INTERNATIONAL STANDARD

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Multilayer piping systems for hot and cold water installations inside buildings —

Part 2: Pipes

Systèmes de canalisations multicouches pour installations d'eau chaude et froide à l'intérieur des bâtiments —

Partie 2: Tubes

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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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 21003-2 was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 2, *Plastics pipes and fittings for water supplies*.

ISO 21003 consists of the following parts, under the general title *Multilayer piping systems for hot and cold water installations inside buildings*:

— *Part 1: General*

— *Part 2: Pipes*

— *Part 3: Fittings*

— *Part 5: Fitness for purpose of the system*

— *Part 7: Guidance for the assessment of conformity* [Technical Specification]

NOTE ISO 21003 does not include a Part 4: *Ancillary equipment*, or a Part 6: *Guidance for installation*.

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Introduction

The system standard of which this is Part 2 specifies the requirements for a multilayer piping system.

The multilayer piping system is intended to be used for hot and cold water installations inside buildings.

In respect of potentially adverse effects on the quality of water intended for human consumption caused by the products covered by ISO 21003:

— no information is provided as to whether the products may be used without restriction in any of the member states of the EU or EFTA;

— it should be noted that, while awaiting the adoption of verifiable European criteria, existing national regulations concerning the use and/or the characteristics of these products remain in force.

Requirements and test methods for material and components other than pipes are specified in ISO 21003-1 and ISO 21003-3. Characteristics relating to fitness for purpose (mainly for joints) are covered in ISO 21003-5. ISO/TS 21003-7 gives guidance on the assessment of conformity.

This part of ISO 21003 specifies the characteristics of pipes.

Other system standards which, at the date of publication of this part of ISO 21003, had been published for plastics piping systems used for the same application are listed in Annex A.

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Multilayer piping systems for hot and cold water installations inside buildings —

Part 2: Pipes

1 Scope

This part of ISO 21003 specifies the characteristics of pipes for multilayer piping systems intended to be used for hot and cold water installations inside buildings for the conveyance of water — whether or not the water is intended for human consumption (domestic systems) or heating systems — under specified design pressures and temperatures appropriate to the class of application (see Table 1 of ISO 21003-1:2008).

It also specifies the test parameters for the test methods referred to in this part of ISO 21003.

ISO 21003 is a reference product standard. It is applicable to multilayer pipes, fittings, their joints, and also to joints with components made of other plastics and non-plastics materials intended to be used for hot and cold water installations. This part of ISO 21003 is intended for use only in conjunction with all the other parts of ISO 21003.

ISO 21003 covers a range of service conditions (application classes) and design pressures. It is not applicable for values of design temperature, T_D, maximum design temperature, T_{max}, and malfunction temperature, T_{mal}, in excess of those in Table 1 of ISO 21003-1:2008.

NOTE 1 It is the responsibility of the purchaser or specifier to make the appropriate selections from these aspects, taking into account their particular requirements and any relevant national regulations and installation practices or codes.

The polymeric materials used for the stress-designed layers are the following: polybutylene (PB), polyethylene of raised temperature resistance (PE-RT), crosslinked polyethylene (PE-X), polypropylene (PP) and chlorinated poly(vinyl chloride) (PVC-C).

The PE-X used shall be fully crosslinked and shall comply with the requirements of the relevant reference product standard (ISO 15875).

NOTE 2 For the purposes of ISO 21003, crosslinked polyethylene (PE-X) as well as adhesives are considered as thermoplastic materials.

Solid-wall pipes with thin outer layers (applied as protection layers or barrier layers, for instance) are not covered by ISO 21003 but are specified in the Amendments to ISO 15874-2, ISO 15875-2 and ISO 15876-2. The total thickness of such outer layers, including the thickness of the adhesives used, shall be $\leqslant$ 0,4 mm.

