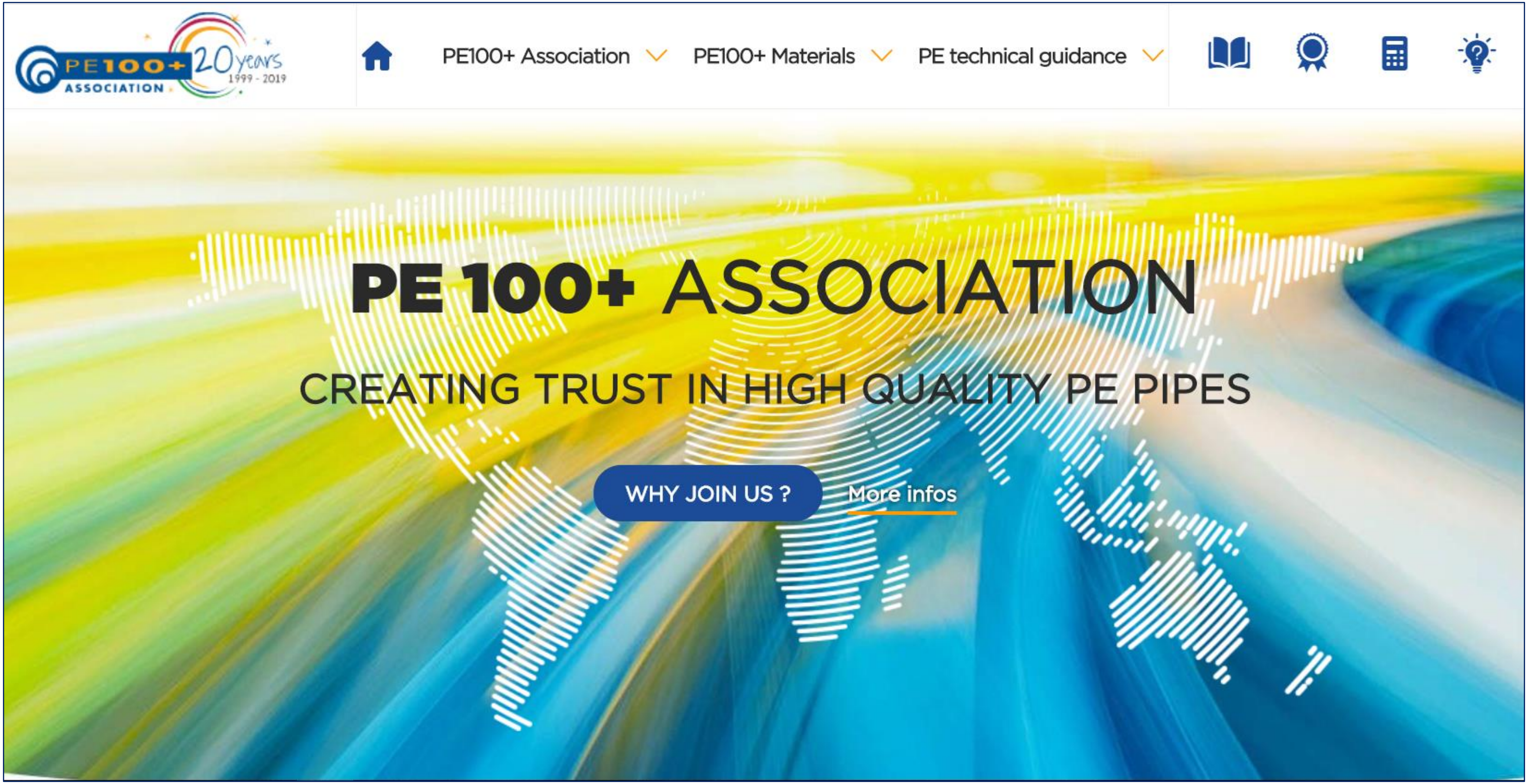
The Design and Application of PE100 Pipe in Trenchless Technologies for New Installation and Rehabilitation - Aspects of New Materials and Support via Online Guide and Tool

P. Schneider, A. Wedgner, T. Sangster
PE100+ Association

Contents

- An brief introduction to the PE100+ Association
- How to classify the different trenchless systems that employ PE pipes and liners?
- PE100-RC materials for challenging trenchless applications
- Measuring the resistance of PE100 and PE100-RC materials to SCG
- The PE100+ Association online No-Dig Technical Guide
- Incorporation of PE100-RC materials in the ISO and EN standards
- Conclusion

