INTERNATIONAL STANDARD

ISO 17484-1

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Plastics piping systems — Multilayer pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar (500 kPa) —

Part 1:
Specifications for systems

Systèmes de canalisations en matières plastiques — Tubes multicouches et leurs assemblages pour une pression maximale de service inférieure ou égale à 5 bar (500 kPa) destinés à l'alimentation en gaz à l'intérieur des bâtiments —

Partie 1: Spécifications pour les systèmes

Reference number
ISO 17484-1:2006(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 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 17484-1 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 17484 consists of the following parts, under the general title *Plastics piping systems — Multilayer pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar (500 kPa)*:

— *Part 1: Specifications for systems*

A Part 2 dealing with the code of practice is planned.

Introduction

This part of ISO 17484 was developed in response to worldwide demand for minimum specification for multi-layered pipes for indoor gas applications.

Multi-layered pipes are delivered generally as a complete system. Pipes, fittings, tools, etc., are not compatible with components of another brand, generally. An advantage is that all components are perfectly geared to one another, but for repairing, the lack of compatibility might be problematic in the future.

Fire safety of systems

Depending on the construction of the house, pipework layout and other local circumstances, it is possible that additional safety devices are required to fulfill the demands of fire safety. Safety aspects of the system will be described in the planned Part 2.

Code of practice

The planned second part of ISO 17484 will be the code of practice for installation.

Recommendations on design, construction and protection in case of fire of the gas indoor installation are given in EN 1775).

References to ISO/TC 138/SC5 work

Test methods referred to in this part of ISO 17484 have been developed by SC 5 as far as possible. However, not all test methods needed are in the working programme of SC 5. These test methods are placed in Annexes B to K of this part of ISO 17484. It is planned that these tests will be developed as International Standards in the future.

For multilayer pipe construction, consisting of a layer of a reference standard material, an adhesive and a non-stress-designed layer, procedure I and the relevant product standards are followed for all aspects, excluding the aspects of delamination and, if applicable, oxygen permeation.

For example, layers can have the following purposes:

— ability to withstand the pressure;

— ability to realize interlayer adhesion;

— ability to block or greatly diminish incoming UV and/or sunlight;

— ability to mechanically protect the outside layer;

— ability to control the longitudinal expansion;

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

Some characteristics can be combined in one layer.

Plastics piping systems — Multilayer pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar (500 kPa) —

Part 1: Specifications for systems

1 Scope

This part of ISO 17484 specifies the general requirements and the performance requirements for multilayer pipe systems based on pipes, fittings and their joints intended to be used for gas supply within buildings.

PE-X and PE pipes composed of one stress-designed layer, adhesive and a barrier layer are also covered by this part of ISO 17484.

This part of ISO 17484 gives guidance for the design of piping systems consisting of multilayer pipes based on thermoplastics, for which at least 60 % of the wall thickness is polymeric material. Polymeric materials intended for stress-designed layers and all inner layers are required to be polyethylene (PE) and/or crosslinked polyethylene (PE-X) in accordance with Annex A of this part of ISO 17484. The outer layer of a metal multilayer is required to be PE or PE-X. PE-RT is considered as PE but with specific properties concerning hoop-stress performance (see 5.4.2.).

This part of ISO 17484 applies to systems that operate at temperatures of – 20 °C up to 60 °C.

For the purpose of this part of ISO 17484, crosslinked polyethylene (PE-X) and adhesive layers are considered as thermoplastic materials.

For sizes greater than 63 mm the requirements of ISO 18225 have to be fulfilled in addition.

This part of ISO 17484 is applicable for piping systems used in buildings to supply gas with a maximum operating pressure up to and including 500 kPa (5 bar) [1)].

This standard applies to the following fuels:

— Category D gaseous fuel: natural gas; see ISO 13623;

— Category E gaseous fuel: LPG vapour, and natural gas or LPG vapour; see ISO 13623.

1) 1 bar = 0,1 MPa = 105 Pa; 1 MPa = 1 N/mm^2

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 3:1973, *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*

ISO 497:1973, *Guide to the choice of series of preferred numbers and of series containing more rounded values of preferred numbers*

ISO 1167 (all parts), *Thermoplastics pipes, fittings and assemblies for the conveyance of fluids — Determination of the resistance to internal pressure*

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

ISO 3503, *Assembled joints between fittings and polyethylene (PE) pressure pipes — Test of leakproofness under internal pressure when subjected to bending*

ISO 8085-3:2001, *Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels — Metric series — Specifications — Part 3: Electrofusion fittings*

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

ISO 10838 (all parts), *Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels*

ISO 11357-6, *Plastics — Differential scanning calorimetry (DSC) — Part 6: Determination of oxidation induction time*

ISO 12162:1995, *Thermoplastics materials for pipes and fittings for pressure applications — Classification and designation — Overall service (design) coefficient*

ISO 13480, *Polyethylene pipes — Resistance to slow crack growth — Cone test method*

ISO 13623:2000, *Petroleum and natural gas industries — Pipeline transportation systems*

ISO 14531-1, *Plastics pipes and fittings — Crosslinked polyethylene (PE-X) pipe systems for the conveyance of gaseous fuels — Metric series — Specifications — Part 1: Pipes*

ISO 17454:2006, *Plastics piping systems — Multilayer pipes — Test method for the adhesion of the different layers using a pulling rig*

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

ISO 18225, *Plastic piping systems — Multilayer piping systems for outdoor gas installations — Specifications for systems*

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

3 Terms, definitions and symbols

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

3.1 Structural definitions

3.1.1
construction group A
group composed of multilayer pipes in which all the layers considered to be designed for stress bearing are made of polymeric materials selected from the list of reference product standards (see Annex A)

