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Plastics piping systems for renovation of underground drainage and sewerage networks under pressure —

Part 4: Lining with cured-in-place pipes

Systèmes de canalisations en plastique pour la rénovation des réseaux de branchements et de collecteurs d'assainissement enterrés sous pression —

Partie 4: Tubage continu par tubes polymérisés sur place

Reference number
ISO 11297-4:2018(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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 8, *Rehabilitation of pipeline systems*.

A list of all the parts in the ISO 11297 series can be found on the ISO website.

Introduction

This document is a part of a system standard for plastics piping systems of various materials used for renovation of existing pipelines in a specified application area. System standards for renovation dealing with the following applications are either available or in preparation:

— ISO 11296: *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks*;

— ISO 11297: *Plastics piping systems for renovation of underground drainage and sewerage networks under pressure* (this document);

— ISO 11298: *Plastics piping systems for renovation of underground water supply networks*;

— ISO 11299: *Plastics piping systems for renovation of underground gas supply networks*;

These system standards are distinguished from system standards for conventionally installed plastics piping systems by the requirement to verify certain characteristics in the "as-installed" condition after site processing. This is in addition to verification of characteristics of plastics piping systems "as-manufactured".

Each of the system standards comprises a

— *Part 1: General*

and all applicable renovation technique family-related parts, which for drainage and sewerage networks under pressure include or potentially include the following:

— *Part 2: Lining with continuous pipes*;

— *Part 3: Lining with close-fit pipes*;

— *Part 4: Lining with cured-in-place pipes* (this document);

— *Part 5: Lining with discrete pipes*;

— *Part 6: Lining with adhesive-backed hoses*.

The requirements for any given renovation technique family are specified in ISO 11297-1, applied in conjunction with the other relevant part. For example, both ISO 11297-1 and this document together specify the requirements relating to lining with cured-in place pipes. For complementary information, see ISO 11295. Not all technique families are pertinent to every area of application and this is reflected in the part numbers included in each system standard.

A consistent structure of clause headings has been adopted for all parts to facilitate direct comparisons across renovation technique families.

Figure 1 shows the common part and clause structure and the relationship between the ISO 11297 series and system standards for other applications.

