2026
TRENCHLESS
MOROCCO

RECOMMANDATIONS ASTEE POUR LA CONCEPTION DES REVÊTEMENTS DE TUYAUX SOUS PRESSION

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TRENCHLESS WORKS

Recommendations for the Design of Pressure Pipe Liners

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The French quality assurance system for cured in place liners (CIPP)


Cahier des clauses techniques générales applicables aux marchés publics de travaux de génie civil

Fascicule 71

Fourniture, pose et réhabilitation de canalisations d'eaux à écoulement sous pression

Version 3.02 – Mars 2019

Version définitive approuvée par le COPIL « EAU-ASSAINISSEMENT » du Référentiel Génie Civil

Ce document a vocation à remplacer le fascicule n°71 actuel, dés lors qu'il aura été signé par le ministère de la transition écologique et solidaire et le ministère de l'économie et des finances.

Fascicule 71 fixes the rules for pressure water and sewerage pipes (Fascicule 70 is for gravity ones)

It clarifies all the requirements at each steps of a project :

- Quality of materials
- Design
- Installation
- Inspection and acceptance of works

In France, technical specifications for public contracts covering new installation and rehabilitation of pipelines in France, ask for specific product evaluation.

The French quality assurance system for cured in place liners (CIPP)

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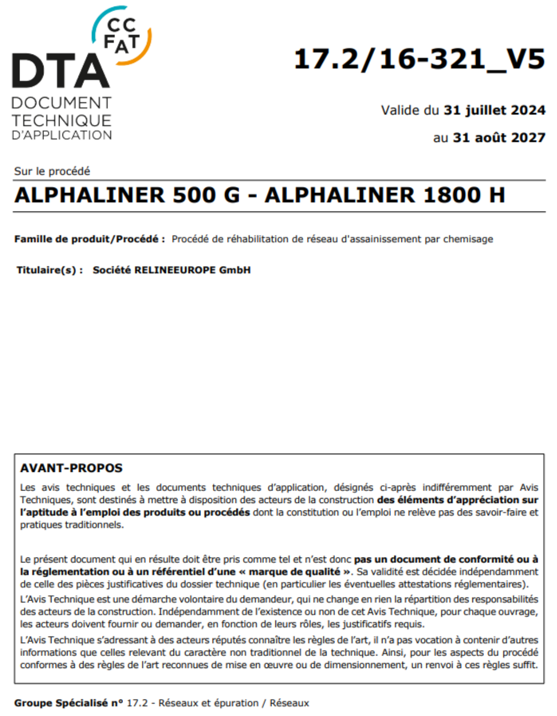
DTA
DOCUMENT TECHNIQUE D'APPLICATION

GOUVERNEMENT

Technical application document (DTA)
A Technical application document is an approval delivered by a group of industry/public Experts members of the committee CCFAT.

The approach is voluntary, and the committee is responsible for processing and issuing the DTA under the authority of the Minister responsible for construction, by decree of March 21, 2012.

In France technical specifications for public contracts as per Fascicule 70 & 71 covering new installation and rehabilitation of pipelines in France, have maken the DTA compulsory for CIPPs.


DTA DOCUMENT TECHNIQUE D'APPLICATION

17.2/16-321_V5

Valide du **31 juillet 2024**
au **31 août 2027**

Sur le procédé
ALPHALINER 500 G - ALPHALINER 1800 H

Famille de produit/Procédé : Procédé de réhabilitation de réseau d'assainissement par chemisage

Titulaire(s) : **Société RELINEEUROPE GmbH**

AVANT-PROPOS

Les avis techniques et les documents techniques d'application, désignés ci-après indifféremment par Avis Techniques, sont destinés à mettre à disposition des acteurs de la construction **des éléments d'appréciation sur l'aptitude à l'emploi des produits ou procédés** dont la constitution ou l'emploi ne relève pas des savoir-faire et pratiques traditionnels.