3.1.2
construction group B
group composed of multilayer pipes in which all the layers considered to be designed for stress bearing are made of polymeric materials selected from the list of reference product standards (see Annex A) and including a stress bearing metallic layer

3.1.3
multilayer pipe
pipe comprising of several stress-designed layers

3.1.4
multilayer M-pipe
multilayer pipe comprising of polymers and one metallic layer of which thickness of the pipe consists of at least 60 % of polymer layers

3.1.5
multilayer P-pipe
pipe comprised of more than one stress-designed polymeric layer (e.g. PE/PE-X)

3.1.6
layer
homogeneous circumferential section of pipe wall that has chemical and/or mechanical and/or physical characteristics different from those of its immediate neighbours

3.1.7
inner layer
layer in contact with the conveyed fluid

3.1.8
outer layer
layer exposed to the external environment

3.2 Geometrical definitions

3.2.1
nominal diameter
d_n
specified diameter, assigned to a nominal size (DN/OD or DN/ID)

NOTE The nominal diameter is expressed in units of millimetres.

3.2.2
outside diameter
d_e
diameter, measured through its cross section at any point of a pipe or the fitting end of a fitting, rounded to the next greater 0,1 mm

3.2.3
mean outside diameter
measured length of the outer circumference of the pipe divided by π, rounded up to the nearest 0,1 mm

NOTE The value for π is taken to be 3,142.

3.2.4
inside diameter
value of the measurement of the diameter through its cross section at any point of a pipe, rounded to the next greater 0,1 mm

3.2.5
SDR_m
metal layer standard dimension ratio, the nominal outside diameter (DN or OD) divided by the nominal wall thickness of the metal layer

3.2.6
wall thickness
difference between the pipe outside diameter used for joining and the pipe bore divided by 2

3.2.7
nominal wall thickness
e_n
wall thickness, corresponding to the minimum wall thickness at any point

NOTE The nominal wall thickness is expressed in units of millimetres.

3.2.8
mean wall thickness
e_m
arithmetic mean of at least four measurements regularly spaced around the same cross-sectional plane of the pipe, including the measured minimum and maximum values obtained, rounded up to the nearest 0,1 mm

3.3 Definitions related to pressure

3.3.1
design pressure
p_D
highest pressure related to the circumstances for which the system has been designed and intended to be used

3.3.2
predicted design pressure
p_{CD}
pressure that represents the predicted design pressure after a lifetime of 50 years, using the 97,5 % reference line

NOTE The predicted design pressure is expressed in units of kilopascals (bars).

3.4 Materials definitions

3.4.1
virgin material
material in a form such as granules or powder that has not been subjected to use or processing other than that required for its manufacture and to which no reprocessable or recyclable material has been added

3.4.2
own reprocessable material
material prepared from rejected unused pipes and fittings, including trimmings from the production of pipes and fittings that can be reprocessed in a manufacturer's plant after having been previously processed by the same manufacturer by a process such as moulding or extrusion and for which the complete formulation is known

3.4.3
reference product standard
International Standard or draft International Standard prepared by Technical Committee ISO/TC 138/SC 4, applicable for non-multilayer pipes, to which this part of ISO 17484 can refer for clauses related to the materials, components (e.g. fittings), and fitness for purpose of the system

3.4.4
stress-designed layer
plastics materials used for layers intended to be stress bearing shall be restricted to the reference material standards

3.5 Definitions related to material characteristics

3.5.1
long-term hydrostatic strength
long-term pressure strength
quantity with the dimensions of stress, which represents the predicted mean strength at a temperature T and a time t

NOTE The long-term hydrostatic strength is expressed in units of megapascals.

3.5.2
P_{LPL}
lower confidence limit of the predicted hydrostatic pressure, which represents the 97,5 % (one-sided) lower confidence limit of the predicted hydrostatic pressure at a temperature T and a time t

NOTE The lower confidence limit of the predicted hydrostatic pressure is expressed in units of kilopascals (bars).

3.5.3
MRP
minimum required pressure, equal to the estimated long-term pressure resistance of a pipe at a temperature of 20 °C and a time 50 years, rounded to the nearest lower value of the R10 series of ISO 3:1973 and ISO 497:1973

3.5.4
overall service (design) coefficient
C factor
overall coefficient with a value greater than 1, which takes into consideration service conditions as well as properties of the components of a piping system other than those represented in the lower confidence limit

NOTE The minimum value of C for various materials is given in 5.2.3.

3.6 Terms related to service conditions

3.6.1
gaseous fuel
any fuel which is in the gaseous state at a temperature of 15 °C and a pressure of 100 kPa (1 bar)

3.6.2
category D gaseous fuels
natural gas

NOTE Categories of gaseous fuels and liquid fuel are defined in detail in ISO 13623:2000.

3.6.3
category E gaseous fuels
LPG vapour

NOTE Categories of gaseous fuels and liquid fuel are defined in detail in ISO 13623:2000.

3.6.4
maximum operating pressure
MOP
maximum pressure at which a system can be operated continuously under normal conditions

4 Requirements for the system

4.1 Pressure drop

The manufacturer shall provide information on the pressure drop in the system.

4.2 Bending

Special attention shall be paid to the pressure drop of bends. Bending properties of the pipe shall be stated by the manufacturer.

4.3 Corrosive conditions

Components exposed to corrosive conditions shall be manufactured from a corrosion-resistant material or protected against corrosion.

5 Pipes

5.1 Material

5.1.1 General

All stress-designed and polymeric inner layers shall be composed of reference materials in accordance with the reference product standards specified in Annex A. It is not necessary for the outer layer to be made of a reference material.

Materials intended for the stress-bearing layers shall conform to the material requirements of the reference product standard(s) specified in Annex A. The pipe manufacturer shall declare the reference material standard applicable to his product, as listed in Annex A.

