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Plastics piping systems — Multi-layered pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar —

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 destinés à l'alimentation en gaz à l'intérieur des bâtiments —

Partie 1: Spécifications pour les systèmes

ICS 23.040.20; 23.040.45; 91.140.40

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Conformément aux dispositions de la Résolution du Conseil 15/1993, ce document est distribué en version anglaise seulement.

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Pour accélérer la distribution, le présent document est distribué tel qu'il est parvenu du secrétariat du comité. Le travail de rédaction et de composition de texte sera effectué au Secrétariat central de l'ISO au stade de publication.

Contents

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 Electro technical Commission (IEC) on all matters of electro technical 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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 17484 Part 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 17484-1: Specification for systems

— ISO 17484-2: Code of practice

Introduction

This part of ISO17484 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 may be problematic in 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 fulfil the demands of fire safety. Safety aspects of the system are described in part 2.

Code of practice

The second part of this standard will be the code of practice for installation.

Recommendations on design, construction and protection in case of fire of the gas indoor installation is given in prEN 1775: 2003 (revision of the EN 1775: 1998)

References to ISO/TC 138/SC5 work

Test methods referred to in this standard are developed by SC 5 as far as possible. However not all test methods needed are in the working programme of SC5. These test methods are placed in the Annex of this standard. When SC5 have developed the missing standard the annex can be deleted.

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

For example layers may have the following purposes:

- the ability to withstand the pressure
- the ability to realize interlayer adhesion
- the ability to block or greatly diminish incoming UV- and/or sunlight
- the ability to mechanically protect the outside layer)
- 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 one layer.

Plastics piping systems — Multi-layered pipe systems for indoor gas installations with a maximum operating pressure up to and including 5 bar — Part 1: Specifications for systems

1 Scope

This International Standard specifies the general requirements and the performance requirements for multi-layer pipe systems based on pipes, fittings and their joints intended to be used for gas supply within buildings.

This International Standard 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. The stress bearing polymeric materials intended for stress design are polyethylene (PE) and cross linked polyethylene (PE-X).This standard applies to systems that will be operated at temperatures of –20ºC up to 60ºC

This standard is applicable for pipes in the system of nominal diameter up to and including 63 mm

The present international standard is applicable to piping systems used in buildings to supply gas with a maximum operating pressure up to and including 5 bar.

This standard applies to:

- Category D gaseous fuel: natural gas. (See ISO 13623)

- Category E gaseous fuel: LPG vapour, and natural gas or LPG vapour. (See ISO 13623)

NOTE 1 The diameter range in this standard has to be limited to 63 mm for practical reasons. Systems with pipe diameters greater than 63 mm shall comply with this standard and with the specific requirement for diameters greater than 63 mm mentioned in ISO 18255

NOTE 2 PE-RT is considered as PE

NOTE 3 Excluded from this standard are:

- PE and PEX pipes consisting of two or more layers of the same MRS classification
- Homogeneous pipes with a removable (peelable) outer layer
- Homogeneous pipes with an external layer that is intended for colouring purposes

For these types of pipes is refereed to ISO 4437 and ISO 14531

NOTE 4
For the purpose of this International Standard crosslinked polyethylene (PE-X) as well as adhesives are to be considered as thermoplastic materials.

2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard 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 apply. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3:1973 Preferred numbers -- Series of preferred numbers

ISO 161-1:1996 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

EN 549:1995 Rubber materials for seals and diaphragms for gas appliances and gas equipment

EN 573-3:2003 Aluminium and aluminium alloys; Chemical composition and forms of wrought products; Part 3: Chemical composition

EN 713:1994 Plastics piping systems - Mechanical joints between fittings and polyolefin pressure pipes - Test method for leaktightness under internal pressure of assemblies subjected to bending

ISO 1167:1996 Thermoplastics pipes for the conveyance of fluids -- Resistance to internal pressure -- Test method

EN 1555-3: 1995 Plastics piping systems for the supply of gaseous fuels; Polyethylene(PE);Part 3: Fittings

EN 1982:1998, Copper and copper alloys - Ingots and castings.