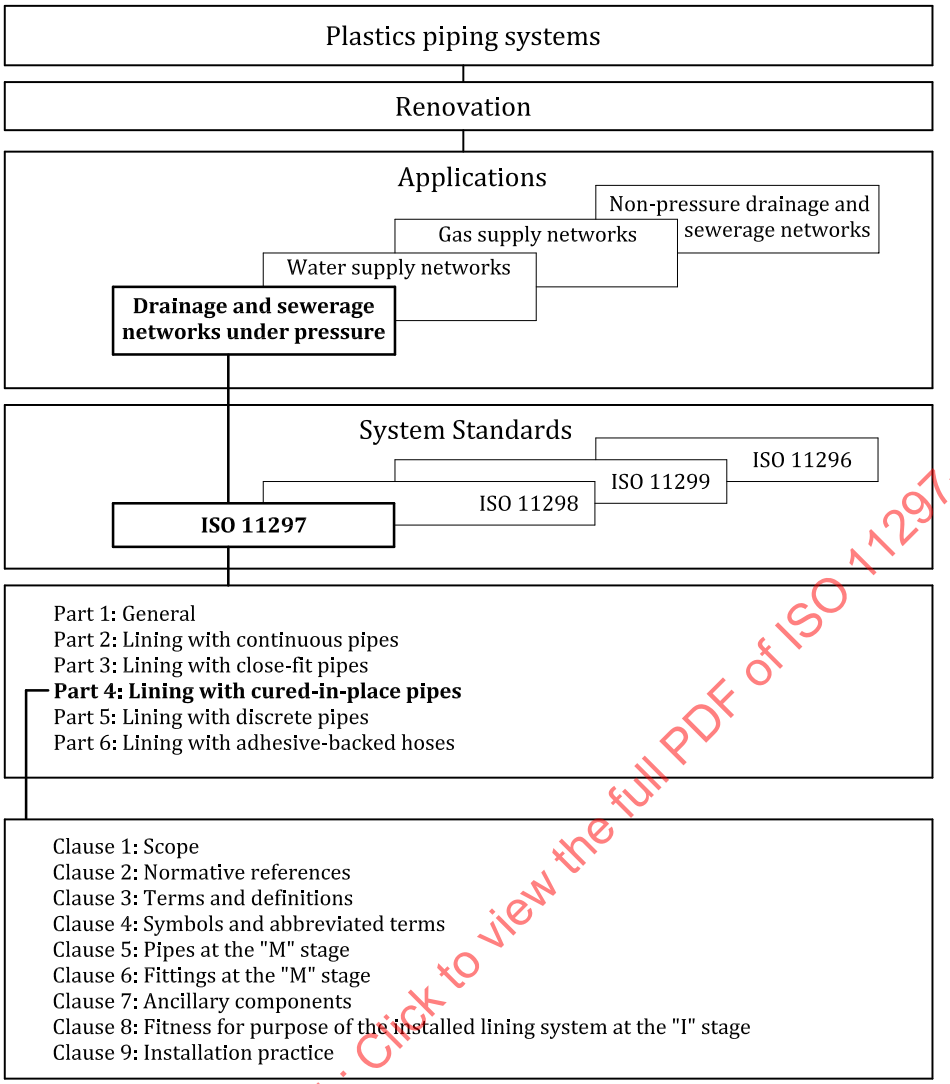


Figure 1 — Format of the renovation system standards

Plastics piping systems for renovation of underground drainage and sewerage networks under pressure —

Part 4: Lining with cured-in-place pipes

1 Scope

This document, in conjunction with ISO 11297-1 and ISO 11296-4, specifies requirements and test methods for cured-in-place pipes and fittings used for the renovation of hydraulically and pneumatically pressurized underground drainage and sewerage networks with service temperatures up to 50 °C.

It applies to independent (fully structural, class A) and interactive (semi-structural, class B) pressure pipe liners, as defined in ISO 11295, which do not rely on adhesion to the existing pipeline.

It applies to the use of various thermosetting resin systems, in combination with compatible fibrous carrier materials, reinforcement, and other process-related plastics components (see 5.1).

It does not include requirements or test methods for resistance to abrasion, cyclic loading or impact, which are outside the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 7432, *Glass-reinforced thermosetting plastics (GRP) pipes and fittings - Test methods to prove the design of locked socket-and-spigot joints, including double-socket joints, with elastomeric seals*

ISO 7509, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Determination of time to failure under sustained internal pressure*

ISO 8521:2009, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes — Test methods for the determination of the apparent initial circumferential tensile strength*

ISO 8533, *Plastics piping systems for pressure and non-pressure drainage and sewerage — Glass-reinforced thermosetting plastics (GRP) systems based on unsaturated polyester (UP) resin — Test methods to prove the design of cemented or wrapped joints*

ISO 10467:—[1)], *Plastics piping systems for drainage and sewerage with or without pressure — Glass-reinforced thermosetting plastics (GRP) based on unsaturated polyester resin (UP) — Specifications for pipes, fittings and joints*

ISO 10928, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Methods for regression analysis and their use*

ISO 10952, *Plastics piping systems — Glass-reinforced thermosetting plastics (GRP) pipes and fittings — Determination of the resistance to chemical attack for the inside of a section in a deflected condition*

ISO 11295:2017, *Classification and information on design and applications of plastics piping systems used for renovation and replacement*

1) To be published. (Revises ISO 10467:2004)

ISO 11296-4:2018, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks — Part 4: Lining with cured-in-place pipes*

ISO 11297-1:2018, *Plastics piping systems for renovation of underground drainage and sewerage networks under pressure — Part 1: General*

ISO 14125:1998, *Fibre-reinforced plastic composites — Determination of flexural properties*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11297-1 and ISO 11296-4 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1 General

No additional definitions apply.

3.2 Techniques

No additional definitions apply.

3.3 Characteristics

3.3.1
projected failure pressure at 50 years
p_{50}
value at 50 years derived from the pressure regression line obtained from long-term pressure tests performed in accordance with ISO 7509 and analysed in accordance with ISO 10928

[SOURCE: ISO 10467:—, 3.12.10]

3.3.2
minimum failure pressure at 50 years
$p_{50,min}$
95% lower confidence level (LCL) of the failure pressure at 50 years

[SOURCE: ISO 10467:—, 3.12.7]

3.4 Materials

No additional definitions apply.

3.5 Product stages

No additional definitions apply.

3.6 Service conditions

3.6.1
PN
nominal pressure
alphanumeric designation for a nominal pressure class, which is the maximum sustained hydraulic internal pressure for which a pipe is designed in the absence of other loading conditions than internal pressure

Note 1 to entry: Nominal pressure is expressed in bars (i.e. 1 bar = 0,1 MPa = 0,1 N/mm^2 = $10^5 \cdot N/m^2$).