A brief introduction to the PE100+ Association



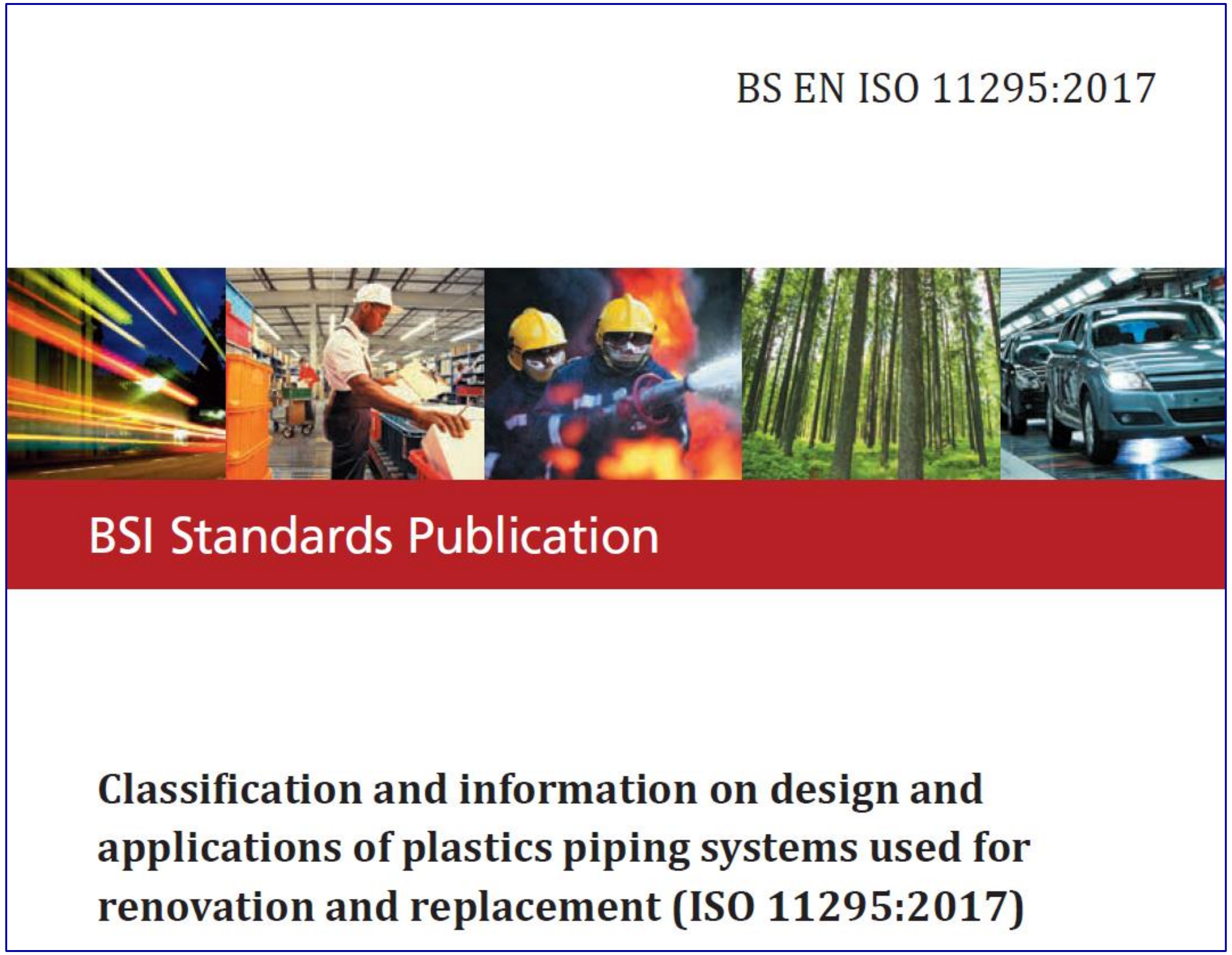
PE100+ Association: The production, testing and listing of consistently high quality PE100 materials

- Founded on Feb. 24, 1999, the PE100+ Association is an industry organisation of 12 polyethylene (PE) manufacturers whose objective is to promote consistent quality at the highest level in the production and the use of polyethylene for PE100 pipes.
- The association funds the KIWA managed 3rd party laboratory testing of PE100 pipes samples produced by member companies on a regular basis.
- Supported by an advisory committee and working closely with other plastic pipe, standards and utility bodies to promote the proper specification, design and use of high quality PE100 pipe systems

How to classify the different trenchless systems that employ PE pipes and liners?