5.1.2 Reprocessable materials

Clean own reprocessable material (except PE-X) of the same polymer type from products manufactured to the reference product standard may be added to the virgin material.

5.1.3 Metallic materials

Aluminium materials used shall be in accordance with EN 573-3.

5.1.4 Product classification and construction group

Multilayer pipes may include polymeric or metallic layers that have several purposes, including the ability to withstand the pressure.

For the purpose of this part of ISO 17484, multilayer pipes are classified in two groups: construction group A and construction group B as defined in 3.1. For these definitions, adhesives are not considered as stress-bearing layers.

The pipe manufacturer shall declare the construction group of the multilayer pipe.

5.2 General characteristics

5.2.1 General

When viewed without magnification, the internal and external surfaces of pipes shall be smooth, clean and free from scoring, cavities and other surface defects to an extent that would prevent conformance with this part of ISO 17484. The ends of the pipe shall be cut cleanly and square to the axis of the pipe.

The following information shall be provided:

— outside diameter;

— wall thickness;

— thickness of the inner layer;

— thickness of the metal layer;

— thickness of the outer layer;

— tolerances.

Dimensions shall be measured in accordance with ISO 3126.

5.2.2 Multilayer pipe construction

The joint line of the metallic layer shall be continuously welded.

5.2.3 Minimum overall service (design) coefficient

The minimum overall service (design) coefficient (C factor) is 2, as used to calculate the design pressure, p_D, taking into account the maximum operating temperature.

5.3 Dimensions of pipes

The outside diameter shall be accordance with ISO 161-1.

All layers shall be of sufficient thickness so that the composite pipe fulfills the requirements of this part of ISO 17484.

5.4 Mechanical properties

5.4.1 Long-term pressure strength

5.4.1.1 General

The long-term pressure strength of the multilayer pipes shall be measured or calculated, as applicable. Consequently, two procedures for the determination of long-term pressure strength of multilayer pipes are defined in this part of ISO 17484: procedure I and procedure II.

Requirement for the predicted design pressure: P_{CD} shall be equal to or greater than the relevant MOP.

The operating temperature shall be taken into account.

The viscoelastic behaviour of PE-X and PE are similar; therefore, procedure I may be applied to P-pipes using layers of both materials. It shall be taken into account that the results of procedure I are generally rather conservative. Reference lines for PE-X can be found in ISO 10146.

NOTE The minimum overall service (design) coefficients for each material can be found in the relevant product standard (see Annex A).

5.4.1.2 Procedure I — Calculation method

This method shall only be used for P-pipes.

The long-term pressure strength shall be calculated using the reference lines of each individual pressure-bearing polymer layer according to of ISO 17456:—, Annex A. The addition rule related to each pressure-bearing layer assumes similar elastic behaviour of each material used and that complete interlayer adhesion exists, with design coefficients coming from the reference product standards.

The cumulative P_D shall be equal to or greater than the relevant MOP.

For details of confirmation testing, see 5.4.1.4.

5.4.1.3 Procedure II — Testing method

This method can be used for both multilayer P- and multilayer M-pipes.

At least one diameter of every “similar construction type” shall be tested in accordance with ISO 9080. For M-pipes, the diameter with the highest SDR_m of the metal layer shall be tested.

The parameters p_{CD} and MRP for each pipe construction shall be determined in accordance with ISO 17456.

For the determination of multilayer M-pipes, the design coefficient of the inner layer shall be used. For multilayer P-pipes, the design coefficients of each layer shall be taken in account (see Annex A).

NOTE To determine the weakest diameter within a construction group, a burst test on each diameter can be performed.

5.4.1.4 Pressure strength of all diameters

All diameters of the similar construction type, excluding the diameter tested in accordance with 5.4.1.3, shall undergo the confirmation testing in accordance with ISO 17456. If the SDR_m for a metal layer having a diameter smaller than the completed tested diameter is less then 90 % of the SDR_m of the completed tested diameter, the smaller diameter may be tested in accordance with the confirmation testing of ISO 17456.

5.4.1.5 Calculation of the control points

5.4.1.5.1 Procedure I for P-pipes

Failure control points for each diameter for 22 h, 165 h and 1 000 h shall be calculated using Equation (A.2) of ISO 17456:—.

5.4.1.5.2 Procedure II for P-pipes and M-pipes

Failure control points for each diameter for 22 h, 165 h and 1 000 h (or other requested testing time) shall be calculated using the 95 % value of the P_{LPL} line of the fully tested diameter.

5.4.2 Strength of the joint line of M-pipe

When the outside diameter of the pipe is increased by 10 %, no failures relative to the joint line of the metal layer shall occur. The test shall be carried out in accordance with Annex B.

5.4.3 Resistance to slow crack growth of the outer layer (cone test) for M-pipes

When tested in accordance with ISO 13480, the crack growth rate of the outer layer shall be less than 10 mm/day.

The test shall be carried out on pipe produced from material used for the outer layer.

5.5 Physical properties

5.5.1 General

The applicable physical characteristics of each stress-designed and inner layer shall be checked in accordance with the corresponding clause of the reference product standard.

5.5.2 Additional requirements

The requirements for the physical properties are listed in Table 1.