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2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

ISO 527-1:1993, *Plastics — Determination of tensile properties — Part 1: General principles*

ISO 527-2:1993, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 2578:1993, *Plastics — Determination of time-temperature limits after prolonged exposure to heat*

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

ISO 6259-1:1997, *Thermoplastics pipes — Determination of tensile properties — Part 1: General test method*

ISO 7686, *Plastics pipes and fittings — Determination of opacity*

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

ISO 10508, *Plastics piping systems for hot and cold water installations — Guidance for classification and design*

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

ISO 15874-2, *Plastics piping systems for hot and cold water installations — Polypropylene (PP) — Part 2: Pipes*

ISO 15875-2, *Plastics piping systems for hot and cold water installations — Crosslinked polyethylene (PE-X) — Part 2: Pipes*

ISO 15876-2, *Plastics piping systems for hot and cold water installations — Polybutylene (PB) — Part 2: Pipes*

ISO 15877-2, *Plastics piping systems for hot and cold water installations — Chlorinated poly(vinyl chloride) (PVC-C) — Part 2: Pipes*

ISO 17454, *Plastics piping systems — Multilayer pipes — Test method for the adhesion of the different layers using a pulling rig*

ISO 17455, *Plastics piping systems — Multilayer pipes — Determination of the oxygen permeability of the barrier pipe*

ISO 17456, *Plastics piping systems — Multilayer pipes —Determination of long-term strength*

ISO 21003-1:2008, *Multilayer piping systems for hot and cold water installations inside buildings — Part 1: General*

ISO 21003-5:2008, *Multilayer piping systems for hot and cold water installations inside buildings — Part 5: Fitness for purpose of the system*

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ISO 22391-2:—[1)], *Plastics piping systems for hot and cold water installations — Polyethylene of raised temperature resistance (PE-RT) — Part 2: Pipes*

EN 713, *Plastics piping systems — Mechanical joints between fittings and polyolefin pressure pipes — Test method for leaktightness under internal pressure of assemblies subjected to bending*

EN 12293, *Plastics piping systems — Thermoplastics pipes and fittings for hot and cold water — Test method for the resistance of mounted assemblies to temperature cycling*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 21003-1 apply.

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO 21003-1 apply.

5 Material

5.1 General

The pipe manufacturer shall declare the materials used for each layer of the multilayer pipe and the function of each layer.

The material characteristics of the stress-designed layers shall comply with the requirements of the relevant reference product standards (see Annex A).

5.2 Processable materials

Clean own reprocessable material which is the same as the virgin material may be added to that virgin material. External reprocessable material shall not be used.

5.3 Influence on water intended for human consumption

All materials of the multilayer piping system, when in contact with water which is intended for human consumption, shall not affect the quality of the drinking water and shall be in compliance with national regulations.

6 General characteristics

6.1 Appearance

When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from any scoring, cavities and other surface defects that would prevent conformance with this part of ISO 21003. The material shall contain no visible impurities. Slight variations in colour are permitted. The ends of each pipe shall be cut cleanly and square to the axis of the pipe.

6.2 Opacity

Multilayer pipes that are declared to be opaque shall not transmit more than 0,2 % of visible light, when tested in accordance with ISO 7686. This requirement is not relevant to M-pipes.

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1) To be published. (Revision of ISO 22391-2:2007)

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7 Construction

Multilayer pipes can include layers made of polymer or layers made of metal.

For example, layers may have the following purposes:

— the ability to withstand pressure;

— the ability to block or greatly reduce the permeation of oxygen or other substances through the pipe wall;

— the ability to create interlayer adhesion;

— the ability to block or greatly diminish the effect of UV and/or sunlight;

— the ability to mechanically protect all other layers (inside layer or outside layer);

— the ability to control the longitudinal expansion;

— the ability to give the multilayer pipe a colour (inside layer or outside layer).

Some characteristics can be combined in the same layer.

For P-type pipes, the pressure strength can be determined in accordance with procedure I or procedure II (see Clause 9). In cases of dispute, procedure II shall be used. For M-type pipes, the pressure strength can only be determined in accordance with procedure II.

8 Geometrical characteristics

8.1 General

Dimensions of multilayer pipes shall be measured in accordance with ISO 3126.

8.2 Dimensions of pipes

The outside diameter should preferably be in accordance with ISO 161-1.

The pipe manufacturer shall give detailed information related to the geometrical characteristics, including the wall thickness, with tolerances for each layer, in a technical file. All layers shall be of sufficient thickness to meet the requirements of this part of ISO 21003.

9 Pressure strength

9.1 Long-term pressure strength (p_{LPL})

The long-term pressure strength of multilayer pipes can be measured (procedure II) or calculated (procedure I), as defined in ISO 17456. Procedure I can only be used for multilayer P-pipes and validation testing shall be carried out at a minimum temperature of T_{max} given in ISO 21003-1:2008, Table 1, for $t = 8\,760$ h at the calculated stress.