EN ISO 11295 provides a guide to the different trenchless techniques and some standardisation

- Many of the systems use methods that were developed by specialist companies in different countries
- Historically companies frequently used different descriptions and buzz words to describe their systems and differentiate themselves from competitors
- Using the classifications given in ISO 11295 helps End Users to clearly specify systems
- **The PE100+ on-line guide draws on the contents of the standard**


BS EN ISO 11295:2017

BSI Standards Publication

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

The 2017 revision now covers pipe bursting and other trenchless replacement techniques

Status of the BS EN ISO 11295 family of renovation and replacement standards

Parts Description	Sewer EN ISO 11296	Pressure Sewer EN ISO 11297	Water Main EN ISO 11298	Gas Main EN ISO 11299
1: General	Published	Published	Published	Published
2: Continuous Pipes	Published	Published	Published	Published
3: Close Fit Pipes	Published	Published	Published	Published
4: Cured In-place Pipes	Published	Published	Drafting	
5: Discrete Pipes				
6: Adhesive Backed Hoses				
7: Spirally-Wound Pipes	Published			
8: Pipe Segments				
9: Anchored Inner Layer				
10: Sprayed Polymeric Mats.				
11: Inserted Hoses				

EN ISO 21225 parts 1 and 2 covers pipe bursting, horizontal directional drilling and impact moling


BS EN ISO 21225-1:2018

BSI Standards Publication

Plastics piping systems for the trenchless replacement of underground pipeline networks

Part 1: Replacement on the line by pipe bursting and pipe extraction (ISO 21225-1:2018)

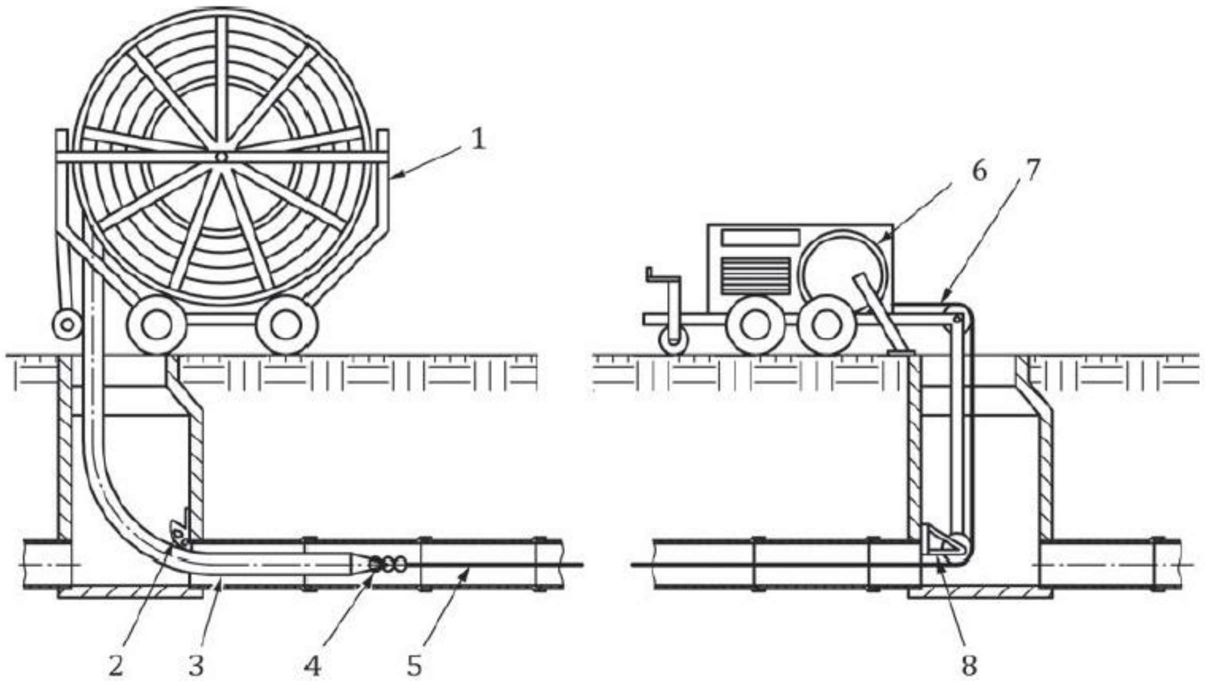

BS EN ISO 21225-2:2018

BSI Standards Publication

Plastics piping systems for the trenchless replacement of underground pipeline networks

Part 2: Replacement off the line by horizontal directional drilling and impact moling

The standards give descriptions of the different systems including helpful diagrams