Table 1 — Physical properties

Characteristic	Requirements	Tests		
		Parameter	Value	Reference
Resistance to gas constituents	⩾ 20 h No delamination	Conditioning	1 500 h/23 °C	Annex C
		Temperature	80 °C	
		Pressure	0,4 p_D	
		Cone test	10 % expansion	
Thermal durability of the outer layer of M-pipes	No visual cracks in outer layer	PE or PE-X		Annex D
		At 100° or	0,5 year	
		at 110°C	0,25 year	
		Strain	3 %	
Oxidation induction time (OIT)	⩾ 20 min	Temperature	200 °C[a]	ISO 11357-6
Delamination: P-pipes	No cracks or delamination	Expansion	10 % (by cone with 15 % slope)	Annex B
		Temperature	23 °C	
Delamination: M-pipes	Peel strength ⩾ 15 N/cm	Temperature	23 °C	Annex E
		Cycling test	− 20 °C/+ 60 °C	
		Number of cycles	10	
Odorant permeability	No perception of THT smell by experienced observer	Odorant Exposure time Temperature	THT 60 days 23 °C	Annex F

[a] Test may be carried out at 210 °C providing that there is clear correlation with the results at 200 °C. In case of dispute, the reference temperature shall be 200 °C.

6 Fittings

6.1 General

6.1.1 Fitting reference standards

Fittings shall comply with the performance requirements the following International Standards:

— mechanical fittings: ISO 10838 (all parts);

— electrofusion fittings: ISO 8085-3;

— PE-X electrofusion fittings: ISO 14531-2;

— mechanical fittings for PE-X: ISO 14531-3.

6.1.2 Installation

During installation of the fitting on the pipe, the aluminium layer, and in particular the welded seam, shall not be torn.

Tools and aids used for installation of the fitting shall not damage the pipe or fitting.

6.2 Materials

The materials from which the fitting components are made shall be such that the level of performance of these components shall at least be equal to that specified for the multilayer pipe connected to the fitting. ISO 10838 (all parts) shall be used as a reference for fitting materials. Materials in contact with the multilayer pipe shall not prevent the pipe from conforming to this specification.

6.3 Dimensions

The values of the nominal inside diameter and the value of the nominal wall thickness and tolerances shall be provided by the supplier.

The tolerances on these values shall also be supplied.

6.4 Transition fittings

The manufacturer shall provide a transition fitting intended to be connected to a standardized system. The connection shall comply with the relevant standards, e.g. ISO 7-1.

6.5 Rubber rings

The technical file shall indicate which rubber standard has been applied.

7 Fitness for purpose

7.1 Diameter classes

The following diameter classes are defined based on ranges of the external diameter.

Table 2 — Diameter classes

Diameter class	1	2	3	4	5	6	7
External diameter (mm)	$d_e < 16$	$16 \leqslant d_e < 20$	$20 \leqslant d_e < 26$	$26 \leqslant d_e < 40$	$40 \leqslant d_e < 50$	$50 \leqslant d_e < 60$	$60 \leqslant D \leqslant 63$

7.2 Relation between maximum operating pressure and qualification test pressure

The relationship between maximum operating pressure (MOP) and qualification test pressure (QTP) is given in Table 3.

Table 3 — Relation between MOP and QTP

MOP		QTP	
kPa	mbar	kPa	mbar
10	100	100	1 000
100	1 000	300	3 000
500	5 000	700	7 000

7.3 Requirements

The requirements for fitness of purpose of joint assemblies are listed in Table 4.

Table 4 — Requirement for fitness purpose of joint assemblies

<table>
<tr><th rowspan="2">Characteristic</th><th rowspan="2">Requirements</th><th colspan="5">Tests</th></tr>
<tr><th>Parameter</th><th colspan="3">Value</th><th>Reference</th></tr>
<tr><td rowspan="8">Tensile load</td><td rowspan="8">No leakage for one hour</td><td>Test temperature</td><td colspan="3">23 ± 2 °C</td><td rowspan="8">Annex G</td></tr>
<tr><td>Type of test samples</td><td colspan="3">End fitting – pipe – end fitting</td></tr>
<tr><td>Pipe length</td><td colspan="3">350 mm</td></tr>
<tr><td>Number of test samples</td><td colspan="3">2 per diameter class</td></tr>
<tr><td>Test pressure</td><td colspan="3">3 kPa (30 mbar)</td></tr>
<tr><td rowspan="3">Tensile strength level</td><td rowspan="2">Class</td><td colspan="2">Strength
kN</td></tr>
<tr><td>1 h test</td><td>800 h test</td></tr>
<tr><td>1
2
3
4
5
6
7</td><td>1,4
1,8
2,1
4,0
6,0
8,0
12,0</td><td>0,9
1,1
1,4
2,4
3,6
4,8
7,2</td></tr>
<tr><td rowspan="7">Joint resistance to crushing</td><td rowspan="7">Tightness
No reduction of outer diameter more than 20 %</td><td>Test temperature</td><td colspan="3">23 ± 2 °C</td><td rowspan="7">Annex H</td></tr>
<tr><td>Type of test samples</td><td colspan="3">End fitting – pipe – end fitting</td></tr>
<tr><td>Pipe length</td><td colspan="3">600 mm</td></tr>
<tr><td>Number of test samples</td><td colspan="3">2 per diameter class</td></tr>
<tr><td>Test pressure</td><td colspan="3">3 kPa (30 mbar)</td></tr>
<tr><td>Force level</td><td colspan="3">2 kN</td></tr>
<tr><td>Position of load applied</td><td colspan="3">10 mm from the insert of fitting or nut</td></tr>
<tr><td></td><td></td><td>Load</td><td colspan="3">Plate with 150 mm side square</td><td></td></tr>
<tr><td rowspan="8">Impact resistance of the joint</td><td rowspan="8">Tightness</td><td>Test temperature</td><td colspan="3">23 ± 2 °C</td><td rowspan="8">Annex I</td></tr>
<tr><td>Type of test samples</td><td colspan="3">End fitting – pipe – coupling – pipe – end fitting with each end fitting fixed on a motionless support</td></tr>
<tr><td>Pipe length</td><td colspan="3">1 000 mm each pipe</td></tr>
<tr><td>Number of test samples</td><td colspan="3">2 per diameter class</td></tr>
<tr><td>Test pressure</td><td colspan="3">3 kPa (30 mbar)</td></tr>
<tr><td>Striker</td><td colspan="3">Spherical head with 1 cm of radius</td></tr>
<tr><td>Impact</td><td colspan="3">600 mm/5 kg</td></tr>
<tr><td>Position of the impact</td><td colspan="3">Onto the fitting</td></tr>
</table>