9.2 Design pressure strength (p_D)

The design pressure strength is derived from the long-term pressure strength, taking in account the application classes and the overall design coefficients given in the relevant product standards (see Annex B).

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10 Thermal durability

10.1 Thermal durability of P-pipes

For P-pipes, the stress-designed layers shall be tested for thermal stability as described in the relevant reference product standards.

The wall thickness of the test pieces shall be equal to the smallest wall thickness in the diameter range.

10.2 Thermal durability of M-pipes

10.2.1 Inner layer

For M-pipes, the material of the inner layer shall be tested for thermal stability as described in the relevant reference product standard. The test pieces shall have a maximum wall thickness of 2 × the thinnest wall thickness allowed for the inner layer. The stress applied in this test shall be 50 % of the stress for a 1 year test duration, in accordance with the relevant reference product standard, without ductile failure occurring.

10.2.2 Outer layer

The thermal durability of the outer layer shall be determined either on the pipe with the thinnest outer layer for each dimension group in accordance with Annex C or, provided the outer layer is a polyolefin, in accordance with Annex C or Annex D irrespective of the thickness of the outer layer.

11 Strength of the weld line of M-pipes

The strength of the weld line is covered by the control points for the resistance to inner water pressure test in accordance with ISO 17456.

12 Delamination

12.1 Multilayer P-pipes

Multilayer P-pipes shall comply with the requirements in Table 1.

Table 1 — Requirements for delamination

Requirement	Test pieces	Test method
No delamination	EN 12293 [a]	EN 12293, visual
[a] Using the test parameters of the relevant application class (see ISO 21003-5:2008, Table 5).		

12.2 Multilayer M-pipes

Multilayer M-pipes shall comply with the requirements in Table 2.

Table 2 — Delamination resistance

Requirement	Conditioning	Test pieces	Test method
$F_{pull} \geqslant 15$ N/cm No delamination	Before and after conditioning in accordance with EN 12293 [a]	ISO 17454	ISO 17454
[a] Using the test parameters of the relevant application class (see ISO 21003-5:2008, Table 5). To pre-stress branch A of the test piece, the reference product standard and the dimensions of the inner layer shall be used.			

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13 Oxygen permeability

In such instances where resistance to oxygen permeation is required, the pipes shall comply with the requirements in Table 3.

Table 3 — Oxygen permeability

Application class (see ISO 10508)	Test temperature °C	Requirement $F_{ox,day}$	Test method
4	40	$\leqslant$ 0,32 mg/m^2·day	ISO 17455
5	80	$\leqslant$ 3,6 mg/m^2·day	ISO 17455

14 Physical and chemical characteristics

Wherever the manufacturer declares the reference product standard, the applicable physical characteristics shall be checked in accordance with the corresponding clause of this reference product standard.

For the metal layer, the manufacturer shall specify the tensile strength, the elongation at break and the wall thickness including tolerances.

15 Performance requirements

When multilayer pipes conforming to this part of ISO 21003 are jointed, the pipes and joints shall conform to ISO 21003-5.

16 Marking

16.1 General requirements

16.1.1 Marking details shall be printed or formed directly on the pipe not less than once per metre in such a way that, after storage, handling and installation, legibility is maintained.

The manufacturer is not responsible for marking being illegible due to actions such as painting, scratching or covering of the components, or due to the use of detergent, etc., on the components, unless agreed or specified by the manufacturer.

16.1.2 Marking shall not initiate cracks or other types of defect which will adversely influence the performance of the pipe.

16.1.3 If printing is used, the colour of the printed information shall differ from the basic colour of the pipe.

16.1.4 The size of the marking shall be such that it is legible without magnification.

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16.2 Minimum required marking

The minimum required marking of the pipe shall comply with the requirements in Table 4.