Le présent document qui en résulte doit être pris comme tel et n'est donc **pas un document de conformité ou à la réglementation ou à un référentiel d'une « marque de qualité »**. Sa validité est décidée indépendamment de celle des pièces justificatives du dossier technique (en particulier les éventuelles attestations réglementaires).

L'Avis Technique est une démarche volontaire du demandeur, qui ne change en rien la répartition des responsabilités des acteurs de la construction. Indépendamment de l'existence ou non de cet Avis Technique, pour chaque ouvrage, les acteurs doivent fournir ou demander, en fonction de leurs rôles, les justificatifs requis.

L'Avis Technique s'adressant à des acteurs réputés connaître les règles de l'art, il n'a pas vocation à contenir d'autres informations que celles relevant du caractère non traditionnel de la technique. Ainsi, pour les aspects du procédé conformes à des règles de l'art reconnues de mise en œuvre ou de dimensionnement, un renvoi à ces règles suffit.

Groupe Spécialisé n° 17.2 - Réseaux et épuration / Réseaux

The French quality assurance system for gravity cured in place liners (CIPP)

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Suitability for use (fitness-for-purpose) of innovative construction processes

DTA DOCUMENT TECHNIQUE D'APPLICATION

Not only based on the product, but on the product implemented on the construction site.

Design

Mechanical + hydraulic

CIPP Production


DTA DOCUMENT TECHNIQUE D'APPLICATION

17.2/16-321_V5

Valide du 31 juillet 2024 au 31 août 2027

Sur le procédé

ALPHALINER 500 G - ALPHALINER 1800 H

AVANT-PROPOS

Compliance with productions control, by audits and feedback

Installation

CERTIFIÉ PAR CSTB NF

SYSTÈMES DE CANALISATIONS EN PLASTIQUE POUR LA RÉNOVATION DES RÉSEAUX D'ASSAINISSEMENT

Compliance with declared performance proven by certification (audit, test, machinery, training...)

Final checkings

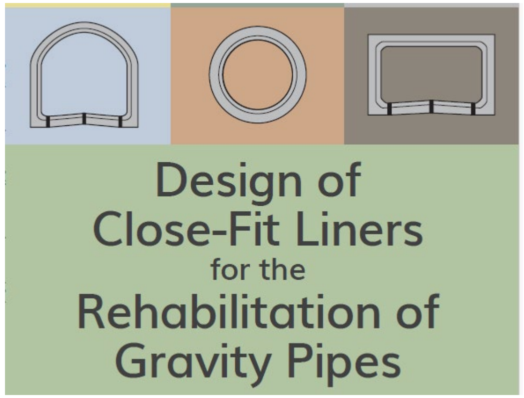
Guide méthodologique sur la réalisation de prélèvements d'échantillons représentatifs des travaux de réhabilitation sans tranchée par tubes polymérisés en place (chemisage)

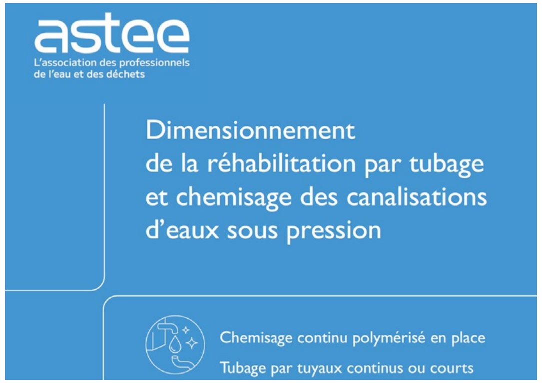
Application réseaux à écoulement libre

TV inspection, leak tests, and mechanical conformity (ISO 11296-4)

Design method - Background

- In 2014, a recommendation for design of circular and non-circular gravity pipe liners was published, along with calculation software (3R 2014).
- The software was well received by the industry and distributed by ASTEE in over 250 copies (in France and Canada).
- Method used by ASCE for drafting the MOP 145 published in sept 2021
- In 2023, it was decided to add the design of liners for pressure pipes along with calculation software.
- In 2025, the design method for pressure liners is published.
- In 2026, a software is available





