer pipe surface after preparation as for fusion jointing either by scraping to remove a layer 0,2 mm thick or by removal of the protective surface coating, as appropriate.

[f] See 5.5 and Table 7.

6 Marking

6.1 Legibility

Marking shall be legible without magnification.

Legibility shall be maintained during storage, handling, installation and use.

6.2 Damage

Marking shall not initiate cracks or other types of failure in the product.

6.3 Minimum marking requirements

Marking shall be in a colour that differs from that of the external pipe surface to be inscribed.

The marking shall be repeated at intervals not greater than 1 m.

Marking on coiled pipes shall include a sequential numbering system indicating the coil length remaining.

The marking shall include the minimum information specified in Table 9.

Table 9 — Minimum marking information

Item	Marking
Manufacturer's name or trademark	Name or symbol
Fuel to be conveyed	Gas
Dimensions	$d_n \times e_n$
SDR ($d_n \geqslant 40$ mm)	SDR (see 5.3.3)
Designation of material	e.g. PE-Xa 100
Minimum operating temperature	e.g. -50 °C
Production period (date/code)	
A reference to this part of ISO 14531	ISO 14531-1

Annex A
(informative)

Dimensions of ancillary PE-X pipes

A.1 Mean outside diameter and out-of-roundness

It is recommended that the mean outside diameter d_{em} and the out-of-roundness (ovality) conform to Table A.1.

Table A.1 — Mean outside diameter and out-of-roundness limits

Dimensions in millimetres

Nominal outside diameter d_n	Minimum mean outside diameter $d_{em,min}$	Maximum mean outside diameter $d_{em,max}$		Maximum absolute out-of-roundness (ovality)[a]
		Grade A	Grade B	Grade N[b]
8	8,0		8,2	1,0
10	10,0		10,2	1,1
12	12,0		12,3	1,1
16	16,0		16,3	1,2
20	20,0		20,3	1,2

[a] Measurement of out-of-roundness is made at the point of manufacture in accordance with ISO 3126.

[b] For straight pipes (and coiled pipes after uncoiling and conditioning) in accordance with requirements agreed between the manufacturer and pipeline operator.

A.2 Minimum wall thickness $e_{y,min}$

Minimum wall thicknesses $e_{y,min}$ are given in Table A.2.

Table A.2 — Minimum wall thickness $e_{y,min}$

Dimensions in millimetres

Nominal outside diameter d_n	Minimum wall thickness $e_{y,min}$
8	1,4
10	1,8
12	1,8
16	2,2
20	2,8

A.3 Tolerance on minimum wall thickness $e_{y,min}$

It is recommended that the tolerances on the minimum wall thickness $e_{y,min}$ conform to Table A.3, which is derived from grade V of ISO 11922-1:1997.

The maximum variation between e_y and $e_{y,min}$ is determined by the tolerance specified in Table A.3.

Table A.3 — Tolerances on minimum wall thickness $e_{y,min}$

Dimensions in millimetres

Minimum wall thickness $e_{y,min}$	Tolerance
$1,0 \leqslant e_{y,min} \leqslant 2,0$	$^{+0,2}_{0}$
$2,0 < e_{y,min} \leqslant 3,0$	$^{+0,4}_{0}$

Annex B
(normative)

Resistance to gas constituents

B.1 Test piece

The following test shall be carried out on a pipe of $d_n = 32$ (wall thickness 2,9 mm).

B.2 Procedure

Prepare a synthetic condensate comprising a mixture of 50 % (by mass) *n*-decane (99 %) and 50 % (by mass) 1,3,5-trimethylbenzene.

Condition the pipe by filling it with condensate and allowing it to stand in air for 1 500 h at (23 ± 2) °C. Immediately after the conditioning period, carry out the test specified in ISO 1167 with the synthetic condensate inside the pipe and water outside, using the test parameters specified in Table 1.

A conditioning period of 24 h at 80 °C may be employed as an alternative but, in cases of dispute, the 1 500 h at 23 °C conditions shall apply.

Care shall be taken in handling the chemicals used in the test and to avoid contamination of equipment normally used for conventional pipe testing with water.