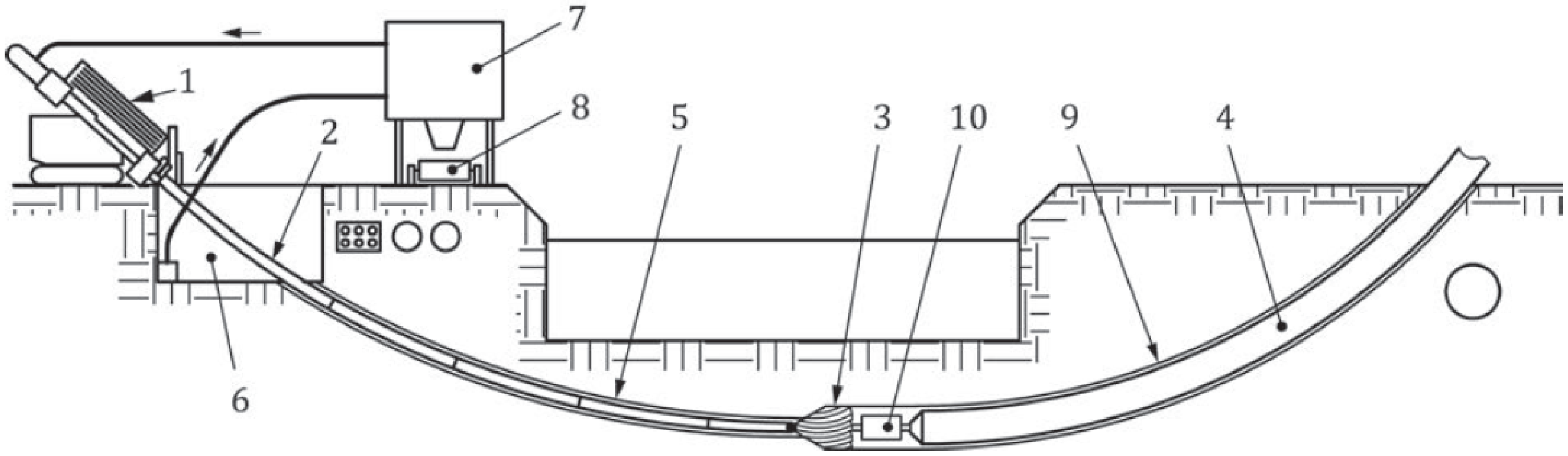
Key

1	drum trailer	4	pulling head	7	guide pulley
2	pipe guide	5	winch cable	8	bracing
3	lining pipe (folded)	6	winch		

NOTE Pipe reverted (unfolded) after insertion by application of heat and/or pressure.

Figure 3 — Lining with close-fit pipes — Schematic representation of installation of a pipe reduced in external dimension in the pipe manufacturing plant (Method A)

and give guidance on their materials, applications, performance and installation



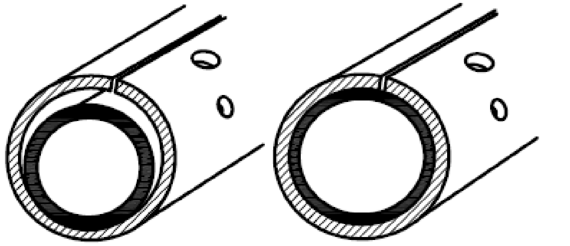
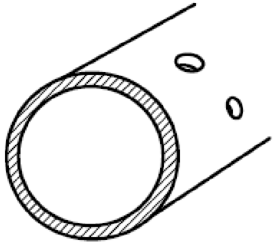
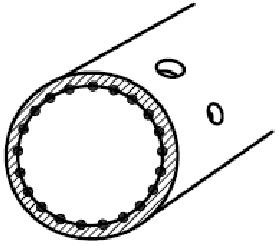
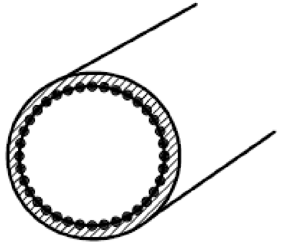
Key

1	drill rig	6	mud sump
2	drill string	7	mud recycling and spoil separation unit
3	back reamer	8	spoil skip
4	new pipe	9	final bore
5	pilot bore	10	spinner

Figure 23 — Schematic representation of replacement by horizontal directional drilling — Pipe installation

They also provides a system for classifying the pipe or liner structural performance

Table 17
Structural classification of pressure pipe liners and correspondence to technique families within the scape of the document (standard)

<table>
<tr><th colspan="2">Class A</th><th colspan="2">Class B</th><th>Class C</th><th>Class D</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td colspan="2">Independent</td><td colspan="4">Interactive</td></tr>
<tr><td colspan="2">Fully structural</td><td colspan="3">Semi-structural</td><td>Non-structural</td></tr>
<tr><td>Lining with continuous pipes</td><td colspan="4">—</td><td rowspan="6">This document is not applicable</td></tr>
<tr><td>Lining with discrete pipes</td><td colspan="4">—</td></tr>
<tr><td rowspan="3">—</td><td colspan="2">Lining with close-fit pipes</td><td colspan="2">—</td></tr>
<tr><td colspan="4">Lining with cured-in-place pipes</td></tr>
<tr><td colspan="2">—</td><td colspan="2">Lining with adhesive-backed hoses</td></tr>
<tr><td>—</td><td>—</td><td colspan="2">Lining with sprayed polymeric materials</td><td>—</td></tr>
<tr><td colspan="6">NOTE 1 Classification of lining with inserted hoses is yet to be determined, pending development of product standards for this technique family.
NOTE 2 Dots in illustrations for Classes C and D depict adhesion.</td></tr>
</table>

PE100-RC materials for challenging trenchless applications

Why do we need PE100 materials with very high resistance to slow crack growth (SCG)?