Principles and originalities of the method

- The method incorporates the requirements of European standards, including Eurocodes (design standards) and thermoplastic product standards for pressure renovation (NF EN ISO 11297 and 11298).
- The method complies with the principles of "limit state" calculations (Eurocode 0), also call LRFD (Load and Resistance Factor Design) in North America.
- The method consists of checking the stability of the liner up to 9 limit states verified depending on the renovation technique and the host pipe state.
- The method calculates the effect of differential settlement on liners installed in segmented pipelines (a world first in this field!).
- The method includes seismic calculations of pressure liners installed in segmented pipeline (again a world first in this field!).

Conditions for applying the method

- The method is only applicable to straight sections of pipes.
- The method does not guarantee the resistance of any liner in the event of a major structural break of host pipe.
- The method does not cover failures resulting from certain geotechnical risks such as seismic faults, landslides, or soil liquefaction.
- A limited number of host pipe failure modes are covered including:
  - **Hole or crack** in the wall of the host pipe;
  - **Rotation of a joint/annular crack** under the effect of differential settlement;
  - **Expansion-contraction of a joint/annular crack** under the effect of a seismic wave.

Conditions for applying the method

- **The liners designed in this method must withstand internal pressure when tested independently of the host pipe.**
- They can be classified as A according to NF EN ISO 11295 (class IV according to AWWA M28), with a reservation regarding the ability to withstand failure of the host pipe.
- Class B liners are not allowed.

Table 16 — Structural classification of pressure pipe liners

Liner characteristics		Class A	Class B	Class C	Class D [a]
Independent pressure pipe liner	Fully structural				
	— Can survive internally or externally induced (burst, bending or shear) failure of host pipe	+			
	— Long-term pressure rating ≥ maximum allowable operating pressure (PFA) [b]	+			
Interactive pressure pipe liner	Semi-structural				
	— with inherent ring stiffness [c, d]		+		
	— with long-term hole and gap spanning at PFA [e]		+	+	

Rehabilitation techniques covered by the method

- **Rehabilitation techniques covered by the method are as follows:**
  - Lining with continuous pipes (with annular grout)
  - Lining with discrete pipes (with annular grout)
  - Lining with close-fit pipe
  - CIPP

- **The following techniques are excluded from the scope of the method:**
  - Lining with adhesive-backed hoses
  - Lining with inserted flexible liners
  - Lining with sprayed polymeric materials

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Design Basics

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Don't neglect (forget) the host pipe !

- The host pipe acts as a casing for the liner.
- The host pipe can provide radial support to the liner against negative pressure.
- The liner transfers typically 95% of the internal pressure to the host pipe!
- **The rehabilitated host pipe is still subject to the effects of pressure in the elbows, ends, and straight sections.**
- The host pipe supports and anchors are subject to the same forces as before rehabilitation.
- The host pipe continues to support loads due to the soil (gravity) or transmitted by the soil (traffic loads).

Design Basics

Design a liner ≠ design a buried pipe

- A much less stiff than host pipe liner is not subject to backfill installation forces or traffic loads.
- Spanning holes, cracks or joints under internal pressure can cause stresses that do not exist in a new pipe.
- The host pipe can impose deformations on the liner, which can result in very high strains/stresses that do not exist in a buried pipe.

Design Basics

The design method is based on Load and Resistance Factor Design (LRFD) principles

- The verification of a structure is based primarily on the observation of its **failure modes** (also called **ultimate limit states**) and on the use of calculation models adapted to each identified failure mode.
- Actions are increased and material strength are reduced by partial safety factors.
- **For each limit state, we verify that the effects of the factored actions remain lower than the reduced resistances.**