B.3 Test report

The test report shall include the following information:

a) a reference to this part of ISO 14531;

b) complete identification of the pipe, including manufacturer, nominal diameter d_n, type of material (e.g. PE-Xa) and production date;

c) the mean outside diameter of the pipe d_{em};

d) the minimum wall thickness of the pipe $e_{y,min}$;

e) the conditioning parameters;

f) the test pressure;

g) the duration of the test;

h) details of the location and mode of any failure;

i) any factors which may have affected the results, such as any incidents or any operating details not specified in this part of ISO 14531;

j) the date of the test.

Annex C
(normative)

Resistance to weathering

C.1 Test method

The test method shall be as given in ISO 16871 except where otherwise specified in this annex.

C.2 Exposure equipment and site

Test racks and specimen fixtures shall be made from inert materials which will not affect the test results.

NOTE Wood, non-corrosive aluminium alloys, stainless steel and ceramics have been found suitable.

Brass, steel or copper shall not be used in the vicinity of the test specimens. The test site shall be equipped with instruments to record the sunlight energy received and the ambient temperature.

The equipment shall be capable of supporting pipe test pieces so that, at latitudes of 45° or more, the exposed surface of each test piece is at 45° to the horizontal and facing towards the equator. At latitudes of less than 45°, the angle of exposure shall be the same as the angle of latitude.

The exposure site shall be on open ground, well away from trees and buildings likely to disrupt incident sunlight.

For exposures at an angle of 45° facing south in the northern hemisphere, no obstruction, including adjacent racks, in an easterly, southerly or westerly direction shall subtend, at any point on the test pieces, an angle greater than 20° in the vertical plane, or in a northerly direction greater than 45°. For exposures in the southern hemisphere facing north, corresponding provisions apply.

C.3 Test pieces

The test pieces shall be at least 1 m long. They shall be selected from the thinnest-walled pipes within a random range of diameters. The batch of pipes from which the test pieces are selected shall conform to all the requirements of this part of ISO 14531. Pipes with external coatings shall be weathered with the coating intact. Pipes supplied with discrete wrappings shall be weathered with the wrapping removed.

C.4 Procedure

Identify the test pieces. After an exposure time sufficient for them to receive the required total incident energy (see Table 8), remove and test them as specified in Table 8.

NOTE The amount of incident energy may be estimated using data provided by local weather stations.

C.5 Test report

The test report shall include the following information:

a) a reference to this part of ISO 14531;

b) complete identification of each pipe, including manufacturer, nominal outside diameter d_n,type of material (e.g. PE-Xa) and production date;

c) the mean outside diameter of the pipe d_{em};

d) the minimum wall thickness of the pipe $e_{y,min}$;

e) a record of the amount of incident sunlight and the ambient temperature;

f) the duration of the weathering exposure;

g) the results of the post-weathering tests specified in Table 8;

h) a description of any visible weathering damage;

i) any factors which may have affected the results, such as any incidents or any operating details not specified in this part of ISO 14531;

j) the date of each test.

Annex D
(normative)

Squeeze-off test method

D.1 Principle

A PE-X pipe, maintained at the temperature specified in Table 7, is squeezed between two parallel bars of circular cross-section located at right angles to the pipe centre-line at a position midway between the pipe ends. The squeeze is subsequently released after an appropriate length of time. The pipe is then subjected to a hydrostatic strength test at 95 °C.

NOTE In certain countries, the squeeze-off technique is used to restrict the flow of gas in PE piping systems while carrying out repair and maintenance operations. The test described here may be used to establish the strength of pipes following squeeze-off.

D.2 Apparatus

D.2.1 Squeeze-off equipment

Use a compressive-loading device comprising a combination of a fixed bar and a movable bar contained within a frame designed to withstand the forces generated by the squeeze-off action.

Each bar shall have a circular cross-section and sufficient rigidity to ensure a uniform distance between the bars along their whole length during squeeze-off. Each bar shall have the same diameter, the value being as specified in Table D.1.

Table D.1 — Squeeze-off compression levels

Nominal outside diameter d_n	Bar diameter mm	Squeeze-off level L[a] %
$d_n \leqslant 63$	25	80
$63 < d_n \leqslant 250$	38	80
$250 < d_n \leqslant 630$	50	90

[a] The squeeze-off level L is the ratio, expressed as a percentage, of the distance between the bars in millimetres and twice the minimum wall thickness of the pipe $e_{y,min}$, also in millimetres.

