

Technical Guide



Plastics piping systems for hot or cold water under pressure

- Preparing application requests for Technical Assessments or Technical Application Documents

CSTB, the Scientific and Technical Center for Building, is a public organization for innovation in building, which performs four key activities, namely research, expertise, evaluation and dissemination of knowledge, organized to satisfy the challenges of the ecological and energy transition in the world of construction. Its field of expertise covers construction products, buildings, and their integration into districts and cities.

With over 900 employees and its subsidiaries and networks of national, European and international partners, the CSTB offers its services to all parties involved in construction to improve the quality and safety of buildings.

Any integral or partial reproduction or representation, by any process whatever, of the pages published in this document, without authorization of the publisher or of the French Copyright Administration Centre (3, Rue Hautefeuille, 75006 Paris), is illegal and constitutes an infringement. Only reproductions strictly reserved for the usage of the copier and not intended for collective use and also any analyses and short quotes, justified by the scientific or informational character of the document in which they are incorporated, are authorized (Law of July 1, 1992 – Articles L 122-4 and L 122-5 and Penal Code, Article 425).

© CSTB 2016

Technical Guide

Plastics piping systems for hot or cold water under pressure

Preparing application requests for Technical Assessments
or Technical Application Documents

CONTENTS

1. Chapter 1 – Purpose of the guide and field of application	2
1.1 Purpose	2
1.2 Field of application	2
2. Chapter 2 – Description of the system	3
2.1 General description	3
2.2 Definition of the constituent materials	3
2.3 Definition of the product	3
2.4 Limits of the accepted application	3
2.5 Sanitary conformity	3
2.6 Installation-work description	3
2.7 Product marketing method	3
3. Chapter 3 – Technical sub-file.....	3
3.1 General characteristics	3
3.2 Evaluation of the service life – durability	4
3.3 Fitness for purpose	4
Appendix A	
Test methods	5
Appendix B	
Specifications.....	7

1. Chapter 1 – Purpose of the guide and field of application

1.1 Purpose

The purpose of this Guide is to define the elements that will be useful when examining requests for Technical Assessments or Technical Application Documents ('DTA') concerning "Piping Systems" composed of plastics-based pipes and metal or plastics-based fittings, the pipes being homogeneous or metal-core multilayer¹.

In the following part of this Guide, the term "Technical Assessment" can be replaced by "DTA".

By "Piping System" we mean the association of pipes and fittings and any tooling enabling their assembly, all these elements being clearly identified, along with the specific design and implementation rules for water networks.

The Technical Assessments on the "Piping systems" cover the three following families:

- family A :
 - For the pipes: Technical Assessment formulated for a type of pipe associated with fittings defined in said Technical Assessment
 - For the fittings: Technical Assessment formulated for a type of fitting associated with pipes defined in said Technical Assessment
- family B :
 - For the pipes: Technical Assessment formulated for piping systems consisting of a type of pipe, associated only with one or more specific types of fittings, defined in the same Assessment (association with other fittings or pipes, covered by Technical Assessments or not, is not in-scope).
 - For the fittings: Technical Assessment formulated for piping systems consisting of a type of fitting, associated only with one or more specific types of pipes defined in the same Assessment (association with other pipes or fittings, covered by Technical Assessments or not, is not in-scope).
- family C : Technical Assessment formulated for a type of pipe, associated with specific fittings, defined in that same Assessment as well as other fittings covered by Technical Assessments.

The specifications of the main products are set down in the following standards:

- piping systems in polypropylene (PP): NF EN ISO 15874
- piping systems in cross-linked polyethylene (PEX): NF EN ISO 15875
- piping systems in polybutylene (PB): NF EN ISO 15876
- piping systems in chlorinated polyvinyl chloride (CPVC): NF EN ISO 15877
- multilayer piping systems: NF EN ISO 21003
- piping systems in polyethylene of raised temperature resistance (PE-RT): NF EN ISO 22391
- fittings with compression ends for use with plastics pipes: NF EN 1254-3
- fittings with push-fit ends: NF EN 1254-6
- press-fittings for use with plastics and multilayer pipes: NF EN 1254-8

¹ Polymer-core multilayer pipes as defined in ISO 21003 are not under the scope of this document.

The evaluation elements checked during the examination comprise, in particular, the description and identification of the products, the performances provided and the description of the proof elements for verifying those performances.