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Design Basics

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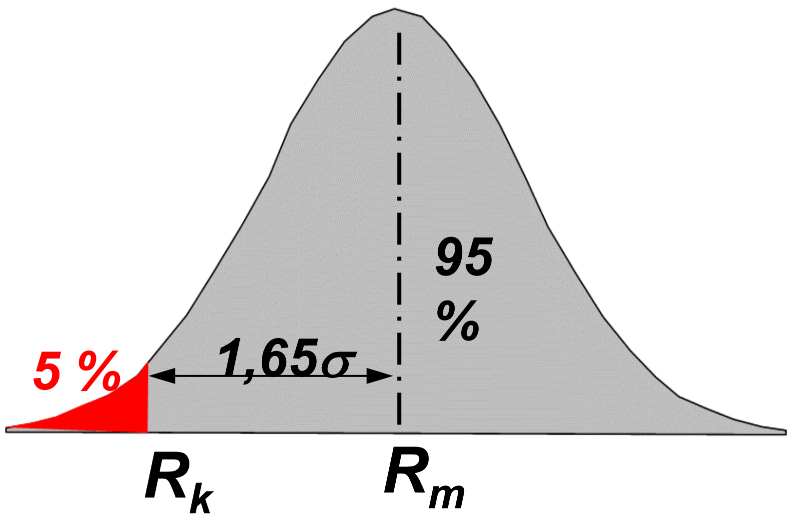
Characteristic Resistance

- Material properties/resistance are represented by **characteristic values** (5% fractile values or 90% Lower Confidence Limit)
- $\mathbf{R_k}$: value whose probability of being exceeded in the bad case scenario is less than 5%.
- Real job sites



Design Basics

Design Resistance

- Design resistance is used in equations.
- Design Resistance = Characteristic resistance / Material safety Factor

$$R_d = \frac{R_k}{\gamma_M}$$

Material properties	Type de réhabilitation	Material safety Factors γ_M
Flexural strength or tensile strength	Slip linings	**1,2**
	CIPP	**1,5**
Flexural modulus short-term or long-term	Slip linings, Close-fit or CIPP	**1,67**

Design Basics

Design Loads

- **Design load = Nominal load × Safety factor**

$$A_d = \gamma_A \cdot A_k$$

Load	Safety factors
Internal pressure	$\gamma_{Q,pi}$ = **1,20**
Vacuum (negative pressure)	$\gamma_{Q,dpi}$ = **1,20**
External groundwater pressure	$\gamma_{Q,we}$ = **1,20**
Ground pressure	$\gamma_{Q,inj}$ = **1,35**
Live loads	γ_Q = 1,5

Design Basics

Limit States

Ultimate limit states (ULS) = Failure or collapse of structure

Serviceability limit states (SLS) = Performance issues (deflection, vibration, durability…)

Design Basics

Limit States

9 ultimate limit states are covered by the calculation method:

- **LS1**: Resistance to internal pressure
- **LS2**: Resistance to internal vacuum and external water table pressure
- **LS3**: Spanning a circular hole under internal pressure
- **LS4**: Spanning a circumferential crack or joint under internal pressure
- **LS5**: Resistance to axial stresses due to thermal effects, the "Poisson" effect, or end thrust
- **LS6**: Ground movements: spanning a joint subjected to rotation under internal pressure
- **LS7**: Ground movements: spanning a joint subjected to axial expansion under internal pressure (Resistance to earthquake waves)
- **LS8**: resistance to loads applied by the soil to the host pipe
- **LS9**: Resistance to grout injection

Design Basics

Table of Limit States to be checked by type of rehabilitation

	LS1	LS2	LS3	LS4	LS5	LS6	LS7	LS8*	LS9
Lining with discrete pipes	X	X						X	X
Lining with continuous pipes	X	X			X			X	X
Lining with close-fit pipes	X	X	X	X	X	X	X	X	
Lining with cured-in-place pipes	X	X	X	X	X	X	X	X	

** Only for host state III.*

Design Basics

- **Checking of Limit States (LRFD requirements)**

Effect of the factored loads ≤ Factored Resistance

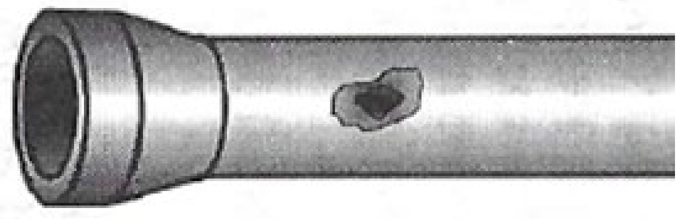
$$E\langle \gamma_A \cdot A_k \rangle \leq \frac{R_k}{\gamma_M}$$