Table 4 (*continued*)

Characteristic	Requirements	Tests		
		Parameter	**Value**	**Reference**
Thermal cycling resistance	Leakage $\leqslant 10^{-4}$ atm·cm^3·s^{-1}	Extreme test temperatures	− 20 °C/+ 60 °C	Annex J
		Number of cycles	10	
		Type of test samples	End fitting – pipe – coupling – pipe – end fitting	
		Pipe length	300 mm each pipe	
		Number of test samples	2 per diameter class	
		Test pressure	QTP according to MOP	
Repeated bending resistance	No damage or modification of the aluminium layer after the test	Minimum bend radius	As declared by the manufacturer	Annex K
		Bend angle	90°	
		Number of bending cycles	3 bend cycles	
		Test pressure	3 kPa (30 mbar)	
		Type of test samples	End fitting – pipe – end fitting	
		Pipe length	350 mm	
		Position of the bend	At a distance equal to one minimum bend radius from the end fitting	
		Number of test samples	4 per diameter class	

8 Marking and documentation

8.1 Legibility

Marking details shall be legible without magnification.

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

8.2 Damage

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

8.3 Minimum marking requirements

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

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

Coils shall be sequentially marked with the length in metres that indicate the length remaining on the coil. The marking shall include the information specified in Table 5.

Table 5 — Minimum marking information

Aspect	Mark or symbol
Manufacturer or trademark	Name or symbol
Internal fluid	Gas
Design pressure	In accordance with national regulations
Dimensions	$d_n \times e_n$
Material designation: Layer construction and type of material required; description from outside to inside	e.g. PE-X-Al-PEX or PE80-PEX
Production period (date/code)	Manufacturer's own reference
Standard reference number	ISO 17484

8.3.1 Additional Instructions

The manufacturer shall provide clear assembly instructions that contain at least the following information:

— instructions that pipe and fitting(s) belong together and are not interchangeable with other products;

— statement if a coupler is fit for repeated assembly;

— if the manufacturer allows the use of a standard bending tool, a statement in the manufacturer's instructions that damage of the external coating shall be avoided if bending the pipe;

— information on gaseous flow rate/pressure drop relationship (reference EN 12117);

— minimum bending radius;

— bending tools to be used;

— if a calibration tool is necessary to insert a stiffener, the manufacturer instructions shall be given.

Annex A
(normative)

List of the reference product standards

As of the date of publication of this part of ISO 17484, the reference product standards published or under preparation are listed in Table A.1.

Table A.1 — List of reference product standards

Reference material	Reference material standard
PE	ISO 4437
PE-X	ISO 14531-1: and ISO 10146
PE-RT	ISO 4437 and ISO 24033
NOTE This list is only applicable for materials in stress-bearing layers.	

Annex B
(normative)

Test for delamination and strength of the joint line

B.1 Principle

Pipe samples are subjected to a cone test in order to determine delamination and strength of the joint line of the pipe sample. With a specially shaped cone, a defined expansion of the pipe is created.

B.2 Pipe sample

The test shall be carried out on a pipe sample with a length of at least $5 \times d_e$.

B.3 Cone

A cone with a pitch of 15° shall be applied. The length of the cone shall be such that an expansion of the pipe of 10 % can be obtained.

B.4 Procedure

The test is conducted as follows.

- Measure the real mean outside diameter of the pipe sample using suitable equipment with an accuracy of at least 0,1 %.
- Multiply this value by 1,1 (10 % expansion); This value is the outside diameter of the expanded part of the pipe sample.
- Measure the wall thickness in accordance to ISO 3126 of the pipe sample at eight separate points equally divided over the pipe diameter with an apparatus having an accuracy of at least 1 %. The calculated value is e_m.
- Calculate d_{cone}, the required size of the cone diameter in order to obtain an expansion of 10 %, using Equation (B.1):

$$d_{cone} = 1{,}1 d_e - (2 e_m) \qquad \text{(B.1)}$$

- Mark the place on the cones where a 10 % expansion is expected.
- Insert the cone in the pipe sample up to the mark sign. The pipe end has been expanded now by 10 %.
- Remove the cone.
- Wait 15 min after the removal of the cone and visually check the sample for cracks and delamination.

B.5 Test report

The test report shall include the following:

— number, type and nominal dimension of the sample;

— test temperature;

— cone dimensions;

— duration of the test;

— any observation made during and after the test;

— any event able to influence the test results.

Annex C
(normative)

Resistance to gas constituents

C.1 Principle

Samples of pipe/fitting assemblies are filled with a liquid containing 50 % *n*-decane and 50 % 1,3,5-trimethylbenzene under pressure for a specified period. After this conditioning period, a cone test is carried out on the pipe in order to determine the grade of delamination.

C.2 Sample

Prepare a sample in accordance with ISO 1167. The test sample should preferably be made of a pipe from dimension Class 6 (see 7.1). The end caps shall be mounted in such a way that the condensate has free access to the pipe ends.

C.3 Procedure

The test is conducted as follows.

— Prepare a synthetic condensate consisting of a mixture of a mass fraction of 50 % *n*-decane (99 %) and a mass fraction of 50 % 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 with a pressure of 0,4 p_D.