1.2 Field of application

This Guide covers the applications defined in the Table below. These applications are taken from standard ISO 10508.

The application classes 2, 4 and 5 are defined in standard ISO 10508. According to that standard, it needs to be remembered that, whatever the application class assigned, the system must also be suitable for carrying cold water at 20°C during 50 years at a design pressure of 10 bars.

It also covers the "Chilled water" application class that corresponds to air-conditioning and cooling installation for which minimal temperature is 5°C.

Class	Service conditions	Maximal working conditions	Accident-mode conditions	Standard application
Class 2	70 °C 49 years	80 °C 1 year	95 °C 100 hours	Hot and cold domestic water supply
Class 4	20 °C - 2,5 years and 40 °C - 20 years and 60 °C - 25 years	70 °C 2,5 years	100 °C 100 hours	Low-temperature radiators, underfloor heating
Class 5	20 °C - 14 years and 60 °C - 25 years and 80 °C - 10 years	90 °C 1 year	100 °C 100 hours	High-temperature radiators

For a system not aiming to be rated class 2, the marking shall be completed with the statement 'heating only'.

For a system aiming to be rated class 4 only for underfloor heating, the marking shall be completed with the statement 'underfloor heating only'.

2. Chapter 2 – Description of the system

2.1 General description

2.1.1 Identification – Field of application

- Name and address of the requester;
- Name and address of the manufacturer: registered office and factory(ies);
- Trade name of the product and associated products;
- Definition of the field of application: corresponding classes and design pressures (pD).

2.1.2 References

The approximate overall number of systems already installed at the time of the request using the products, and list of earlier applications shall be communicated.

2.1.3 Production

The quantities of average annual production output of the factories for the products considered shall be communicated.

2.2 Definition of the constituent materials

The origin, nature and percentage in weight (with their tolerances) of all the product's constituents are to be communicated, confidentially or not.

2.3 Definition of the product

The product definition includes, in particular:

- range of products produced (diameters, thicknesses, tolerances) (see Appendix B);
- various colours proposed for the pipes;
- format of the delivered pipes (straight and/or coiled bars, bare and or pre-sheathed pipes);
- list of pipes or associated fittings and any other accessories;
- in the case of press-fittings, list of various equipment items/components for assembling pipes and fittings;
- profile(s) (for radial-compression crimping) and corresponding tools (trade name and/or press-fitting force), for which the applicant will have provided proof of fitness for purpose.
- list of the main physical, physical-chemical and mechanical characteristics;
- quality assurance checks (procedures, frequencies, specifications) carried out at delivery, during production, and in the factory laboratory;
- product markings;
- description of the production process from acceptance of the raw materials to the finished product;
- packaging, labelling, warehousing and storage conditions in preparation for transportation.

2.4 Limits of the accepted application

The limits in the accepted fields of application considered shall be specified.

2.5 Sanitary conformity

Products whose field of application covers Class 2 shall be the subject of Sanitary Conformity Notices (decree of May 29 1997 and amendments relating to materials and items used in fix-work installations for the production, treatment and distribution of water intended for human consumption).

2.6 Installation-work description

The description of the system installation rules shall be supplied for each application class planned. Any do's and don'ts shall be clearly indicated.

2.7 Product marketing method

The applicant shall specify the product marketing method employed.

3. Chapter 3 – Technical sub-file

This sub-file shall include all the test reports, interpretations or inferences by which the applicant expects to provide proof of those claimed product properties that are demonstrable and evidence of those claimed product properties that are subject to evaluation.

The test methods and the specifications used to examine the file are given in *Appendix A* and *Appendix B*, respectively.

3.1 General characteristics

Depending on the types of products/materials involved and their claimed applications, the following characteristics are liable to be required as part of the file:

- nature of the materials of the range of pipes, fittings and accessories, as well as their tradenames;
- density;
- melt flow index (for the polyolefins);
- Vicat softening point (for non-crystalline products);
- gel content (for the PEX);
- heat reversion (pipes);
- impact strength (pipes);
- visual effects of heating (fittings);
- tensile strength (pipes);
- resistance to pressure;
- regression curves of extruded materials (pipes) or injected materials (fittings);
- oxidation resistance;
- opacity;
- coefficient of thermal expansion;
- thermal conductivity;
- resistance to delamination (multilayer pipes);
- resistance to crushing (sheaths);
- leaktightness of the sheaths;
- any other characteristic specific to the product proposed.