Note 2 to entry: The designation for reference or marking purposes consists of the letters PN plus a number.

[SOURCE: ISO 10467:—, 3.12.2, modified — the last part of the definition has been deleted for simplification.]

4 Symbols and abbreviated terms

4.1 Symbols

d_i	inside diameter
E_0	short-term flexural modulus
E_x	long-term flexural modulus at *x* years
$e_{c,min}$	minimum wall thickness of composite at any point
p_{50}	projected failure pressure at 50 years
$p_{50,min}$	minimum failure pressure at 50 years
S_0	initial specific ring stiffness
$\alpha_{x,\,dry}$	dry creep factor at *x* years
$\alpha_{x,\,wet}$	wet creep factor at *x* years
ε_{fb}	flexural strain at first break
σ_{fb}	flexural stress at first break
σ_L	ultimate longitudinal tensile stress
σ_x	long-term flexural strength at *x* years

4.2 Abbreviated terms

CIPP	Cured-in-place pipe
GRP	Glass-reinforced thermosetting plastics
LCL	Lower confidence limit
PET	Poly(ethylene terephthalate)
PN	Nominal pressure

5 Pipes at the “M” stage

5.1 Materials

Lining tube materials shall conform to the requirements of ISO 11296-4:2018, 5.1.

5.2 Characteristics

Colouration may be used for resin mix and/or impregnation control, subject to any national restrictions on choice of colour as specified in ISO 11297-1.

Material, geometric, mechanical, physical and jointing characteristics shall comply with the requirements of ISO 11296-4:2018, 5.3 to 5.7, respectively.

5.3 Marking

The marking shall conform to ISO 11297-1:2018, 5.8. It shall be applied to the outside of the lining tube as delivered to the installation site or, in the case of pre-packaged lining tubes, on the outside of the packaging.

For compliance with ISO 11297-1:2018, 5.8 c), the dimension marked shall be the nominal outside diameter.

For compliance with ISO 11297-1:2018, 5.8 d), the dimension marked shall be the nominal CIPP wall thickness.

For compliance with ISO 11297-1:2018, 5.8 f), the manufacturer's information shall enable identification of the lining tube structure and (if pre-impregnated) the resin system used.

6 Fittings at the “M” stage

GRP flange adapters used for end connections to class A and class B liners shall conform to the requirements of ISO 10467.

NOTE 1 This clause specifies fittings of plastics materials applicable to connecting and sealing the CIPP liner to the network. Metallic fittings principally comprising metallic components and elastomeric seals are specified in Clause 7, tests on pipe-fitting assemblies are covered in Clause 8, and system-related installation procedures, e.g. for making load-bearing and non-load bearing end connections, are covered in Clause 9.

NOTE 2 Attention is drawn to the distinct end-sealing requirements for interactive (class B) and independent (class A) pressure pipe liners, as defined in ISO 11295.

7 Ancillary components

Where fittings comprising metallic and/or elastomer end seals, flange adaptors or couplings are used, full details including applicable reference standards shall be documented in the installation manual.

8 Fitness for purpose of the installed lining system at the “I” stage

8.1 Materials

The pipe and any fittings may consist of different mutually compatible material components selected from the ranges defined in 5.1 and Clause 6.

Adhesives used to fix and/or seal the CIPP liner to GRP or metallic components shall be compatible with the resin system of the liner.

The nature of the bond of any semi-permanent internal membrane to the underlying composite shall be such as to prevent large pieces becoming detached and risking blockage of the sewer as a result of abrasion or jetting in service.

NOTE This document does not specify requirements for any end product functions of internal membranes (see ISO 11296-4:2018, Annex A).

The material class of the composite in accordance with ISO 14125:1998, Table 3 shall be declared.

8.2 General characteristics

A feature of cured-in-place pipes is that they generally conform to the surface features of the existing pipeline. At bends and at irregularities in the existing pipeline, including local reductions of internal perimeter, folding can occur. Such folding has potential impacts on both hydraulic and structural performance of CIPP designed for pressure applications.

For hydraulic performance, the CIPP shall not introduce surface irregularities in addition to those of the existing pipeline, which exceed 2 % of the nominal diameter or 6 mm, whichever is the greater.

NOTE 1 This requirement can be changed, where appropriate, to meet hydraulic performance requirements of the lined pipe.