ISO 3126:1974 Plastics pipes -- Measurement of dimensions

ISO 3503:1976, Assembled joints between fittings and polyethylene (PE) pressure pipes Test of leakproofness under internal pressure when subjected to bending.

ISO 4437:1997, Buried polyethylene (PE) pipes for the supply of gaseous fuels -- Metric series -- Specifications

ISO 8085-2:2001 Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels -- Metric series -- Specifications -- Part 2: Spigot fittings for butt fusion, for socket fusion using heated tools and for use with electrofusion fittings

ISO 9080:2003, Plastics piping and ducting systems — Determination of long-term hydrostatic strength of thermoplastics material in pipe form by extrapolation

ISO 10508:1995 Thermoplastics pipes and fittings for hot and cold water systems

EN 10088-2:1995, Stainless steels. Part 2: Technical delivery conditions for sheet / plate and strip for general purposes

ISO 10838-1:2000 Mechanical fittings for polyethylene piping systems for the supply of gaseous fuels -- Part 1: Metal fittings for pipes of nominal outside diameter less than or equal to 63 mm

EN 12117:1997, Plastics piping systems - Fittings, valves and ancillaries - Determination of the gaseous flow rates/pressure drop relationship

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

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

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

ISO/DIS 17454: Plastics piping systems - Multilayer M pipes – Test methods for the adhesion of the different layers by using a pulling rig

ISO/DIS 17456: Plastics piping systems - Multilayer pipes – Determination of the long term hydrostatic strength

ISO CD 18225: Plastics piping systems- Multilayer piping systems for outdoor gas installations – Specifications for systems

ISO CD 20003-1: Plastics piping systems- Multilayer piping systems for hot and cold water installation inside buildings — Part 1: General

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1 Structural definitions

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

construction group B
group comprising multilayer pipes in which all the layers considered to be 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

3.1.2
multilayer pipe
pipe comprising more than one layer within a non-homogeneous wall thickness structure in which at least 60% of the wall thickness is polymeric material. The plastic layers may be from different polymeric materials.

3.1.3
multilayer M pipe
multilayer pipe comprising layers of polymers and one metal layer. The wall thickness of the pipe consists of at least 60 % of polymer layers

3.1.4
multilayer P pipe
multilayer pipe comprising two or more polymeric layers

3.1.5
layer
a homogeneous circumferential section of pipe wall that has chemical and/or mechanical and/or physical characteristics different from those of its immediate neighbours.

3.1.6
Inner layer
layer which is in contact of the transported fluid

3.1.7
Outer layer
layer which is external and also can play a protective role

3.1.8
embedded layer(s)
layer that is in contact on both sides to other pipe layers

3.2 Geometrical definitions

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

3.2.2
outside diameter d_e
value of the measurement of the outside diameter through its cross section at any point of a pipe, rounded to the next greater 0,1mm

3.2.3
mean outside diameter d_{em}
measured length of the outer circumference of the pipe divided by π [1], rounded up to the nearest 0,1 mm

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

3.2.5
mean inside diameter d_{im}
average value of a number of equally spaced measurements of inside diameter in the same cross section of the pipe

3.2.6
wall thickness
difference between the pipe outside diameter used for joining and the pipe bore.

3.2.7
total wall thickness *e*
measured total wall thickness at any point

3.2.8
layer wall thickness e_l
measured wall thickness at any point of a layer

3.2.9
minimum layer wall thickness e_{lmin}
minimum measured wall thickness at any point of a layer

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

3.3.2
predicted design pressure p_{CD}
pressure with the dimension of pressure (bar) which represents the predicted design pressure after a life time of 50 years using the 97,5 % reference line.

3.3.3
circumferential hoop stress in a layer σ_l
stress, in MPa, induced in the wall of a layer when a pressure is applied using water as a medium

[1] The value for π is taken to be 3,142

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 will 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.