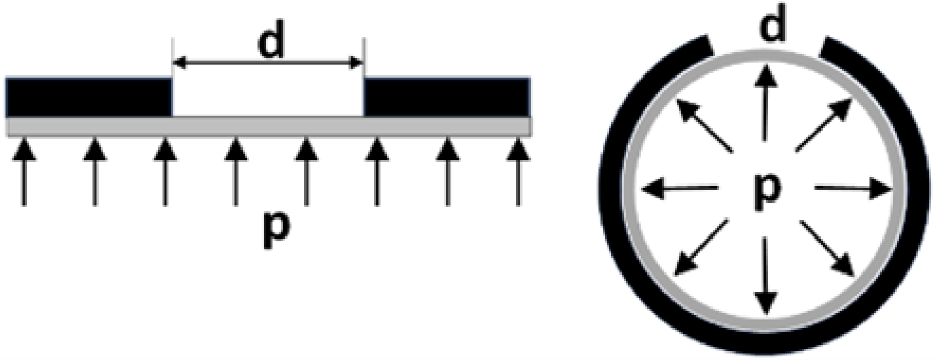
DCR = Demand Capacity Ratio = $\dfrac{\textbf{Effect of Factored Loads}}{\textbf{Factored Résistance}}$ **≤1.0**

LS examples

LS3 – Hole spanning

- Holes can be observed in aged grey cast iron pipe due to graphitization.
- Another case is that of a connection covered by the liner.
- The calculation model is that of a circular flat plate with built-in edge subjected to transverse pressure (ASTM F1216).
- The hole diameter is limited to the dimension shown in Eq. X1.5 (ASTM F1216).
- The default diameter is 30 mm, but a different value can be used (but limited to dMax).