3.2 Evaluation of the service life – durability

3.2.1 Factors to consider concerning service life

The defined application classes are those described in paragraph 1.2.

The design pressures (pD) to be considered are those defined in chapter 1 of Appendix B.

For these applications, the pressure variations other than water hammer are considered as negligible influences on performance ageing.

The other factors to be considered are those related to ambient environment (UV radiation, presence of air and oxygen).

Furthermore, the manufacturer shall indicate, if needed, the precautionary measures required for the use of these products in terms of contact with coating materials and paints.

3.2.2 Tests to be performed in relation to these factors

3.2.2.1 Determination of long-term hydrostatic strength by extrapolation

It is necessary to provide regression curves produced in accordance with standard NF EN ISO 9080 or ISO 17456 (for multilayer pipes), and established or validated by an accredited test laboratory or an EA (European Co-operation for Accreditation) member organization.

3.2.2.2 Data on oxidation processes

The manufacturer shall provide data on oxidation processes that demonstrates efficiency and non-migration of the antioxidant system. In particular, the data may include tests after accelerated ageing in air and in water at high temperature. This data is to be verified by an accredited test laboratory, chiefly through tensile strength tests and/or by differential thermal analysis after ageing.

3.3 Fitness for purpose

Fitness for purpose is evaluated with regard to the regulations in force, routine usage and practice of installations in France, in particular specifying the minimal range allowing for implementation of an installation and the allied experimental verifications on the system.

In the case of press-fittings, the full range of tools proposed must be represented.

In cases involving families A and C, a test will be run on samples representative of the different types of fittings or the different types of pipes.

3.3.1 Constitution of the range

In order to ensure that a network can be effectively installed in a building, a range shall include:

- at least 3 diameters from among DN 12, 16, 20 and 25 in the case of PEX, PB and PE-RT type 2 pipes;
- at least 3 diameters within the range 14 to 32 mm in the case of multilayer pipes;
- at least DN 20, 25, 32, 40 and 50 in the case of PP-R and CPVC pipes.

Comments:

1) In the case of piping systems limited to underfloor heating only, the range can be limited to a single diameter.

2) In the case of piping systems applied in a collective water distribution system, minimum diameter of pipe range can be DN 25.

All the diameters in the range shall mandatorily include fittings making it possible to connect to the network (fitting threaded or tapped at gas pitch).

In the case of pipes in straight bars, the range proposed shall also include, for each diameter, elbows, tees, sleeves, reducers and plugs.

3.3.2 Experimental circuits

The experimental circuits are composed of pipes and fittings of various diameters, representative of the range proposed by the requester.

In the case of press-fittings, the full range of tools proposed must be represented.

3.3.3 Fittings and assemblies

As a complement to the experimental circuit tests that will have to be run in order to verify the fitness for purpose, pressure resistance tests to at least 1000 hours of stress are to be carried out as well as tests on resistance to pull-out and resistance to alternating pressures (CPVC) or pressure cycles.

Appendix A Test methods

1. Standardized test methods

The table below specifies the main standardized test methods used. In particular, these methods come from European standards 15874 to 15877, 21003 and 22391 on PP, PEX, PB, CPVC, multilayer and PE-RT pipes.

Reference standard	Type of test
NF EN ISO 10147	Pipes made of crosslinked polyethylene (PEX) - Determination of gel content
NF EN 712	Resistance to pull-out under constant longitudinal force
NF EN 713	Leaktightness under internal pressure of assemblies subjected to bending
NF EN 727	Determination of Vicat softening point
NF EN 728	Determination of oxidation induction time
NF EN 744	Resistance to external blows – Pipes
NF EN ISO 580	Plastics piping and ducting systems — Injection-moulded thermoplastics fittings — Methods for visually assessing the effects of heating
NF EN ISO 1167	Determination of resistance to internal pressure
NF EN ISO 1133	Determination of melt flow index
NF EN ISO 2505	Determination of longitudinal heat reversion – Pipes
NF EN ISO 3126	Controlling dimensional properties
NF EN ISO 6259	Determination of tensile properties – Pipes
NF EN ISO 7686	Plastic pipes and fittings – Determination of opacity
NF EN ISO 9080	Determination of long-term hydrostatic strength by extrapolation
NF EN 12293	Resistance of mounted assemblies to temperature cycling
NF EN 12294	Leaktightness under vacuum
NF EN 12295	Resistance of mounted assemblies to pressure cycling
ISO 17454	Test method for the adhesion of the different layers using a pulling rig
NF T54-094	Determination of resistance to alternating pressures
NF EN 61386-1 et NF EN 61386-22	Conduit systems for cable management – Part 22: particular requirements – Pliable conduit systems

2. Complements to the test methods

2.1 Burst test

The test specimens are prepared as described in standard NF EN 1167.