The problem

- Demanding installation techniques are increasingly used:
  - Open-trench without imported bedding
  - Directional drilling
  - Lining, relining and pipe bursting
- These create challenging conditions which lead to an increased risk of failure from slow crack growth initiated by external scratching / scoring and rock impingement (point-load).

The solution

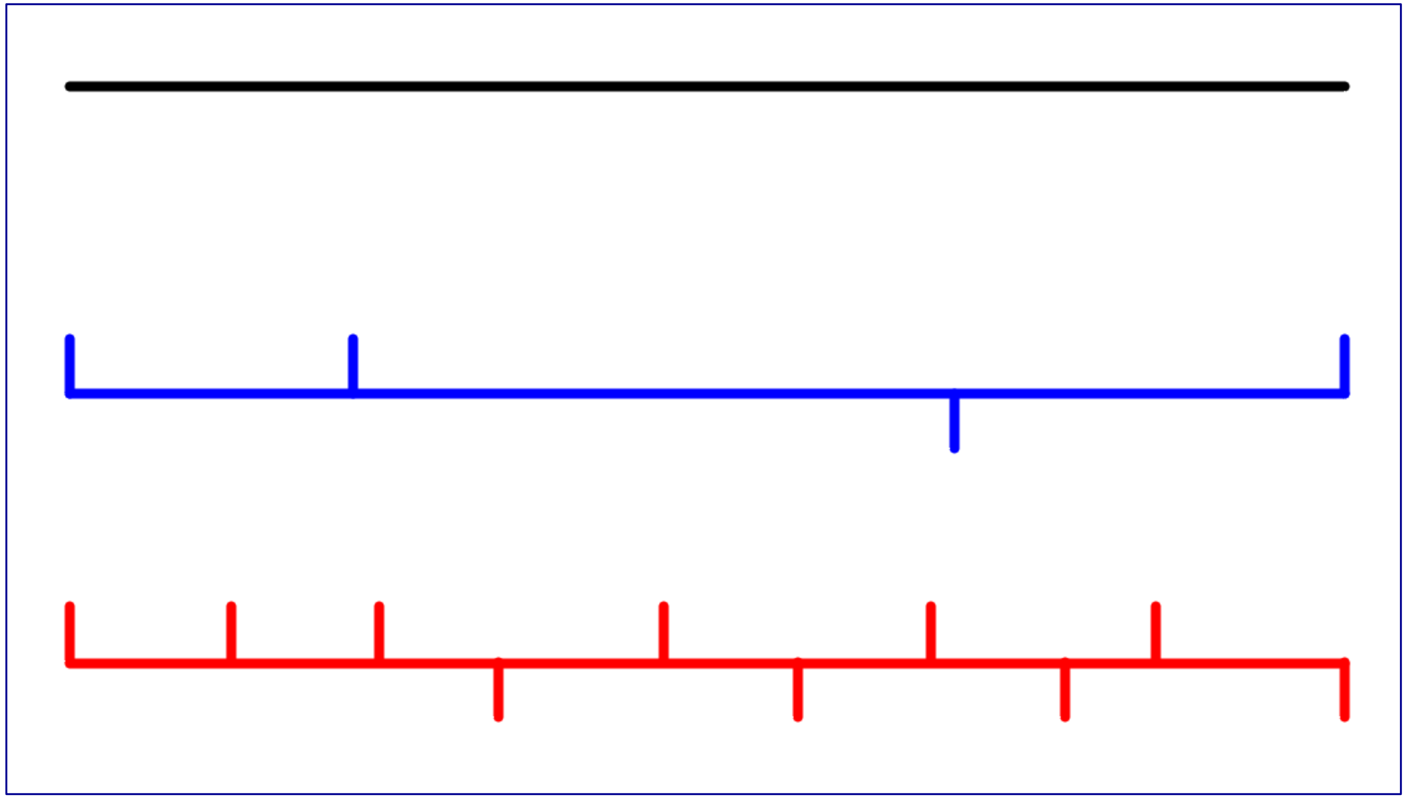
- PE industry developed resins with very high stress crack resistance, the PE100-RC grades

What makes the types of High Density polyethylene (HDPE) PE100 perform differently?