— After the above procedure, test in accordance with Annex B, taking into account the dimensions of the pipe after conditioning.

— Check the sample for leakage and for delamination of the layers.

C.4 Test report

The test report shall include the following:

— number, type and nominal dimension of the sample;

— test temperature;

— duration of the test;

— any observation made during and after the test;

— any event able to influence the test results.

Annex D
(normative)

Thermal durability of the outer layer of M-pipes

D.1 Principle

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

D.2 Apparatus

D.2.1 Oven.

D.2.2 Bending template, such as that described in EN 713.

D.3 Procedure

The test is conducted as follows.

— Age the PE , PE-X or PE-RT in an oven for 0,5 years at 100 °C or 0,25 years at 110 °C [2].

NOTE This assumes a duration of 25 years at 60 °C during the 50-year lifetime of the pipe. Taken into account is the time/temperature extrapolation method of ISO 9080, which gives a test time of 0,5 years (6 months) at 100 °C or 0,25 years (3 months) at 110 °C.

— Deform the test piece by bending with bending template at (23 ± 2) °C for a duration ranging from a minimum of 3 s to a maximum of 10 s (for complete deformation).

Table D.1 — Parameters

Total pipe length l_1	**Bending length** l_2	**Bending radius** R
$10d_e$	$7{,}5d_e$	$16d_e$
d_e is the outside diameter of the pipe.		

A strain of 3 % is required, equivalent to a bending radius of $16d_e$.

2) These oven aging times and temperatures are based on temperature profiles. The temperature variation is assumed as follows:

— 120 h at 70 °C per year
— 3 months at 60 °C
— 3 months at 50 °C
— 3 months at 40 °C
— 3 months at 30 °C

EXAMPLE Calculation of the relationship between bending radius and strain.

For a pipe with 32 mm outside diameter, the required bending template radius is calculated as follows:

$R = 16 \times d_e = 16 \times 32 \text{ mm} = 512 \text{ mm}$

Strain of the outer fibre in relation to the neutral axis of the pipe is calculated as follows:

$\varepsilon = (R + d_e)/(R + d_e/2) - 1 = (17 \times d_e/16{,}5 \times d_e) - 1 = 0{,}030\,3 = 3{,}0\ \%$.

D.4 Test report

The test report shall include the following:

- number, type and nominal dimension of the sample;
- presence of cracks;
- duration of the test;
- any observation made during and after the test;
- any event able to influence the test results.

Annex E
(normative)

Adhesion test

E.1 Principle

Adhesion strength should be determined by a peel test according to ISO 17454 that is carried out before and after thermal cycling.

E.2 Sample

Samples for peel test and for thermal cycling shall be prepared in accordance with ISO 17454 and with this part of ISO 17484:2006, Annex J, respectively. All samples shall be prepared from the same pipe.

E.3 Procedure

The test is conducted as follows.

— Carry out a peel test according to ISO 17454 at (23 ± 2) °C.

— Carry out a thermal cycle test according to Annex J, with a thermal cycle between – 20 °C and + 60 °C. The number of cycles is 10. The pipe is to be pressurized.

— After the thermal cycling, a test sample shall be prepared for the peel test according to ISO 17454.

— Carry out a peel test according to ISO 17454 at (23 ± 2) °C. The peeling zones should be at the ends and centre of the test piece.

E.4 Test report

The test report shall include the following:

— peel strength, expressed in newtons per centimetre;

— name of the test;

— number, type and nominal dimension of the sample;

— nest temperature.

Annex F
(normative)

Odour permeability

F.1 Principle

A flow with a defined concentration of THT is conveyed through a pipe sample. After a defined period, the THT permeability through the pipe wall will be detected by an experienced person.

NOTE THT is an odorant that is added to the gas for safety reasons. (A customer can detect small gas leakages by smelling). THT is the most common type of odorant.

F.2 Samples

Each end of a pipe is fitted with a valve. The length of the pipe is such that the distance between the valves is 250 mm.

F.3 Procedure

The test is conducted as follows.

— An air flow with a THT concentration of 100 mg/m^3 at a pressure of 0,1 ± 0,02 MPa (1 ± 0,2 bar) is passed through the pipe at a temperature of (23 ± 2) °C.

— After 60 days of exposure an experienced observer has to detect the presence THT odour.

F.4 Test report

The test report shall include the following:

— detection of THT odor;

— delamination and leakage;

— number, type and nominal dimension of the sample;

— test temperature;

— duration of the test;

— any observation made during and after the test;

— any event able to influence the test results.

Annex G
(normative)

Resistance to tensile load on joints

G.1 Principle

Samples of pipe/fitting joint are subjected to a tensile load force in order to establish the short- and long-term resistance to tensile loads.

G.2 Samples

A sample consists of a pipe with two end fittings. One fitting shall have a possibility to establish a pressure connection. The free length of pipe between the end fittings is 350 mm.

G.3 Procedure

G.3.1 Short-term (1 h) test

The test is conducted as follows.

— Carry out testing at an ambient temperature of (23 ± 2) °C.

— Put the test sample in the tensile testing machine.

— Apply 3 kPa (30 mbar), check it and maintain it up to the completion of the test.

— Raise the tensile load until the specified value has been attained as given as test parameters in 7.3 in such a way that the test piece is pulled at a speed of 0,1 ± 0,05 l/min where l is 350 mm.

— keep the tensile load constant for 1 h while monitoring the pressure.

G.3.2 Long-term (800 h) test

The test is conducted as follows.

— Carry out testing at an ambient temperature of (23 ± 2) °C.

— Put the test sample in a constant load apparatus.

— Apply the load as given in 7.3.

— Keep the tensile load constant for 800 h while monitoring the pressure.