3.5 Definitions related to material characteristics

3.5.1
long-term hydrostatic strength σ_{LTHS}
quantity with the dimensions of stress, expressed in megapascals (MPa), which represents the predicted mean strength at a temperature *T* and a time *t*

3.5.2
lower confidence limit of the predicted hydrostatic strength σ_{LPL}
quantity, with the dimensions of stress, expressed in megapascals (MPa), which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength for a single value at a temperature T and a time t. It is noted as:

$$\sigma_{LPL} = \sigma_{(T,t,0,975)}$$

3.4.3
lower confidence limit of the predicted hydrostatic pressure (P_{LPL})
quantity with the dimension of pressure, which represents the 97,5 % (one sided) lower confidence limit of the predicted hydrostatic pressure at a temperature T and a time t

3.5.4
minimum required strength MRS
value of σ_{LPL} at a temperature 20 ºC and a time 50 years ($\sigma_{(20,50years,0,975)}$), rounded down to the next smaller value of the R10 series or of the R20 series conforming to ISO 3, ISO 497 and ISO 12162, depending on the value of σ_{LPL}

3.5.5
minimum required pressure MRP
value of the estimated long-term pressure resistance of a pipe at a temperature of 20 ºC and a time 50 years, ,rounded to the nearest lower value of the R10 series of ISO 3:1973 and ISO 497:1973

3.5.6
overall service (design) coefficient, C
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 1 Minimum values of C for various materials are given in clause 5.

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 ºC and a pressure of 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

3.6.3 category E gaseous fuels
LPG vapour

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

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 and the bending properties of the pipe.

4.2 Corrosive conditions

Components exposed to corrosive conditions shall be of corrosion-resistant material or protected against corrosion.

5 Pipes

5.1 Material

5.1.1 General

Materials intended for the stress bearing layers shall conform to the material requirements of the reference product standard(s). See 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 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

Aluminum materials shall be according to EN 573-3

5.1.4 Product classification and construction group

The multilayer pipes can include polymeric or metallic layers which may have several purposes including the ability to withstand the pressure.

For the purpose of this International standard, multilayer pipes are classified in two construction groups A and 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 standard. The ends of the pipe shall be cut cleanly and square to the axis of the pipe.

Following data of pipes required:
- outside diameter
- wall thickness
- thickness of the inner layer
- thickness of the aluminum layer
- thickness of the outer layer

and the 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 continuous welded

5.2.3 Minimum Safety coefficient

The minimum safety coefficient is 2, based on that the Design pressure (DP) which is at least greater or equal to maximum operating pressure (MOP) taking into account the maximum operating temperature."

5.3 Dimensions of pipes
The outside diameter shall preferably be according to ISO 161-1

All layers shall be of sufficient thickness so that the composite pipe fulfills the requirements of this standard

5.4 Mechanical properties

5.4.1 Long Term Hydrostatic Strength

5.4.1.1 General
The long-term pressure strength of the multilayer pipes can be measured or calculated, as applicable. Consequently two procedures for the determination of long-term pressure strength of multilayer pipes are defined in this International standard: Procedure I and Procedure II.

Requirement for the predicted design pressure: $P_{CD} \geq MOP$. The operating temperature has to be taken into account.

NOTE The elastic behaviour of PEX and PE are similar therefore Procedure I may be applied. It shall be taken into account that the results of Procedure I are rather conservative generally" Reference lines of PEX can be found in ISO 10146

NOTE: The minimum service (design) coefficients can be found in the relevant product standard (see annex A)

5.4.1.2 Procedure I
NOTE Procedure I can 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 Annex A of ISO/DIS 17456:2003. The addition rule related to each pressure bearing layer assumes that a complete interlayer adhesion exists with design coefficients coming form the reference product standards and similar elastic behaviour is existing.

The cumulative P_{CD} shall be equal or greater than the relevant MOP.

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

5.4.1.3 Procedure II
At least one diameter of every "similar construction type" shall be tested according to ISO 9080. For M-pipes the diameter with the highest SDR_m of the metal layer shall be tested.

To calculate the parameters p_{CD} and MRP for each pipe construction ISO/DIS 17456 shall be used.

For the calculations of M-pipes the design coefficient of the inner layer shall be used. For P-pipes the design coefficients of each layer has to 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 conformation testing in accordance with ISO/DIS 17456 If the SDR_m (metal layer) of a smaller diameter 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 conformation testing of ISO 17456.