NOTE 2 For structural performance, the effect of folding depends on the type and degree of reinforcement of the lining tube, and whether the installed liner is designed to act as an independent or interactive pressure pipe liner.

For pressure pipe liners in general, the installation process shall not introduce any folds or displacements of the reinforcing layers which reduce the strength of the cured composite below the value declared for design in either hoop or longitudinal direction.

The lining system supplier shall declare the minimum longitudinal radius that the system is capable of negotiating without generating such strength reducing folds, taking account of all relevant parameters.

By definition for interactive pressure pipe liners (class B according to ISO 11295:2017, Table 1), the radial expansion of the liner when subject to the mean operating pressure shall be sufficient to close any initial annular gap which can result from the installation process.

NOTE 3 Thermal shrinkage of a CIPP liner, when cooled from its curing temperature to ambient temperature, usually produces a small initial uniform annular gap. Annular gaps can also arise on the outside of the liner at bends depending on the stretch characteristics of the lining tube.

8.3 Material characteristics

Resin cure shall be demonstrated by conformity to 8.5.

8.4 Geometric characteristics

8.4.1 General

NOTE The likelihood of local folding of CIPP at bends, changes of cross-section or stepped joints in the existing pipe (see 8.2) can affect the minimum free bore attainable in the renovated pipeline.

8.4.2 CIPP wall structure

The specification and verification of the wall structure shall conform to ISO 11296-4:2018, 8.4.2.

8.4.3 Wall thickness

When measured in a laboratory in accordance with the relevant test method specified, the wall thickness of the installed pipe shall conform to the requirements of Table 1.

NOTE Wall thickness measured along the cut edge of the CIPP at points of access might not be representative of the main body of the liner.

Table 1 — Geometric characteristics

Characteristic	Requirement	Test method
Minimum wall thickness, $e_{c,min}$, of the composite	Not less than the design thickness or 3 mm, whichever is greater	ISO 11296-4:2018, B.4.1

8.5 Mechanical characteristics

8.5.1 Reference conditions for testing

The requirements of ISO 11296-4:2018, 8.5.1 apply.

8.5.2 Test requirements

When tested in accordance with the methods given in Tables 2 and 3, the mechanical characteristics of pipe samples taken from actual or simulated installations in accordance with 8.8 shall conform to these tables. Where requirements are specified in Tables 2, 3, and 4 as declared values, these declarations shall be documented for each CIPP product, with supporting test data or references to such data, in the installation manual for that product.

Table 2 — Short-term mechanical characteristics of pipes

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Initial circumferential tensile wall strength	Declared value in N/mm, i.e. ultimate circumferential tensile force per unit length of pipe	In accordance with ISO 10467:2018, 5.3.6, limited to method A		ISO 8521:2009, Method A
Initial specific ring stiffness, S_0	Declared value, but not less than 750 N/m^2 [a]	In accordance with ISO 11296-4:2018, Table 5		
Short-term flexural modulus[b], E_0	Declared value in MPa			
Flexural stress at first break[b], σ_{fb}	Declared value in MPa			
Flexural strain at first break[b], ε_{fb}	Declared value but not less than 0,75 %			
Ultimate longitudinal tensile stress, σ_L	Declared value in MPa	In accordance with ISO 11296-4:2018, Table 5		
Ultimate elongation	Declared value but not less than 1,0 %			

[a] The minimum required value may be reduced where the surge pressure is higher than 20 kPa absolute (−80 kPa gauge pressure). The absolute minimum ring stiffness shall be 250 N/m^2.

[b] To be tested in circumferential direction and, if required, also in the longitudinal direction.

Table 3 — Long-term mechanical characteristics of pipes

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Long-term failure pressure[a,b], $p_{50,min}$	Declared value but not less than 0,25 MPa (2,5 bar)[c]	End caps Number and free length of the test pieces Environmental fluid: — external: — internal: Test piece diameter and construction	Type 1 or Type 2 ISO 10467:—, 5.3.7.3 and 5.3.7.4 Water or air Water See footnote[d]	ISO 7509 with extrapolation and determination of 95 % LCL according to ISO 10928 (see Figure 2)
Dry creep factor[e], $\alpha_{x,\,dry}$	Declared value	In accordance with ISO 11296-4:2018, Table 6		
Long-term flexural modulus under dry conditions[e], $E_{x,\,dry}$	Declared value in MPa			
Wet creep factor[e], $\alpha_{x,\,wet}$	Declared value			
Long-term flexural modulus under wet conditions[e], $E_{x,wet}$	Declared value in MPa			
Long-term flexural strength under dry conditions[f], $\sigma_{x,\,dry}$	Declared value in MPa at 50 years	Composition of test liquid Relative humidity Direction of testing	None (50 ± 5) % Longitudinal	ISO 11296-4:2018, Annex D
Long-term flexural strength under wet conditions[f], $\sigma_{x,\,wet}$	Declared value in MPa at 50 years	Composition of test liquid Direction of testing	Water Longitudinal	ISO 11296-4:2018, Annex D

a The allowable operating pressure is given by PFA = $p_{50,min}/2$.