The procedure is as follows:

- Increase the pressure continuously to obtain a failure of the test specimen after a duration of 60 to 70 seconds;
- Note the pressure recorded, and calculate any appropriate corresponding maximal strain.

2.2 Test to determine opacity

This test is carried out as described in standard ISO 7686 and mandatorily using an integration sphere.

2.3 Tests on the corrugated sheaths

2.3.1 Corrugated sheaths leaktightness

This test is performed according to the following procedure:

- Single sheath: visually inspect the sheath held braced in bent position (corresponding to the pipe's minimum bending radius) in two planes:
 - perpendicular to the mating plane
 - on the mating plane

- Multiple sheaths:

- Identical test after separating sheaths — can be scaled down to bending on the mating plane if sheath-to-sheath locking creates too much stiffness to enable bending perpendicularly to the mating plane.

2.3.2 Test of resistance to crushing on corrugated sheaths

This test is performed based on the conditions defined in standards NF EN 61386-1 and NF EN 61386-22.

2.3.3 Dimensional checks

The measure of inner sheath diameter is performed using an in-out slide caliper (value measured is the mean of the biggest and smallest readings recorded).

2.4 Specific requirement on polymer plastic-coated outer-layer polymer pipes

The base pipe shall meet the dimensional requirements from the corresponding product standard. The barrier layer is an add-on that lends the finished product a bigger outer diameter and wall thickness than given in the standard.

Tests	Base pipe	Base plus coating	Comments
NF EN ISO 6259 Determination of tensile properties – Pipes	X	X	Post-ageing tests shall be carried out on the base pipe only
Tests related to oxidation resistance (see 3.2.2.2)	X		
NF EN 728 or NF EN ISO 11357 Determination of oxidation induction time	X		
NF EN ISO 10147 Pipes made of crosslinked polyethylene (PEX) - Determination of gel content	X		
NF EN ISO 10147 Determination of longitudinal heat reversion – Pipes		X	
NF EN ISO 1133 Determination of melt flow index	X		
NF EN ISO 1167 Determination of resistance to internal pressure	X	X	The tests shall be performed taking readings of base pipe thickness only
Resistance of mounted assemblies to alternating pressure cycling		X	
NF EN ISO 9080 Determination of long-term hydrostatic strength by extrapolation	X	X	The tests shall be performed taking readings of base pipe thickness only
Thermal stability 110°C 8760 h		X	The tests shall be performed taking readings of base pipe thickness only
Experimental heating circuit		X	
NF EN 12293 Resistance of mounted assemblies to temperature cycling		X	

Appendix B Specifications

The specifications are taken from the products' reference standards specified in this guide's scope (*chapter 1*), and complemented by the following characteristics inherent to routine use and practice in France, as specified in particular by the conditions of application described in the national prefaces to the European standards.

1. Design pressures per application class

Class of application	Design pressures
Class 2	6 bars
	10 bars
Class 4 (underfloor heating only)	4 bars
	6 bars
Class 4 (low-temperature radiators)	6 bars
	10 bars
Class 5	6 bars
Chilled water	10 bars

2. Dimensional characteristics of the pipes – Choice of series according to ISO 4065 and product standards

Material	Dimensions of the pipes
PEX	Class A Series S = 5 Class C (underfloor heating only)
PB	
PP-B	
PE-RT	

In the case of plastic-coated outer-layer pipes, the acceptable tolerance on the total finished-product thickness is +0.1 mm.

PP-R	Class A Series S = 2,5
	Class A Series S = 5 (chilled water)
CPVC	Class A Series S = 4
	Class A Series S = 6,3
Multilayer	(*)

(*) Comment

The series and dimensional characteristics of multilayer pipes have not yet been standardized and so remain free to set by the manufacturer. The manufacturer will need to supply data corroborating the sizing of the tubes based on standards NF EN ISO 21003 and ISO 17456.