The movable bar may be hydraulically or manually operated to achieve the levels of compression specified in Table D.1.

Means shall be provided for measuring the distance between the bars and maintaining it to within ± 0,2 mm of the required value during the squeeze-off phase.

D.2.2 Conditioning apparatus (before squeeze-off)

Required is apparatus capable of maintaining the test piece temperature to within ± 1,5 °C of the squeeze-off temperature used (see Table 7). Provision shall be made to prevent the accumulation of ice on pipe surfaces where it is likely to affect compression of the test piece.

D.2.3 Pressure test equipment

The equipment shall conform to the requirements of ISO 1167, including type A end caps, and be capable of maintaining the test pressure corresponding to the stress specified in Table 7 to within ± 2 % and the test temperature to within (95 ± 1) °C.

D.3 Test piece

The test piece shall be a pipe of which the minimum free length, between fittings if present, shall be 250 mm or six times the nominal outside diameter d_n, whichever is the greater.

The position of maximum wall thickness shall be located and marked on the pipe to facilitate alignment as specified in D.4.3.

The test piece shall be closed off with type A end caps (see ISO 1167) to facilitate the conduct of a pressure test following squeeze-off and release.

D.4 Procedure

D.4.1 Calculate the final distance x, in millimetres, required between the squeeze bars to achieve the necessary squeeze-off level L using the following equation:

$$x = \frac{2Le_{y,min}}{100}$$

where

$e_{y,min}$ is the minimum wall thickness of the pipe as specified in Tables 4 and 5;

L is the squeeze-off level as specified in Table D.1.

D.4.2 Condition the test piece at the squeeze-off temperature (see Table 7) for a time at least as long as that defined in ISO 1167 for the pipe wall thickness concerned. Any conditioning fluids used shall not affect the properties of the test piece.

D.4.3 Position the test piece centrally within the squeeze bars with the position of maximum wall thickness of the pipe set to lie in the plane of squeeze. Set the squeeze bars at right angles to the pipe centre-line and midway between the pipe ends. Remove the test piece from the conditioning environment and squeeze it at ambient temperature within the following time interval after removal:

a) 30 s for $d_n \leqslant 110$;

b) 90 s for $110 < d_n \leqslant 200$;

c) 180 s for $d_n > 200$.

D.4.4 Use a rate of compression of 25 mm/min to 50 mm/min to reach the final squeeze-off distance x and maintain this position for a period of (15 ± 1) min. Start to release the squeeze load immediately the hold time has elapsed so that the load is fully released within 1 min.

D.4.5 Prepare the test piece for pressure testing in accordance with ISO 1167. The pressure test parameters (pressure and time) shall conform to the requirements specified in Table 7.

D.4.6 After testing, inspect the test piece and record the position and mode of any failure.

D.5 Test report

The test report shall include the following information:

a) a reference to this part of ISO 14531;

b) complete identification of each pipe, including manufacturer, nominal outside diameter d_n, type of material (e.g. PE-Xa) and production date;

c) the mean outside diameter of the pipe d_{em};

d) the minimum wall thickness $e_{y,min}$ of the pipe;

e) the squeeze-off bar diameter;

f) the final distance x between the squeeze-off bars;

g) the squeeze-off temperature;

h) the test pressure;

i) the duration of the test;

j) details of the location and mode of any failure;

k) any factors which may have affected the results, such as any incidents or any operating details not specified in this part of ISO 14531;

l) the date of the test.

Annex E
(informative)

Pipe design schedule incorporating information regarding operating temperature limits and a pipe wall thickness selection method

E.1 General

PE-X pipes designed in accordance with the guidelines given in clauses E.2 to E.4 and conforming to the requirements of this part of ISO 14531 may be considered suitable for use in PE-X pipelines under the temperature conditions given in Table E.1.

The minimum operating temperature θ_{min} is taken to be the minimum operating temperature (above and/or below ground) expected during the service life of the pipeline.

The maximum operating temperature θ_{max} is taken to be the maximum operating temperature (above and/or below ground) expected during the service life of the pipeline.