b To express $p_{50,min}$ as a circumferential force per unit length as in the case of short-term test according to ISO 8521:2009, Method A, apply the formula, $F = p \cdot d_i/2$.

c The minimum value of 2,5 bar is for the purposes of type testing only.

d Test pieces shall be representative of a given CIPP pressure liner construction for which a validated calculation method for extrapolating failure pressures to other sizes and/or constructions shall be available from the manufacturer.

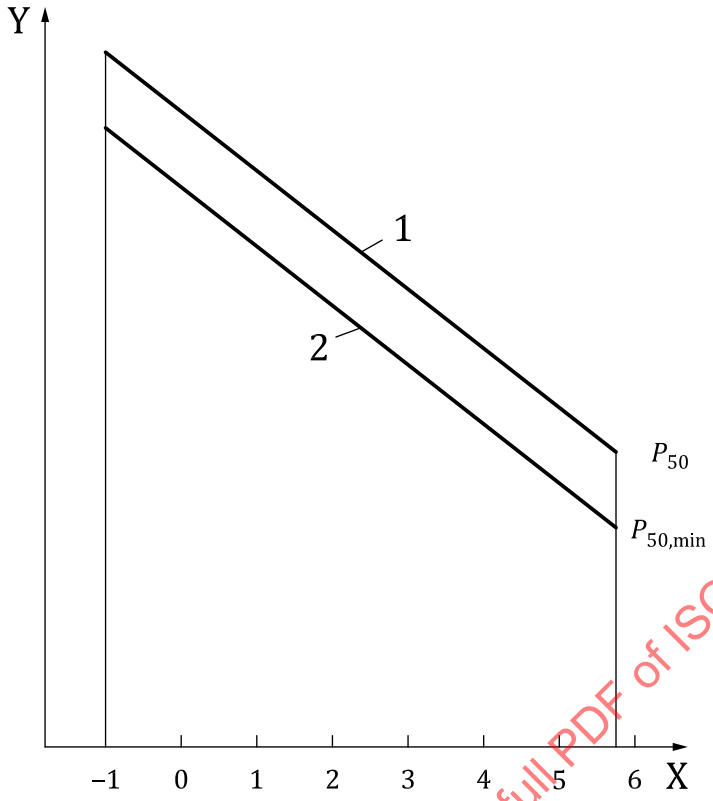
e It is expected that only one of these methods of creep testing (ring test or 3-point flexural test, dry or wet) will be applied, according to national preferences.

f It is expected that only one of these methods of long-term strength testing (dry or wet) will be applied, according to national preferences.

NOTE 1 The dry creep factor referred to in Table 4 is the inverse of the creep ratio for thermoplastics liner pipes defined in ISO 11297-3. To compare the creep performance of CIPP with that of a thermoplastics liner pipe, an equivalent creep ratio at x years for CIPP can be computed simply as $1/(\alpha_{x,\,dry})$.

NOTE 2 To enable an independent pressure pipe liner to conform to the Class A requirement, according to ISO 11295:2017, Table 1, of capability to survive failure of a brittle existing pipeline, it can be necessary to use an external membrane or other measures to ensure that the liner does not bond to the host.

NOTE 3 Where acid resistance is required, a re-rating factor on $p_{50,min}$ can be obtained from the ratio of long-term flexural strength under acid conditions (see Table 4) to the long-term flexural strength under wet conditions (see Table 3).



Key

X	log (time in hours)
Y	log (pressure)
1	mean regression line
2	95 % LCL line
p_{50}	projected failure pressure at 50 years (= 438 000 h)
$p_{50,min}$	minimum failure pressure at 50 years

Figure 2 — Derivation of long-term failure pressure

8.6 Physical characteristics

There are no requirements for physical characteristics of the installed lining system.