— For the short-term test, pressure inside the samples is monitored and any leakage should be recorded (location, time of appearance).

— For the long-term test, pressurize the sample after test period with a pressure of 3 kPa (30 mbar). Check the sample for leakage.

G.4 Test report

The test report shall include the following:

— type of the sample;

— air pressure (initial pressure, pressure vs. time plotting);

— any leakage occurring during the phase (time of occurrence, strain/strength at the moment of the leak, failure description);

— any problem during the test able to influence the result of the test.

Annex H
(normative)

Crush test on joints

H.1 Principle

Pipe crushing in the vicinity of a pipe joint is considered as critical. In order to determine the resistance to crushing, a pipe sample is crushed very close to a pipe joint. After the test a tightness test will be carried out.

H.2 Samples

The test sample is made of an end-fitting pipe-end fitting and the joints are made in accordance with the manufacturer's instructions. The pipe length is 600 mm.

H.3 Procedure

The test is conducted as follows.

— Perform a tightness test at 3 kPa (30 mbar).

— Apply a load on a plate (a square with 150-mm sides) positioned close to the fitting (10 mm from the insert of the fitting or nut) to obtain a force level of 2 kN (see Figure 1). This can be achieved in a tensile testing machine.

Alternatively, it can be a square with 75-mm sides and a force level of 1 kN.

Dimensions in millimetres

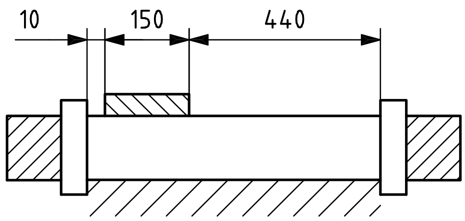


Figure H.1 — Resistance to crushing close to a fitting test assembly

— Wait for the strain to be constant.

— Check the tightness.

— Perform a visual observation.

— Measure the pipe diameter and calculate the remaining deformation.

— Control the test sample on tightness by applying a test pressure of 10 kPa (100 mbar).

H.4 Test report

The test report shall include the following:

- number, type and nominal dimension of the sample;
- test temperature;
- crushing force;
- duration of the test;
- any observation made during and after the test;
- any event able to influence the test results.

Annex I
(normative)

Impact resistance test on joints

I.1 Principle

The impact-resistance of joints is determined by the impact of a falling striker of defined dimensions and mass dropped from a defined height.

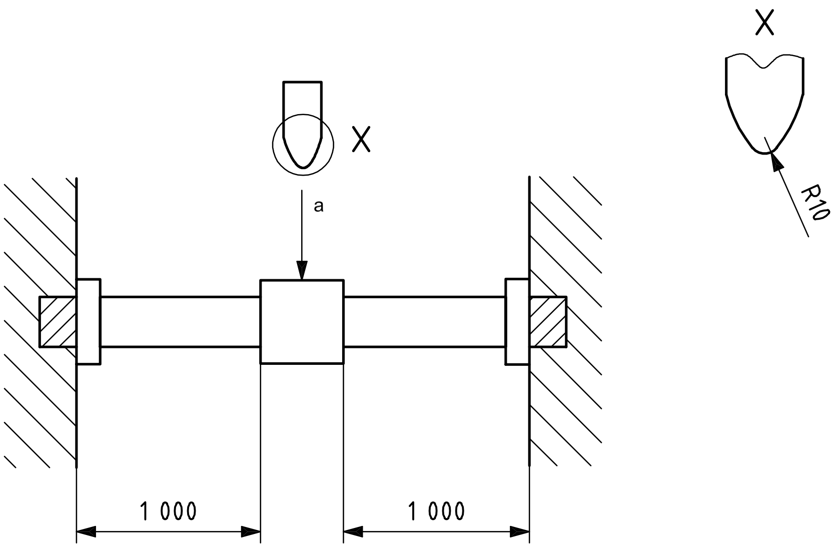
I.2 Pipe samples

The test sample is made of an end-fitting pipe-coupling pipe-end fitting and the joints are made in accordance with the manufacturer instructions. Each pipe length is 1 000 mm.

I.3 Shape and mass of striker

The striker shall have a spherical head with a radius of 10 mm and a mass of 5 kg (see Figure I.1).

Dimensions in millimetres



a Impact.

Figure I.1 — Impact resistance test assembly

I.4 Procedure

The test is conducted as follows.

- Each end fitting is fixed on a motionless support.
- Perform a tightness test at 100 kPa (1 bar).
- Drop a striker from a height of 600 mm on the pipe close to the fitting (10 mm from the insert of the fitting or the nut).
- Perform a tightness test at 100 kPa (1 bar).
- Check the sample for leakage by means of a foaming solution.

I.5 Test report

The test report shall include the following:

- leakage;
- name of the test;
- number, type and nominal dimension of the sample;
- test temperature.

Annex J
(normative)

Thermal cycling test on joints

J.1 Principle

To establish the negative influence of cycles of low and high temperatures, a sample of a pipe with fittings will be subjected to a number of thermal cycles. The sample will be pressurized. The leak rate is determined by measuring the volume of the sample and by measuring the pressure before and after the test.

J.2 Samples

A sample consists of the combination of an end fitting-pipe-coupling-pipe-end fitting.

J.3 Procedure

The test is conducted as follows.

— Fill up the samples with water and measure the water volume; empty the sample.

— Pressurize the sample under the specified QTP air pressure, close it off so that the pressure level is maintained at the right level.

— Place the samples in an appropriate oven and apply the following cycle $N = 10$ times while monitoring the pressure inside the sample and reporting any leakage appearing.

— Measure the pressure at ambient temperature after the N cycles are completed; the expansion of the pipe shall be taken into account.