The minimum/maximum operating temperatures for PE-X pipeline systems are as given in Table E.1.

Table E.1 — Minimum/maximum operating temperature limits for PE-X pipelines

Temperature class	Minimum temperature[a] θ_{min} °C	Maximum temperature θ_{max} °C
Class 1	−50	+60
Class 2	−35	+60
Class 3	−20	+60

[a] The minimum operating temperature is determined by the RCP performance required for the envisaged application (see Table 1 and Table 7).

It is recommended that PE-X pipelines incorporating PE fusion fittings conforming to ISO 14531-2 and ISO 8085-3 be restricted to an operating temperature range of −20 °C to +40 °C and a maximum operating pressure (MOP) calculated as in ISO 8085-3.

E.2 Nominal wall thickness e_n

Calculated the nominal wall thickness e_n using the following equation:

$$e_n = \frac{d_n}{\text{SDR}}$$

in which SDR is determined from the following relationship and then rounded down to the nearest lower value given in ISO 4065:

$$\text{SDR} = \frac{20 \times \text{MRS}_{\theta,t}}{\text{DP}_\text{P} \times C_\text{M} \times C_\text{A}} + 1$$

where

$MRS_{\theta,t}$ is the σ_{LPL} of the pipe material, in megapascals, calculated using ISO 9080 for a specific design temperature θ and lifetime t (see 4.2.2) and then classified in accordance with Table E.2;

DP_P is the pipe design pressure, which is equal to or greater than the MOP;

C_M is a coefficient equal to 1,25 that reflects the effect on $MRS_{\theta,t}$ of the material/process-related properties of the pipe other than those represented in σ_{LPL};

C_A is an application-based safety coefficient introduced by the pipeline operator that takes into account the pipeline MOP, the operating conditions (e.g. type of gas being conveyed, pipe location in remote areas or urban sites) and any relevant national regulations.

NOTE Rounding of the SDR value may lead to a valve of $C > C_M \times C_A$. The product of C_M and C_A is nominally equal to C, the overall service (design) coefficient as defined in ISO 12162.

Table E.2 — Values of $MRS_{\theta,t}$ classified by category

Range of σ_{LPL} at given θ and t MPa	$MRS_{\theta,t}$ MPa
$5,00 \leqslant \sigma_{LPL} \leqslant 5,69$	5,00
$5,60 \leqslant \sigma_{LPL} \leqslant 6,29$	5,60
$6,30 \leqslant \sigma_{LPL} \leqslant 7,19$	6,30
$7,20 \leqslant \sigma_{LPL} \leqslant 7,99$	7,20
$8,00 \leqslant \sigma_{LPL} \leqslant 8,99$	8,00
$9,00 \leqslant \sigma_{LPL} \leqslant 9,99$	9,00
$10,00 \leqslant \sigma_{LPL} \leqslant 11,19$	10,00
$11,20 \leqslant \sigma_{LPL} \leqslant 12,49$	11,20
$12,50 \leqslant \sigma_{LPL} \leqslant 13,99$	12,50

E.3 Design temperature θ

The design temperature θ is the anticipated maximum operating temperature of the pipe at the intended pipe location. It should not be less than 0 °C.

NOTE A design based upon the maximum operating temperature is regarded as conservative and an advantage may be gained from a precise analysis that incorporates Miner's rule (ISO 13760) utilizing safety factors agreed between the manufacturer and pipeline operator.

E.4 Overall service (design) coefficient C

Using the rounded SDR value determined in accordance with clause E.2, calculate the design stress σ_S from the following equation:

$$\sigma_s = \frac{DP_P}{20}(SDR - 1)$$

and then the overall service (design) coefficient C from

$$C = \frac{MRS_{\theta,t}}{\sigma_s}$$

The coefficient C should conform to the value required by the pipeline operator.

NOTE Currently, for gas applications, a minimum value of C equal to 2,0 is incorporated in ISO 4437 for PE pipes.

Bibliography

[1] ISO 2505-2, *Thermoplastics pipes — Longitudinal reversion — Part 2: Determination parameters*

[2] ISO 13478, *Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Full-scale test (FST)*

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