8.7 Additional characteristics

8.7.1 Resistance to strain and stress corrosion

When tested in accordance with the methods given in Table 4, the resistance of the CIPP to chemical attack under constant deflection (strain corrosion resistance) and its long-term flexural strength under acid conditions (stress corrosion resistance) shall conform to the requirements stated in Table 4.

The test temperature and pre-conditioning specified in ISO 11296-4:2018, 8.5.1 also apply here.

NOTE If the carrier material/reinforcement consists entirely of fibres of PET, testing experience indicates that no strain corrosion failure occurs.

Table 4 — Resistance to strain and stress corrosion

Characteristic	Requirement	Test parameter		Test method
		Parameter	Value	
Resistance to chemical attack in a deflected condition	Minimum extrapolated failure strain at 50 years: declared value but not less than 0,45 %	Composition of test liquid	0,5 mol/l sulfuric acid	ISO 10952
		Number of test pieces	18	
		Test piece length for:		
		$d_n \leq 300$ mm	$d_n \pm 5$ %	
		$d_n > 300$ mm	300 mm ± 5 %	
		Test piece diameter	150 mm ≤ d_n ≤ 400 mm	
		Time to which the extrapolated value is to be calculated	50 years	
Long-term flexural strength under acid conditions, $\sigma_{x,acid}$	Declared value in MPa at 50 years	Composition of test liquid	0,5 mol/l sulfuric acid	ISO 11296-4:2018, Annex D
		Direction of testing	Longitudinal	
NOTE The relevance of these tests depends on the liner design conditions but it would normally be expected that either one or the other is carried out.				

8.7.2 Leak tightness of liner terminations

When tested in accordance with the methods given in Table 5, the liner terminations, regardless of type as described in 9.7, shall conform to the requirements stated in Table 5.

Table 5 — Leak tightness of liner terminations

Characteristic	Requirement	Test parameter		Test method
		Parameter	Value	
Initial leak tightness	No leakage	Test pressure	1,5 × PN	ISO 7432 or ISO 8533 as applicable
		Time	15 min	
External pressure differential	No leakage	Test pressure	−80 kPa	ISO 7432 or ISO 8533 as applicable
		Time	1 h	

8.8 Sampling

Simulated installations used to produce samples for type testing shall be executed in accordance with ISO 11296-4:2018, 9.4.3.

Off-cut samples for installation quality control should preferably be formed by confining an otherwise free section of liner during inflation and cure to the same perimeter as the pipe being lined. Where possible, such supported samples shall be formed at an intermediate access point in preference to one or other end of the overall installation.

Any other method of acquiring non-destructive off-cut samples shall be documented in the installation manual and supported by test data demonstrating that the relevant characteristics of such samples do not systematically exceed those of samples cut from the actual pipe wall.

9 Installation practice

9.1 Preparatory work

Site preparation required for installation of specific CIPP lining techniques shall be documented in the installation manual.

NOTE For general guidance on preparatory work, see ISO 11295.

9.2 Storage, handling and transport of pipe components

Raw materials shall be stored and used in accordance with the recommendation of their respective manufacturers. The liner shall be stored, impregnated and transported under conditions which do not impair performance of the as-installed product in such a way as to prevent conformity to this document.

9.3 Equipment

All technique specific equipment shall be documented in the installation manual, in accordance with the requirements of ISO 11296-4:2018, 9.3.

9.4 Installation

Environmental precautions, installation procedures and production of representative "I" stage samples for type testing shall conform to ISO 11296-4:2018, 9.4.

9.5 Process-related inspection and testing

Process-related inspection and testing shall conform to ISO 11297-1:2018, 9.5.

9.6 Lining termination

The lining termination shall prevent the cut edges of the composite becoming exposed to either the effluent in the pipe or to groundwater.

NOTE The method of lining termination generally depends on the method of reconnection to the existing pipeline system as documented in the installation manual.

9.7 Reconnections to the existing pipeline system

The ends of the liner shall be reconnected to the existing pipeline system by one of the following methods:

a) attaching a flange adapter or other coupling directly to the liner pipe independent of the host;

b) sealing the liner pipe internally either to the existing pipeline (interactive liners only) or to a new spool piece attached to or anchored independently from the existing pipeline.

The detailed method of reconnection is technique-specific and shall be documented within the installation manual.

9.8 Final inspection and testing

Final inspection and testing shall conform to ISO 11297-1:2018, 9.8. For CIPP, an internal visual inspection of the installed lining system shall be undertaken in all cases.