Table 4 — Minimum required marking

Information	Marking	
	P-pipes	M-pipes
Number of this International Standard [a]	ISO 21003	ISO 21003
Manufacturer's name and/or trade mark	Name or code	Name or code
Nominal outside diameter and nominal wall thickness	e.g. 32 × 2,5	e.g. 32 × 2,5
Composition of the pipe [b, c]	e.g. PE-Xb/EVOH/PE-Xb or PE-Xc/barrier layer/PE-Xc or PE-Xa/PVC-C	e.g. PE-Xb/Al/PE-Xb
Application class with design pressure	e.g. Class 5/6 bar	e.g. Class 2/10 bar
Opacity [d]	e.g. Opaque	e.g. Opaque
Manufacturer's information	[e]	[e]

[a] Marking with individual parts of ISO 21003, e.g. ISO 21003-2, on pipes, is not permitted. Only systems in accordance with the complete standard, ISO 21003-1, ISO 21003-2, ISO 21003-3 and ISO 21003-5, shall be marked with ISO 21003.

[b] In the order from inside to outside. Adhesives are not mentioned. The manufacturer may also indicate other (non-stress-designed) layers.

[c] For PE-X materials, the type of crosslinking shall be mentioned:

peroxide	PE-Xa
silane	PE-Xb
electron beam	PE-Xc
azo	PE-Xd

For PP materials, the type of PP shall be mentioned:

homopolymer	PP-H
block polymer	PP-B
random copolymer	PP-R

For PE-RT materials, the type of PE-RT shall be mentioned (see ISO 22391-2:—):

PE-RT, type I
PE-RT, type II

[d] If declared by the manufacturer.

[e] To provide traceability, the following details shall be given:

a) the production period, year and month, in figures or in code;
b) a name or code for the production site if the manufacturer is producing at different sites.

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Annex A
(normative)

List of reference product standards

Table A.1 — List of reference product standards

Material	Reference product standard
PB	ISO 15876-1, ISO 15876-2, ISO 15876-3, ISO 15876-5
PE-RT	ISO 22391-1, ISO 22391-2, ISO 22391-3, ISO 22391-5
PE-X	ISO 15875-1, ISO 15875-2, ISO 15875-3, ISO 15875-5
PP	ISO 15874-1, ISO 15874-2, ISO 15874-3, ISO 15874-5
PVC-C	ISO 15877-1, ISO 15877-2, ISO 15877-3, ISO 15877-5

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Annex B
(normative)

Design coefficients for multilayer pipes

B.1 Multilayer polymer pipes (only polymer layers) for which the long-term hydrostatic strength has been determined for each material and for which the design coefficients are known (calculation method)

The long-term pressure strength is calculated using the additive rule, adding the pressure strength of each layer intended to be stress-bearing.

The long-term pressure strength (resistance to pressure) takes into account the lower confidence limit of the predicted hydrostatic strength, p_{LPL} (as stated in the relevant reference product standard), the design coefficient and the dimensions of each layer.

B.2 Multilayer polymer pipes (only polymer layers), p_{LPL} not known, design coefficients for each material known (test method)

The long-term pressure strength of each individual construction is determined using ISO 9080. The pressure strength takes into account the lower confidence limit of the predicted pressure, p_{LPL} (as stated in the relevant reference product standard), and an overall design coefficient calculated from the individual design coefficients and the fraction (percentage) of the total wall thickness to which they apply:

$$C_{tot} = \frac{e_1}{e_{tot}} \times C_1 + \frac{e_2}{e_{tot}} \times C_2 + \ldots + \frac{e_n}{e_{tot}} \times C_n \qquad \text{(B.1)}$$

where

$e_1, e_2, \ldots e_n$ are the wall thicknesses of the individual stress-designed layers;

e_{tot} is the total wall thickness of the stress-designed layers;

$C_1, C_2, \ldots C_n$ are the design coefficients of the individual stress-designed layers;

C_{tot} is the overall design coefficient.

B.3 Multilayer metal pipes (polymer and metal layers) (test method)

The long-term pressure strength of each individual construction is determined using ISO 9080. The pressure strength takes into account the lower confidence limit of the predicted pressure, p_{LPL}, and the design coefficient of the inner layer.