5.4.1.5 Calculation for the control points

5.4.1.5.1 Procedure I P-pipes
Failure control points for each diameter for 22 h, 165 h and 1000 h shall be calculated, using the formula 2 in

Annex A of ISO 17456:2004.

5.4.1.5.2 Procedure II P-pipes and M-pipes

Failure control points for each diameter for 22 h, 165 h and 1000 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 shall occur. The test shall be carried out in accordance with Annex B.

5.4.3 Crack resistance of the outer layer

When testing at a temperature of -20ºC according to Annex B no cracks are allowed in the outer layer.

5.4.4 Resistance of slow crack growth of the outer layer (notch test) for M pipes

When testing at a temperature of -20ºC according to Annex E no crack growth is allowed in the outer layer.

5.5 Physical properties

5.5.1 General

The applicable physical characteristics of each layer shall be checked in accordance with the corresponding clause of the product standard

5.5.2 Requirements

Table 1: Physical properties

Characteristic	Requirements	Test parameters		Test
		Parameter	Value	
Resistance to gas constituents	≥ 20 h No delamination	Conditioning Temperature Pressure Cone test	1500h/23 ºC 80 ºC 0,4 P_D 10% expansion	Annex C
Thermal stability of the outer layer of M-pipes	No visual cracks in outer layer	PE or PE-X At 100° At 110°C Strain	 0,5 year 0,25 year 3 %	Annex D
Delamination - P-pipes - M-pipes	 No cracks or delamination Peel strength ≥15N/cm	 Expansion Temperature Temperature Cycling test Number of cycles	 10 % (by cone with 15% slope) 23ºC 23ºC -20ºC/60ºC 10	 Annex B Annex F
Odorant permeability	No perception of THT smell by experienced observer	Odorant Exposure time Temperature	THT 35 days 23ºC	Annex G

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6 Fittings

6.1 General

6.1.1 Fitting reference standards

Fittings shall comply with:

Mechanical fittings: ISO 10838

Electrofusion fittings EN 1555-3 or ISO 8085-3

6.1.2 Installation

Due to 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 and 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 will 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.

NOTE

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 standardised system. The connection shall comply with the relevant standards.

6.5 Rubber rings

In the technical file shall be indicated which rubber standard has been applied

7 Fitness for purpose

7.1 Diameter classes

Following diameter classes are defined according to a range of external diameters.

Table 2: Diameter classes

Diameter classes	1	2	3	4	5	6	7
External diameter (mm)	D < 16	16 ≤ D < 20	20 ≤ D < 26	26 ≤ D < 40	40 ≤ D < 50	50 ≤ D < 60	60 ≤ D ≤ 63

7.2 Relation between MOP and Qualification Test Pressure (QTP)

Table 3: Relation between MOP and QTP

: Maximum Operating Pressure "MOP" (mbar)	Qualification Test Pressure “QTP” (mbar)
100	1000
1000	3000
5000	7000

7.3 Requirements

Table 4: Requirement for fitness for purpose

Characteristic	Requirements	Test parameters			Test
		Parameter	Value		
Tensile load	No leakage for one hour	Test temperature Type of test samples Pipe length Number of test samples Test pressure Tensile strength level:	23 ± 2 °C End fitting – pipe – end fitting 350 mm 2 per each diameter class 30 mbar		Annex H
			Class	1 h test	800 h test
				kN	
			1	1,4	0,9
			2	1,8	1,1
			3	2,1	1,4
			4	4,0	2,4
			5	6,0	3,6
			6	8,0	4,8
			7	12,0	7,2
Joint resistance to crushing	Tightness No reduction of outer diameter more than 20%	Test temperature Type of test samples Pipe length Number of test samples Test pressure Force level Position of load applied Load	23 ± 2 °C End fitting – pipe – end fitting 600 mm 2 per diameter class 30 mbar 2 kN 10 mm from the insert of fitting or nut plate with 150 mm side square		Annex I
Impact resistance of the joint	Tightness	Test temperature Type of test samples Pipe length Number of test samples Test pressure Striker Impact Position of the impact	23 ± 2 °C End fitting – pipe – coupling – pipe - end fitting with each end fitting fixed on a motionless support 1000 mm each pipe 2 per diameter class 30 mbar spherical head with 1 cm of radius 600 mm/ 5 kg onto the fitting		Annex J
Thermal cycling resistance	leakage $\leq 10^{-4}$atm.cm^3.s^{-1}	Extreme test temperatures Number of cycles Type of test samples Pipe length Number of test samples Test pressure	-20 °C / + 60 ° C 10 End fitting – pipe – coupling – pipe - end fitting 300 mm each pipe 2 per diameter class QTP according to MOP		Annex K