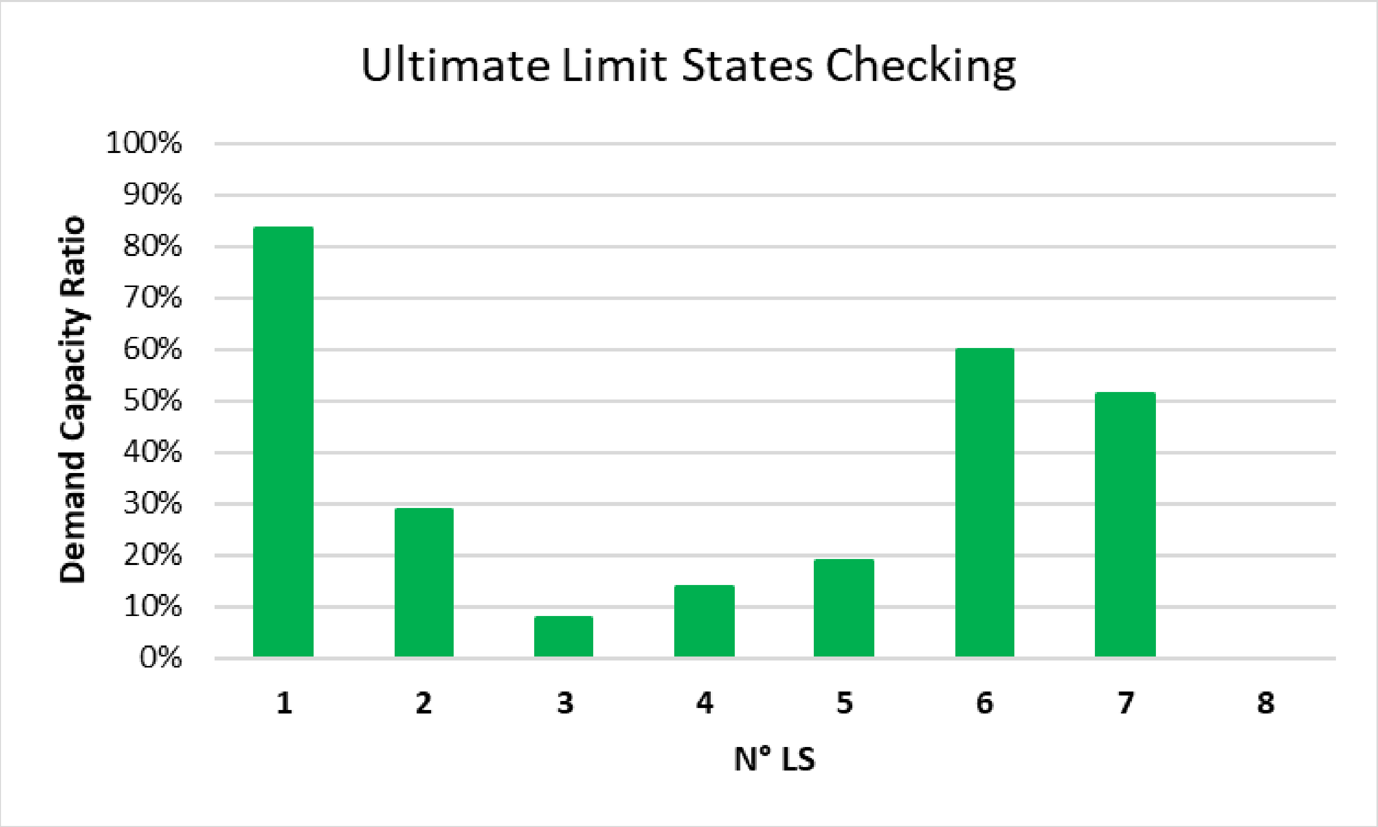
$$d_{Max} = 1{,}83 \cdot \mathrm{D} \cdot \left(\frac{e}{D}\right)^{1/2}$$

Eq X1.5 (ASTM 1216)

$$\frac{d_{Max}}{\mathrm{D}} \approx 33\% \text{ to } 43\% \text{ (DN500 to DN100)}$$

Design Basics

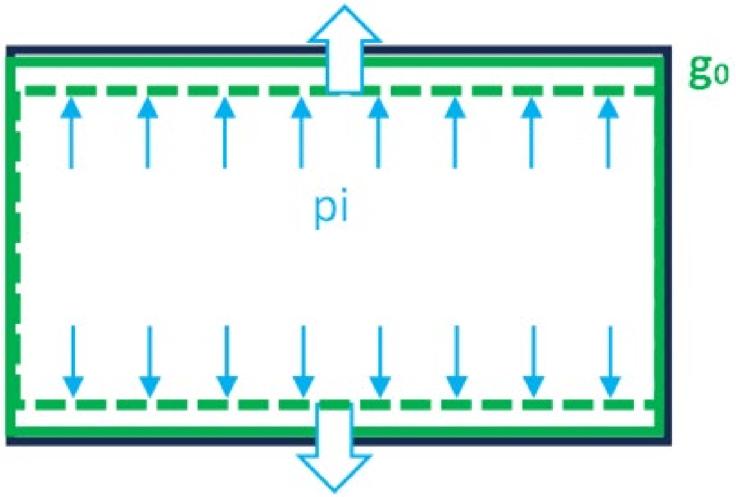
- **Example of Limit States checking for a pressure CIPP liner**



Conclusion

Key points:

- A liner even "fully structural" does not act alone. Its behavior depends strongly on its interaction with the host pipe. The internal pressure locks the liner onto the host pipe.
- Deformations imposed by the host pipe (due to settlement or seismic waves) can cause high axial stresses in a liner, mainly due to internal pressure inducing axial shear stresses.
- Therefore, it is important to measure the axial characteristics (strength and moduli) of liners and not just the circumferential characteristics.



Conclusion

Key points:

- A software is available (ASTEE production)