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Annex C
(normative)

Determination of the thermal durability of the outer layer of M-pipes from resistance to cracking after oven ageing

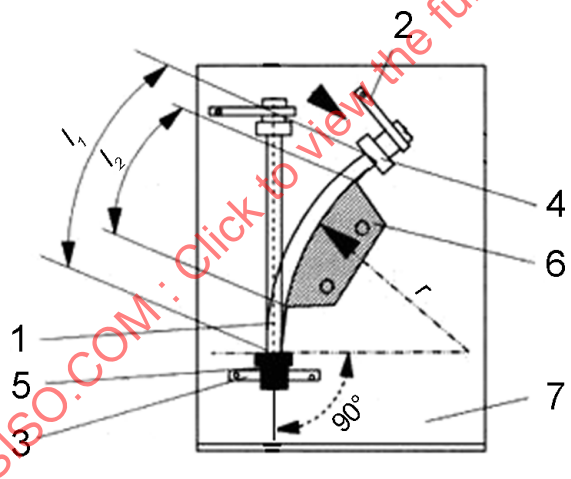
C.1 Principle of the method

A test piece of M-pipe is placed in an oven at an elevated temperature for a defined length of time. After this oven aging, the test piece is bent to produce a required axial strain in the outside layer. The layer is then examined visually for cracks.

C.2 Apparatus

C.2.1 Oven.

C.2.2 Bending template.



Key

1 pipe
2 stop block
3 connection nipple
4 end fitting
5 test fitting
6 bending gauge
7 vertical panel on which test rig is mounted

l_1 total length of pipe
l_2 length of bending gauge
r bend radius

Figure C.1 — Bending template

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C.3 Procedure

C.3.1 Oven aging

a) Polyolefins 110 °C/1 year

b) PVC-C 95 °C/1 year

C.3.2 Deformation

a) Bend with a bending template similar to that described in EN 713 at (23 ± 1) °C, waiting at least 24 h after manufacture. For the bending parameters, see Table C.1.

b) Speed of deformation: min. 3 s, max. 10 s (for the complete deformation).

Table C.1 — Bending parameters

Pipe material	Total pipe length l_1	Length of bending gauge l_2	Bend radius r
Polyolefins	$10D$	$7,5D$	$16D$
PVC-C	$10D$	$7,5D$	$28D$
D = outside diameter of pipe.			

The bend radii in Table C.1 have been chosen to give a flexural strain of 3 % for polyolefin pipes and 1,75 % for PVC-C pipes.

EXAMPLE For a pipe with an outside diameter of 32 mm, the required bend radius is calculated as follows:

$$r = 16 \times D = 16 \times 32 \text{ mm} = 512 \text{ mm}$$

The flexural strain, ε, on the outer layer relative to the unstrained layer of the pipe is given by:

$$\varepsilon = [(r + D)/(r + D/2)] - 1 = [17 \times D/16,5 \times D] - 1 = 0,030\,3 \quad \text{(i.e. 3,0 \%)}$$

C.4 Requirement

No cracks shall be visible in the outer layer.

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Annex D
(normative)

Determination of the thermal durability of the outer layer of M-pipes from the elongation at break after 50 years

D.1 Principle of the method

Test pieces, prepared in accordance with ISO 527-2, are exposed in an oven at a series of different temperatures. After a defined period of exposure at a particular temperature, the elongation at break, ε_B, of the test piece is determined.

The elongation at break, ε_B, expressed as a percentage of the elongation at break of unexposed test pieces, is plotted against the log of the exposure time at each of the temperatures (see Figure D.1).

The logarithm of time is then plotted as an Arrhenius plot against the reciprocal of the thermodynamic (absolute) exposure temperature (see Figure D.2).

The Arrhenius plot is extrapolated to determine the temperature at which the elongation at break would be reduced to 25 % over 50 years, in order to meet the requirements for the application classes specified in ISO 10508.

NOTE This method is based on that in ISO 2578.

D.2 Apparatus

D.2.1 **Oven**, meeting the requirements of ISO 2578:1993, Clause 9, with a temperature tolerance of ± 2 °C.

D.2.2 **Tensile-testing machine**, meeting the requirements of ISO 527-1:1993, Subclause 5.1.

The speed of testing shall be as stated by the manufacturer and shall be in accordance with the recommended speed given in ISO 527-1:1993, Subclause 5.1.2.

D.3 Test piece preparation

The test pieces shall meet the requirements of ISO 527-2:1993, Clause 6. Their thickness shall be 2 mm.

Prepare sufficient test pieces to carry out five determinations at each of at least five different exposure times at each of three different exposure temperatures, i.e. for each curve in Figure D.1 a minimum of 25 test pieces will be necessary.