3. Tensile properties (pipes)

Under the test conditions of standard NF EN ISO 6259, the pipes shall be compliant with the following specifications:

Material	RSE (MPa)	Rr (MPa)	A (%)
PEX	≥ 20	or ≥ 20	≥ 200
PB	≥ 15	≥ 25	≥ 125
PP-B	≥ 23	≥ 23	≥ 600
PP-R	≥ 20	or ≥ 20	≥ 500
CPVC	≥ 50	or ≥ 50	≥ 40
PE-RT	≥ 20	or ≥ 20	≥ 400

The size of the tensile specimens shall be compliant with type 1 or type 2 under standard NF EN ISO 6259 for gauges at DN > 25 mm and to type 1BA of standard NF EN ISO 527 for diameters DN ≤ 25 mm.

4. Oxidation Induction Time (OIT)

Under the test conditions of standard NF EN 728 (or NF EN ISO 11357) according to the isothermal method (for a product weight of 15 ± 2 mg and an oxygen flow rate of 50 mL/min), Oxidation Induction Time (OIT) shall conform to the following minima:

- PEX: 30 min at 200°C
- PB: 20 min at 210°C
- PP-R: 20 min at 200°C
- PE-RT: 40 min at 200°C

5. Oxidation resistance of PEX pipes

The pipes shall meet one of the following specifications:

- elongation at break on the test specimen after ageing for 500 hours in boiling water, then 100 hours in a 160°C oven shall be greater than 50% of the elongation at break of a new test specimen;
- Oxidation induction time (OIT) of the test specimen after ageing for 500 hours in boiling water, then 100 hours in a 160°C oven shall be compliant with the specifications given in chapter 4 for new test specimens.

6. Resistance to pressure cycles on CPVC fittings

Under the test conditions of standard T 54-094, the fittings shall comply with the following specifications:

- DN < 110 mm: minimal resistance of 5000 cycles of 20/60 bars at 1 Hz.
- DN > 110 mm: minimal resistance of 2500 cycles of 20/60 bars at 0.4 Hz

7. Experimental heating circuit

For systems claiming a class-5 rating, a circuit composed of pipes and fittings representative of the proposed product range shall be subjected to continuous circulation of water at 110°C under the test pressure defined in the table below, for a minimal duration of 1000 hours without failure.

Material	Test pressure
PEX/PB	4 bars
Multilayer	6 bars

8. Opacity – Transmittance

The pipes shall demonstrate a less than 14% transmittance when tested under the test conditions defined in *paragraph 2.2 of Appendix A*.

9. Heat reversion

For the materials mentioned below, heat reversion is evaluated according to Standard NF EN ISO 2505, under the following conditions:

Material	Reversion (shrinkage) (%)	Temperature (°C)	Minimal duration (minutes)	
			Liquid bath	Hot-air oven
PEX	≤ 3	120	15 for thickness ≤ 8 mm 30 for 8 mm < thickness ≤ 16 mm	60 for thickness ≤ 8 mm 120 for 8 mm < thickness ≤ 16 mm 240 for thickness > 16 mm
PB	≤ 2	110		
PP-B	≤ 2	150		
PP-R	≤ 2	135		
CPVC	≤ 5	150		
PE-RT	≤ 2	110		

10. Resistance to delamination (multilayer pipes)

Conditioning	Resistance to delamination
New pipes	25 N/cm
Pipes after thermal cycling test	15 N/cm

11. Tests on the corrugated sheaths

- Leaktightness: visual inspection of the ducting held braced in bent position must not find any sign of cracking or tearing.
- Resistance to crushing: for pre-sheathed pipes, the minimum sheath resistance to crushing is 450 N.
- Dimensional control: the specifications on minimal inner bore diameters are defined in “Technical Specifications (‘CPT’) governing installation of plastics piping systems – Straight and/or coiled tube pipes” (CSTB Book 2808 V2 of November 2011).

SIÈGE SOCIAL

84, AVENUE JEAN JAURÈS | CHAMPS-SUR-MARNE | 77447 MARNE-LA-VALLÉE CEDEX 2
TÉL. (33) 01 64 68 82 82 | FAX (33) 01 60 05 70 37 | www.cstb.fr

CSTB
le futur en construction

CENTRE SCIENTIFIQUE ET TECHNIQUE DU BÂTIMENT | MARNE-LA-VALLÉE | PARIS | GRENOBLE | NANTES | SOPHIA ANTIPOLIS