Single use HDPE
No side branches

Regular PE100
Some side branches

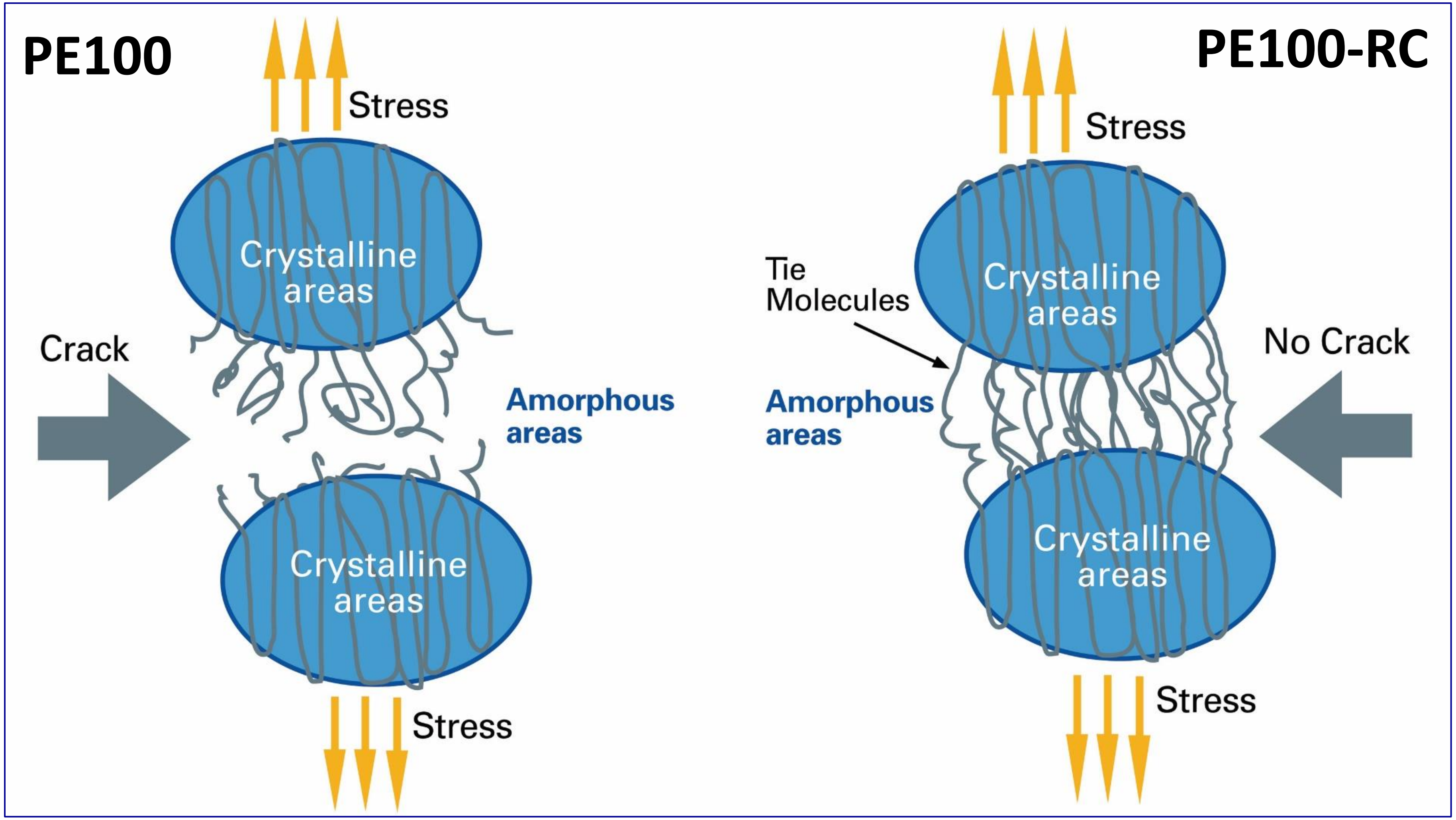
PE100-RC
More side branches



HDPE for single use applications is typically made from pure ethylene whilst regular PE100 uses butene or hexene to form the side branches which improve the stress crack resistance. PE100-RC materials have more side branches

The higher number of sides branches is the key difference

Side branches on tie molecules catch on each other as the stress pulls the resin apart at the crack tip, typically increasing time to failure by a factor of 10



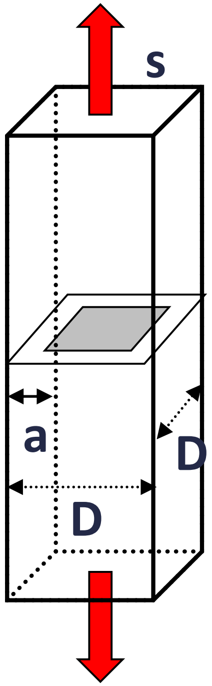
Measuring the resistance of PE100 and PE100-RC materials to SCG

The Full Notched Creep Test (FNCT) – ISO 16770

- Tensile creep test under constant load
- Result: Time to failure
- Failure mode must be brittle!