D.4 Procedure

To determine the elongation at break of unexposed test pieces, test at least five test pieces on the tensile-testing machine (D.2.2), using the method described in ISO 527-1. The test temperature shall be (23 ± 2) °C. The mean value of the measured elongation at break is taken as the 100 % value of the elongation at break of the test material.

Calculate the elongation at break, ε_B, of the test pieces using the procedure given in ISO 6259-1:1997, Subclause 9.1.

When the outer protective layer is made of PE, use the following temperatures: 110 °C, 100 °C, 90 °C (unless higher temperatures are specified by the manufacturer, e.g. 120 °C, 110 °C, 100 °C).

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When the outer protective layer is made of a material other than PE, the temperatures shall be as specified by the manufacturer.

At each of the exposure temperatures, expose at least 25 test pieces, removing them, five at a time, from the oven at increasing exposure times for conditioning at (23 ± 2) °C and testing, using the same method as with the unexposed test pieces.

Express the elongation at break, ε_B, of the exposed test pieces as a percentage of the elongation at break of the unexposed test pieces.

The percentage values found shall be as follows:

— at least one value shall be between 50 % and 75 %;

— at least two values shall be between 25 % and 50 %;

— at least one value shall be lower than 25 %.

Plot the percentage values against the logarithm of their exposure time (see Figure D.1). Plot a curve for each temperature. Record the values of log$t$ corresponding to the points of intersection of the temperature lines with the 25 % value (horizontal line) and plot these values against $1/T$ as shown in Figure D.2.

Calculate a regression line in accordance with ISO 2578:1993, Annex A.

Determine the exposure temperature which, over a lifetime of 50 years (T_{50y}), would reduce the elongation at break to 25 % of its original value.

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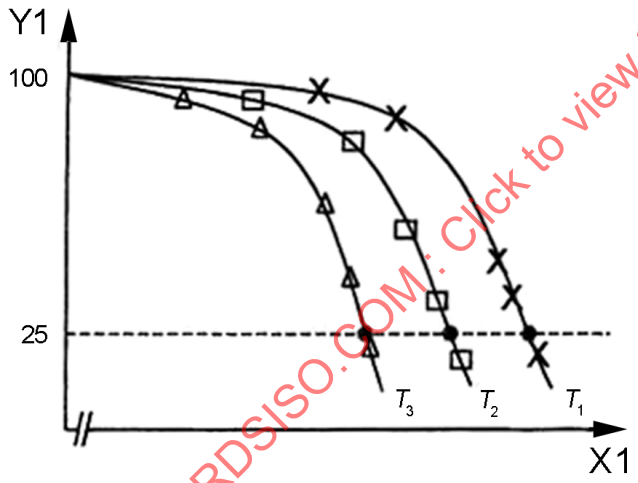
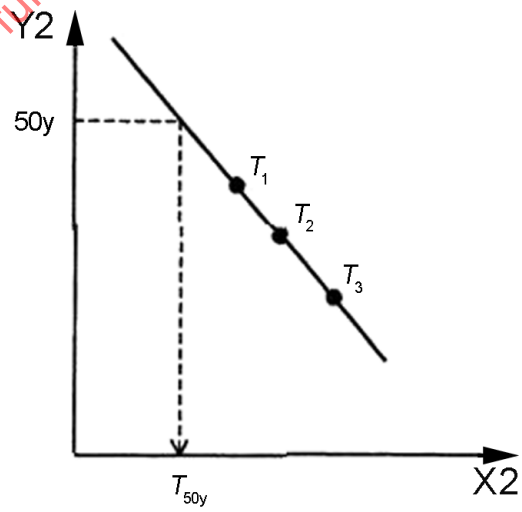


Key

X_1	log$t$ (t in years)
Y_1	% ε_B (elongation at break expressed as a percentage of the original, unexposed, elongation at break)
T_1, T_2, T_3	exposure temperatures used (°C)

Figure D.1 — Log of exposure time versus elongation at break expressed as percentage of original, unexposed, elongation at break



Key

X_2	$1/T$ (T in °C)
Y_2	log$t$ (t in years)
T_1, T_2, T_3	exposure temperatures used (°C)
T_{50y}	exposure temperature at which the elongation at break would be reduced to 25 % after 50 years

Figure D.2 — $1/T$ versus log$t$ at 25 % reduction in elongation at break (see Figure D.1)

Polyolefins for which the percentage elongation at break does not fall below 25 % of the original elongation at break after 8 760 h at an exposure temperature 40 °C above the desired application temperature can be extrapolated with an extrapolation factor of 50 on the application temperature. For temperatures less than 40 °C above the application temperature, the extrapolation factors stated in ISO 9080 shall apply.