Characteristic	Requirements	Test parameters		Test
		Parameter	Value	
Repeated bending resistance	No damage or modification of the aluminum layer after the test	Minimum bend radius Bend angle Number of bending cycles Test pressure Type of test samples Pipe length Position of the bend Number of test samples	as declared by the manufacturer 90° 3 bend cycles 30 mbar End fitting – pipe – end fitting 350 mm at a distance equal to one minimum bend radius from the end fitting 4 per diameter class	Annex F

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 which will indicate the length remaining on the coil.The marking shall include the information specified in 5.

Table 5 Minimum marking information

Aspect	Mark or symbol
Manufacturer or trademark	Name or symbol
Internal fluid	Gas
Pressure class	p_D
Dimensions	d_n x 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)[2]	Alpha
Standard reference number	ISO 17484

Instructions

The manufacturer shall provide clear assembly instructions that contain minimal 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;

[1] In clear figures or in code providing traceability to production period within year and month and if the manufacturer is producing at different sites, the production sites

- if the manufacturer allows the use of a standard bending tool, he shall state in the manufacturer's instructions that damage of the external coating shall be avoided in 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 must be given.

Annex A (Normative)
List of the reference product standards

At the time this International Standard has been issued, the reference product standards published or under preparation are listed in Table A.1.

Table A1 — List of reference product standards

Reference material	Reference material standard
PE	ISO 4437-1: 2002,
PE-X	ISO 14531-1:

NOTE:
This list is only applicable on materials in stress bearing layers.

Annex B (Normative) Test for delamination , crack resistance and strength of the joint line

B.1 Pipe sample

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

B.2 Cone

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

B.3 Procedure

- Measure the real mean outside diameter of the pipe sample using a suitable measure instrument with an accuracy of at least 0,1 %
- Multiply this value wit 1,1 (10% expanding); This value will be the outside diameter of the expanded part of the pipe sample.
- Measure the wall thickness of the pipe sample on 8 separate pint equally divided over the pipe diameter with an apparatus with an accuracy of at least 1 %. The calculate value is e_m
- Calculate the required sized of the cone diameter in order to obtain an expansion of 10 %. In formulae:

  $d_{cone} = 1,1*d_e – (2*e_m)$

- Mark the place on the cones where a 10 % expansion will be obtained.
- Insert the cone in the pipe sample up the the mark sign. The pipe end has been expanded up now by 10 %.
- Remove the cone
- After 15 min of the removal of the cone, the sample will be visual checked on cracks and delamination

B.4 Report

- 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 unforeseen event able to influence the test results

Annex C (Normative) Resistance to gas constituents

C.1 Sample

Prepare a sample according ISO 1167. Preferably the test sample will be made of pipe from dimension class 6 (se 7.2). The end caps shall be mounted in such a way that the condensate has free access to the pipe ends.

C.2 Procedure

- Prepare a synthetic condensate comprising 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 1500 h at (23 ± 2) ºC with a pressure of 0,4 P_D. Perform the test in accordance with ISO 1167, but using the synthetic condensate inside the pipe at a temperature of 80 ºC.
- After these test the cone test according to Anne B shall be carried out.
- Check the sample on leakage and on delamination of the layers.