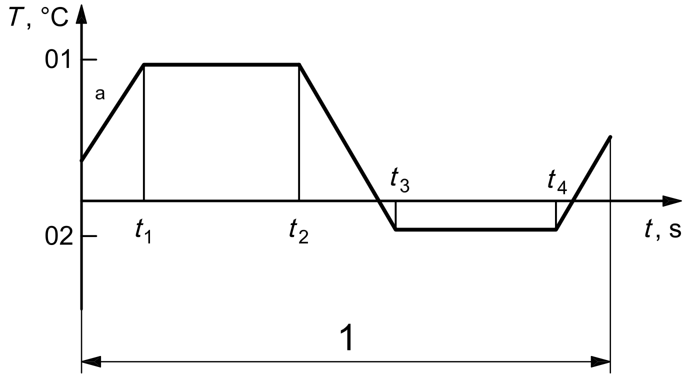
— Calculate the total leak rate with the following equation:

$$Q_\mathrm{l} = \frac{(P_\mathrm{i} - P_\mathrm{f})V}{t}$$

where

Q_l	mean leak rate, expressed in bar cubic centimetres per second (atmosphere cubic centimetres per second);
P_f	absolute final pressure in the sample, expressed in bars (atmospheres);
P_i	absolute initial pressure in the sample, expressed in bars (atmospheres);
V	sample volume, expressed in cubic centimetres;
t	test duration, expressed in seconds.

Dimensions in millimetres



Key

1 1 cycle

a Rate of temperature rise is 1°C/min.

Figure J.1 — Heat cycle layout

J.4 Test report

The test report shall include the following:

— type of sample, DN and volume;

— type of test;

— air pressure (initial pressure, pressure vs. time plotting or final pressure if not possible).

Annex K
(normative)

Repeated bending test

K.1 Principle

Using a special dimensioned mandrel, the resistance to repeat bending is determined of samples from pipe fitting assemblies. After the bending procedure the leak tightness is determined.

K.2 Samples

The test sample is made of an end fitting-pipe-end fitting under a 3 kPa (30 mbar) test pressure. One extremity is fixed, the other is free.

K.3 Special tools

A special tool (spring, bending tool) should be used if required by the manufacturer. If not, the samples are bent by hand.

K.4 Procedure

The test is conducted as follows.

a) The test sample should be put between two mandrels as shown in Figure K.1.

b) The mandrel radius is the minimum bend radius, i.e., the pipe radius where the minimum bend radius is declared by the manufacturer. The welded seam is on the inside of the bend.

c) Bend the pipe from position A to position B. The time between positions A and B should be around 10 s. Wait half a minute.

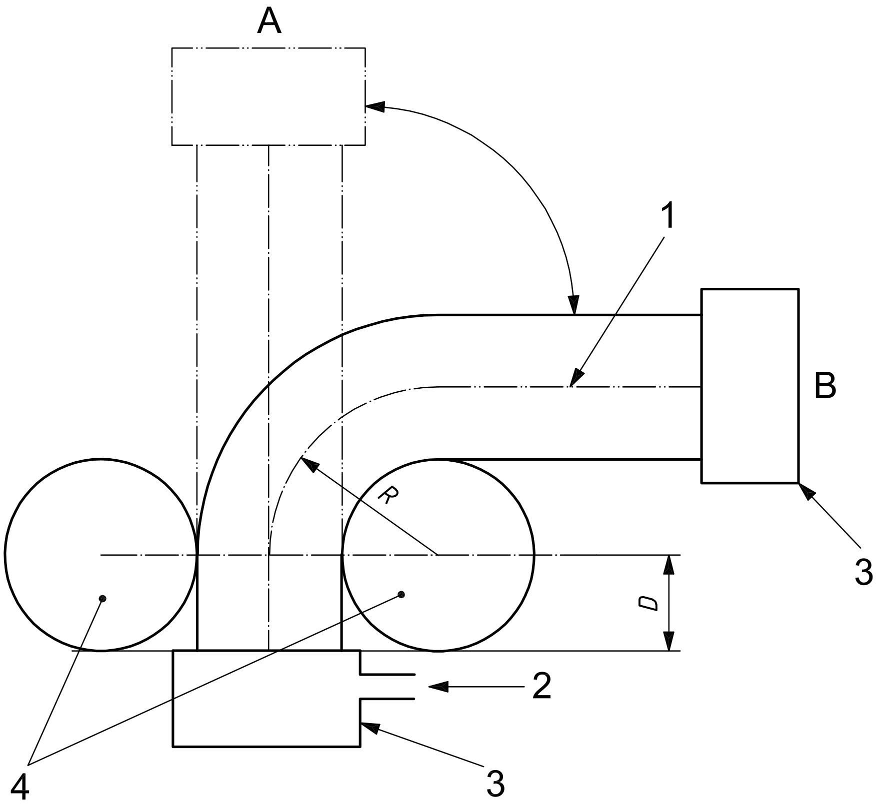
d) Put the pipe back into the position A.

e) Repeat steps c) and d) 2 times.

f) Check during the test if disbonding of the layer has occurred.

g) Peel off the outer layer of the pipe and watch for any damage to or modification of the aluminium layer.

The pipe may be bent in different positions during examination if this can improve the damage detection. Inspect visually for any delamination or disbonding, such as blisters, pitting and notches.



Key

A unbent position

B bent position

1 pipe longitudinal axis

2 air source; pressure sensor plug

3 end fittings

4 mandrels

R bend radius

D 1 minimum bend radius

Figure K.1 — Multilayer repeated bending test assembly

K.5 Test report

The test report shall include the following:

— type of sample;

— air pressure (initial pressure, pressure vs. time plotting);

— any leakage occurring during the test (time of occurrence, number of bends done, location);

— any event during the test which could influence the result of the test.

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