Acceleration by:

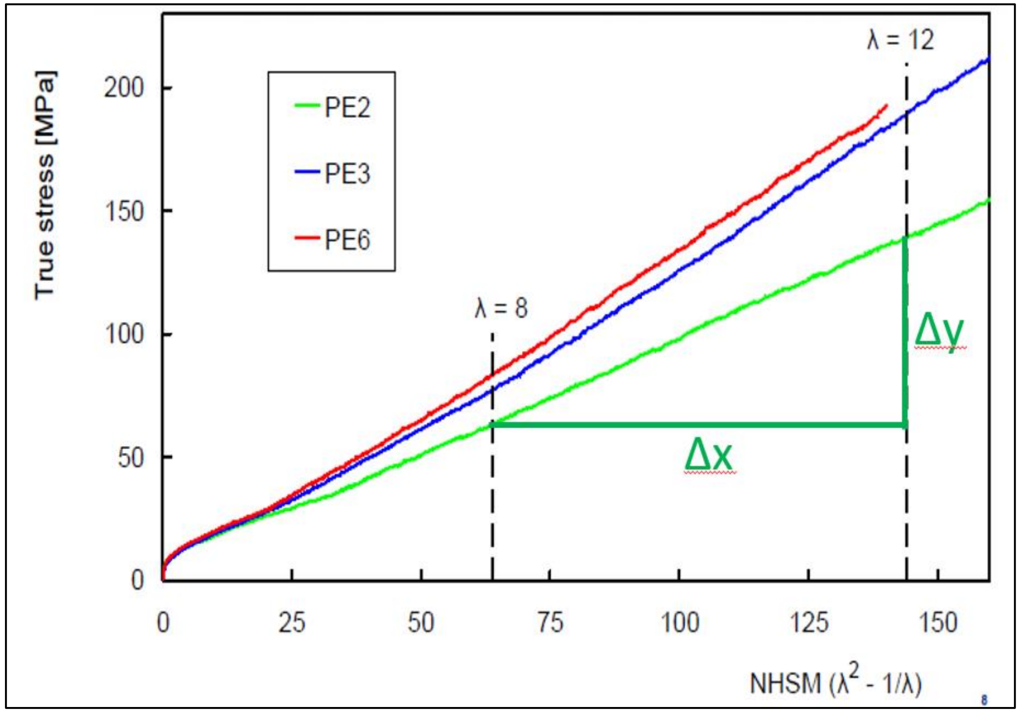
- Higher temperature
- Surfactant solutions

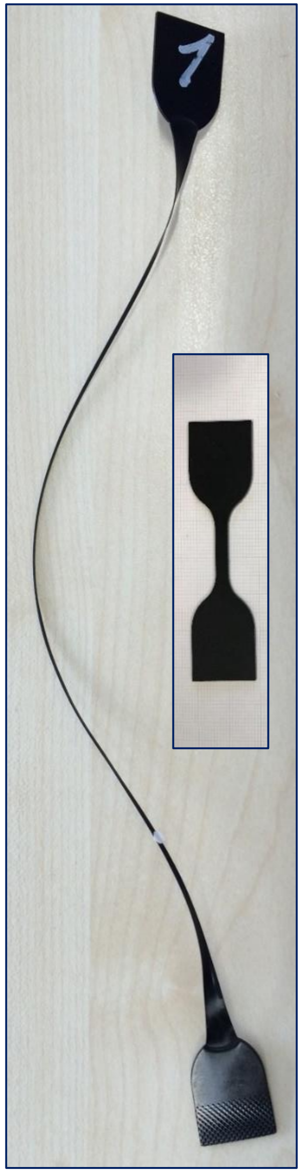


- Test specimen: 110x10x10mm
- Notch depth 1.6mm full circumference
- Stress = 4 MPa
- 2% Arkopal N100 or other surfactant solutions
- Temp. = 80 or 90°C