C.3 Report

- Number, type and nominal dimension of the sample;
- Test temperature;
- Duration of the test;
- Any observation made during and after the test ;
- Any unforeseen event able to influence the test results

Annex D (Normative) Thermal stability of the outer layer of M-pipes

D.1 Principle of the method

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

- Oven

- Bending template

D.3 Procedure

Oven aging: PE or PE-X 0.5y at 100°C or 0.25y at 110°C. *1)

PVC-C 95°C/1 year

Deformation: Bending with bending template similar to EN 713 at (23 ± 2) ºC

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

d_e: outside diameter of the pipe

Table D1: Parameters

Total pipe length l_1	Bending length l_2	Bending radius R
10 d_e	7,5 d_e	16 d_e

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

D.4 Report

- Number, type and nominal dimension of the sample;
- Presence of cracks
- Duration of the test;
- Any observation made during and after the test ;
- Any unforeseen event able to influence the test results

Example

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 fibre of the pipe:

$$\varepsilon = (R + d_e) / (R + d_e/2) \} - 1 = \{17 \times d_e / 16{,}5 \times d_e \} - 1 = 0{,}0303 \ (3{,}0\ \%)$$

NOTE temperature collective

A temperature collective is assumed in the following way:

120 hours at 70°C per year

3 month at 60°C

3 month at 50°C

3 month at 40°C

3 month at 30°C

Using the van´`t Hoff rule (10°K difference equivalent to 2times reaction time) these temperatures are converted to 60°C and taken into account for 50 years life time

120 hours 70°C –240 hours 60°C –	0.33 month 60°C --- 1.375 years
3 month 60	3 month 60°C --- 12.5 years
3 month 50°C	1.5 month 60°C --- 6.25 years
3 month 40°C, -- 1.5 month 50°C -	0.75 month 60°C --- 3.125 years
3 month 30 °C, -- 1.5 month 40°C--, 0.75 month 50°C,------	0,375 month 60°C --- 1.55 years

The assumed temperature collective results in a temperature duration of 25 years at 60°C for the life time of 50 years of the pipe.

Taken into account the Time / Temperature Extrapolation method of ISO 9080 this gives a test time of 0.5 years (6 month) at 100°C or 025 years (3month) at 110°C.

Annex E (Normative) Resistance of slow crack growth of the outer layer (notch test) for M pipes

E.1 Samples

- A piece of pipe with a length of 100 mm shall be used as test sample.

E.2 Procedure

- Cut a longitudinal notch into the outer layer down to the metal layer with a razor blade, notch length 50mm, at a temperature of (23 ± 2) ºC,
- Store the test piece at -20°C for 24h.
- Check with an optical instrument with a magnification of 8 times, if crack growth has been occurred.

E.3 Report

- Crack growth
- Name of the test;
- Number, type and nominal dimension of the sample;
- Test temperature

Annex F (Normative) Adhesion test

F.1 Sample

Samples for peel test shall be prepared according to ISO 17454 and samples for thermal cycling according Annex J of ISO 17454. All samples shall be prepared from the same pipe.

F.2 Procedure

- Carry out a peel test according to ISO 17454 at (23 ± 2) ºC
- Carry out a thermal cycle test according to Annex J, with a thermal cycle between -20ºC and +60ºC. The number of cycles will be 10. The pipe will not 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) ºC. The peeling zones should be at the ends and centre of the test piece.

F.3 Report

- Peel strength in N/cm
- Name of the test;
- Number, type and nominal dimension of the sample;
- Test temperature;

Annex G (Normative)
Odour permeability

G.1 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.

G.2 Procedure

- An air flow with a THT content of 100 mg/m3 at a pressure of 0.1 $\pm$ 0.02 MPa (1 $\pm$ 0.2 bar) is passed through the pipe at a temperature of 23 $\pm$ 2 C.
- After 35 days of exposure an experienced observer has to detect the presence THT odour.

G.3 Report

- 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 unforeseen event able to influence the test results

Annex H (Normative) Resistance to tensile load on joints

H.1 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.

H.2 Procedure

H.2.1 Short term test (1h)

- carry out testing at an ambient temperature of 23 ± 2 ºC;
- put the test sample in the tensile testing machine;
- apply 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 7.4 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 hour while monitoring the pressure

H.2.2 Long term test (800 h)

- carry out testing at an ambient temperature of 23 ± 2 ºC;
- put the test sample in a constant load apparatus;
- apply the load as given in 7.4
- keep the tensile load constant for 800 h while monitoring the pressure
- Short term test: Pressure inside the samples is monitored and any leakage should be recorded (location, time of appearance)
- Long term test: Pressurize the sample after test period with a pressure of 30 mbar. Check the sample on leakage

H.3 Report

- 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 which occurrence could influence the result of the test.