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Annex E
(normative)

Multilayer M-pipes — Choice of p_D and the use of Miner's rule

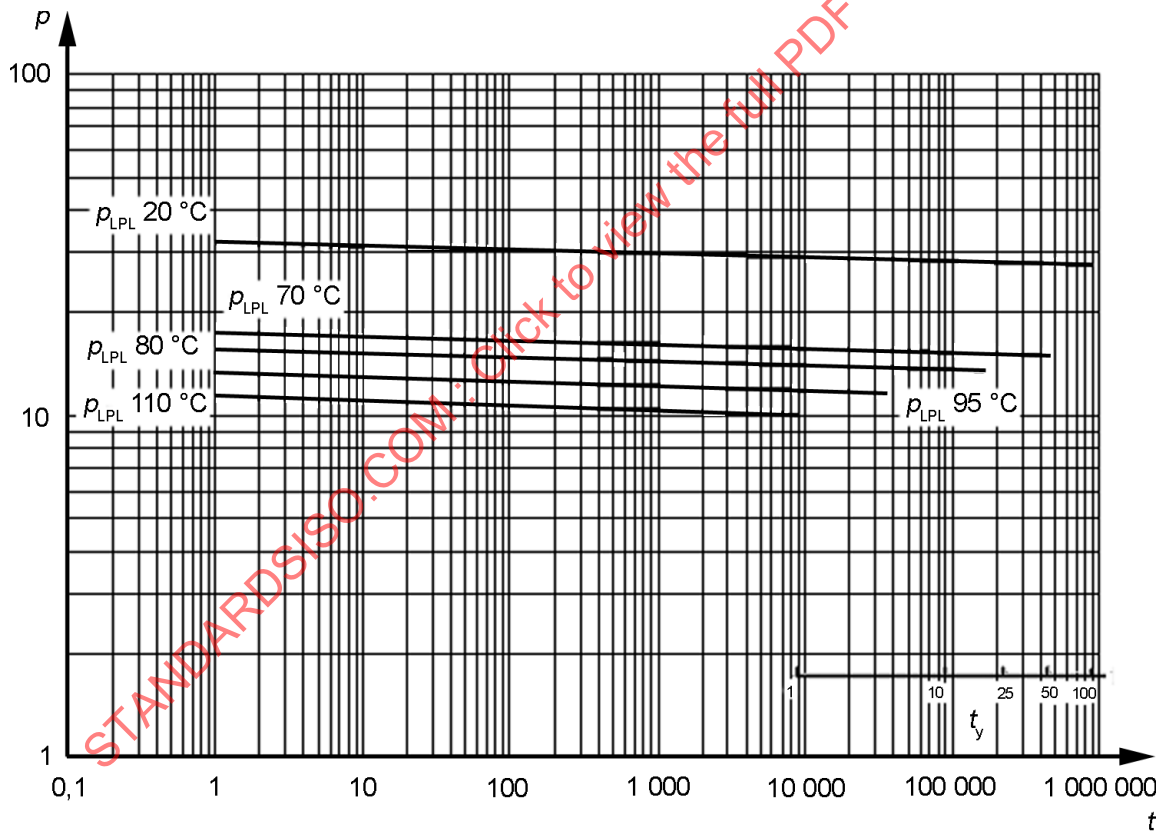
E.1 Basics

This annex describes the use of Miner's rule to calculate the design pressure for a specific class (see ISO 10508):

a) following ISO 17456 (determination of the long-term pressure strength in accordance with ISO 9080 on one dimension per group);

b) by mathematical description of linearized p_{LPL} curves, using coefficients (3- or 4-parameter model).

EXAMPLE See Figure E.1 (the figure does not illustrate reference curves).



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Key

t time (h)
t_y time (years)
p pressure (bar)
p_{LPL} lower confidence limit of the predicted hydrostatic pressure (bar)

Figure E.1 — Example of long-term pressure strength diagram for M-pipes
(dimensions 32 mm × 3 mm, PE-Xb/Al/PE-Xb)

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