Annex I (Normative) Crush test on joints

I.1 Samples

The test sample is made of an end fitting-pipe-end fitting and the joints are made according to the manufacturer instructions; the pipe length is 600 mm

I.2 Procedure

- Perform a tightness test at 30 mbar
- Apply a load on a plate (150 mm side square) 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;

NOTE: Alternatively it can be 75 mm side square and a force level of 1 kN

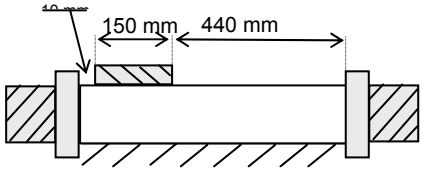


Figure I1: resistance to crushing close a fitting test assembly

- 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 100 mbar.

I.3 Report

- 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 unforeseen event able to influence the test results

Annex J (Normative) Impact resistance test on joints

J.1 Pipe samples

The test sample is made of an end fitting-pipe-coupling-pipe-end fitting and the joints are made according to the manufacturer instructions; each pipe length is 1000 mm.

J.2 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)

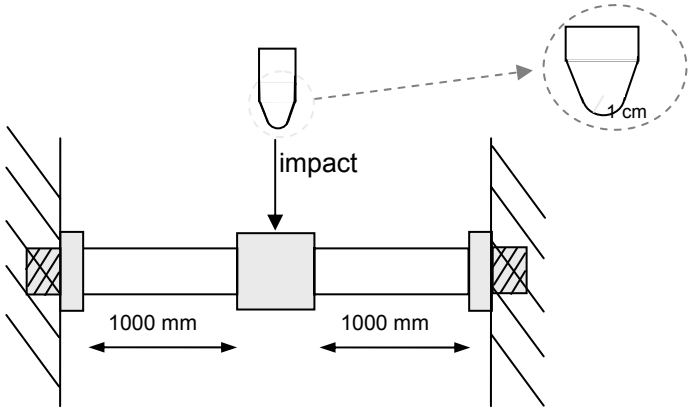


Figure J1: Impact resistance test assembly

J.3 Procedure

- Each end fitting is fixed on a motionless support;
- Perform a tightness test at 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 1 bar
- Check the sample on leakage by means of a foaming solution

J.4 Report

- Leakage
- Name of the test;
- Number, type and nominal dimension of the sample;
- Test temperature

Annex K (Normative) Thermal cycling test on joints

K.1 Samples

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

K.2 Procedure

- Fill up the samples with water and measure the water volume;
- 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;
- Calculate the total leak rate with the following equation:

$$Q_l = \frac{(P_i - P_f)V}{t}$$

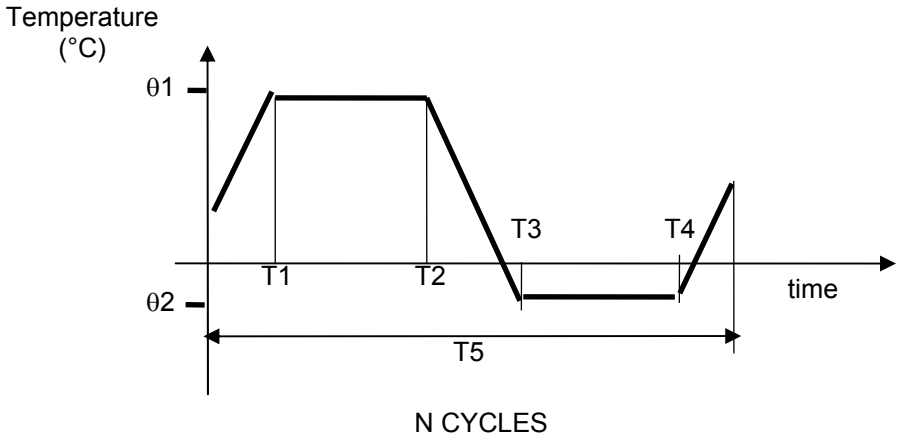
Where: Q_l : mean leak rate (atm.cm^3.s^{-1})

P_f : absolute final pressure in the sample (atm)

P_i : absolute initial pressure in the sample (atm)

V : sample volume (cm^3)

t : test duration (s)



θ1	60 ºC
θ2	-20 ºC
T1	(θ1-ambient temperature) minutes*
T2	T1 + 3 hours
T3	T2 + 90 minutes
T4	T3 + 3 hours
T5	9 hours
N cycles	10

* The temperature rise rate is 1°C per minute

Figure K1: Heat cycle layout

K.3 Report

- Type of the sample, DN, volume...;
- Name of the test ;
- Air pressure (initial pressure, pressure vs. time plotting or final pressure if not possible).

Annex L (Normative) Repeated bending test

L.1 Samples

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

L.2 Special tools

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

L.3 Procedure

- The test sample should be put between two mandrels as follows :
- Mandrel radius = minimum bend radius - pipe radius where the minimum bend radius is declared by the manufacturer; the welded seam is on the inside of the bend
- Bend the pipe from position A to position B. The time between A and B should be around 10 seconds. Wait half a minute;
- Put the pipe back into the position A
- Repeat foregoing steps 2 times;

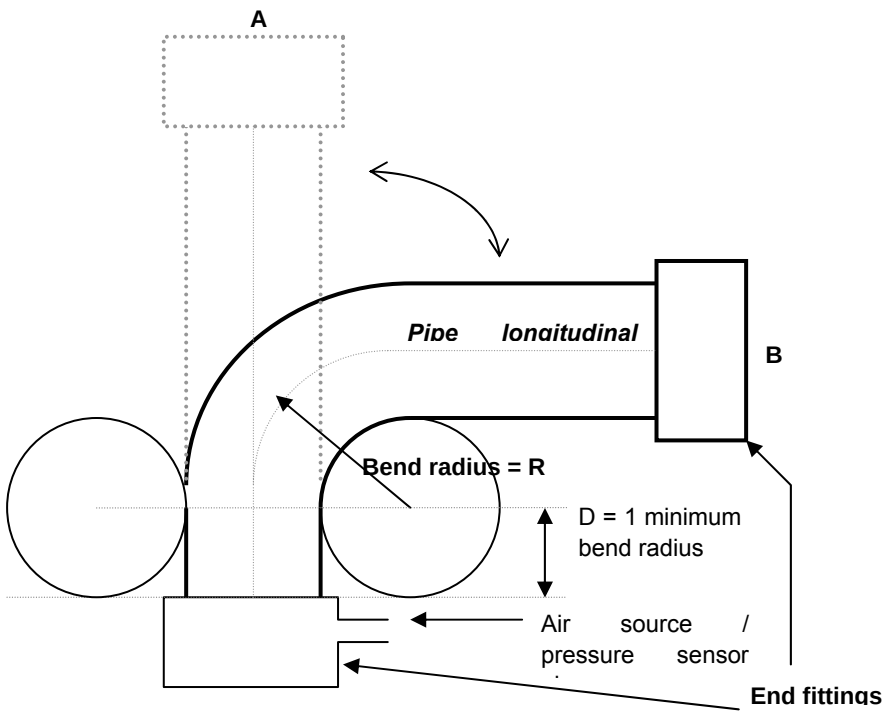


Figure K1: Multilayer repeated bending test assembly

- Check during the test if disbanding of the layer has been occurred

- Peal off the outer layer of the pipe and watch for any damage / modification of the aluminium layer. The pipe may be bent in different positions during examination if this can improve the damage detection. Inspect visually any delamination, disbanding like blisters, pitting and notches.

L.4 Report

- Type of the sample;
- Air pressure (initial pressure, pressure vs. time plotting);
- Any leakage occurring during the phase (time of occurrence, number of bends done, location) ;
- Any problem during the test which occurrence could influence the result of the test.

Annex M (Informative) Bibliography

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