The Strain Hardening Test – ISO 18488

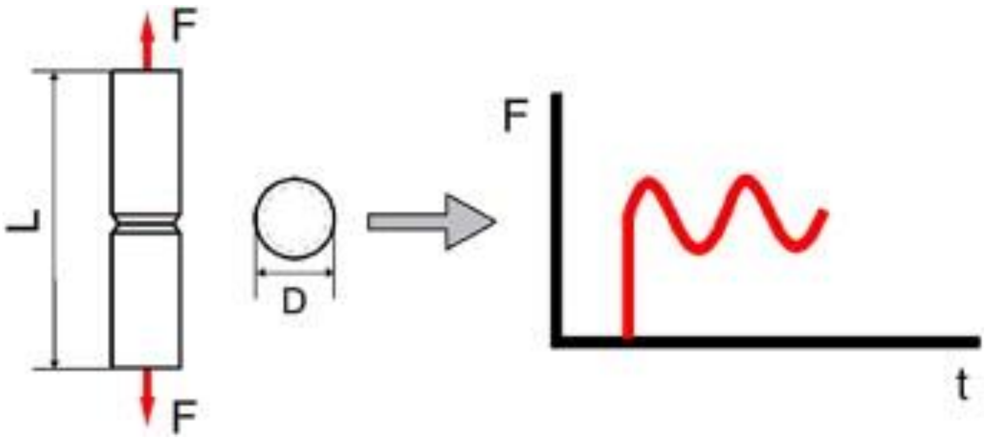
- Essentially a modified tensile test undertaken at 80°C
- Specimen thickness 0.3 or 1 mm
- **Strain hardening modulus <Gp>** is calculated from true strain stress curve



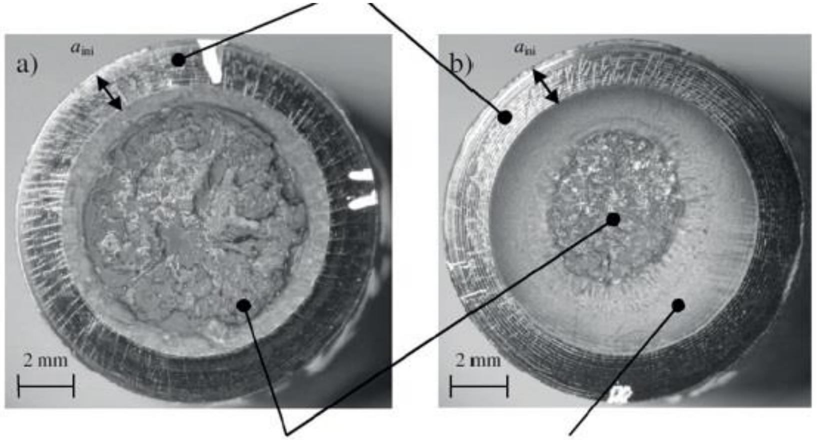


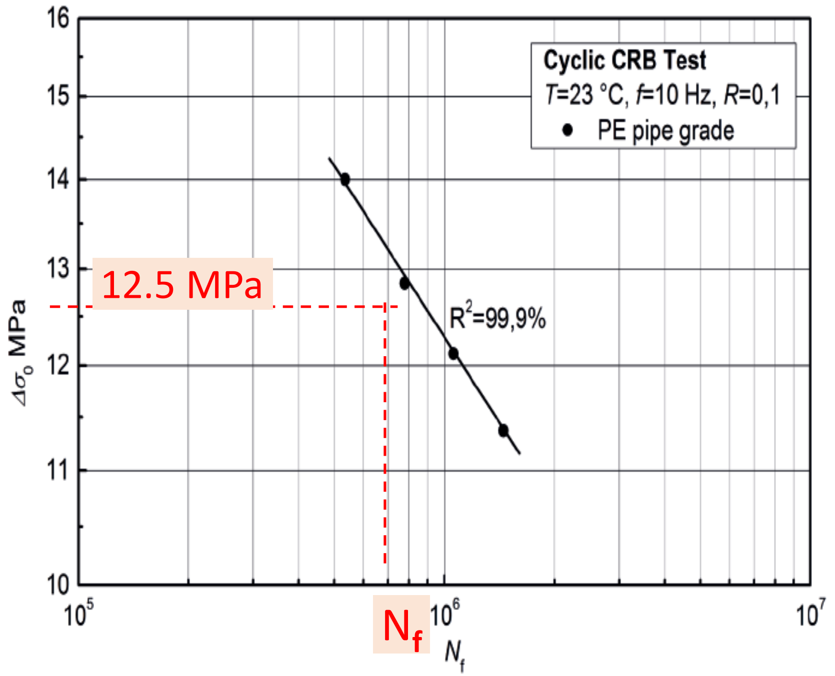
The Cracked Round Bar (CRB) Test – ISO 18498

- Test Temperature is 23° in air
- Razor blade notched bar D = 14mm
- Acceleration by Cyclic load: Fmin/Fmax = 1:10



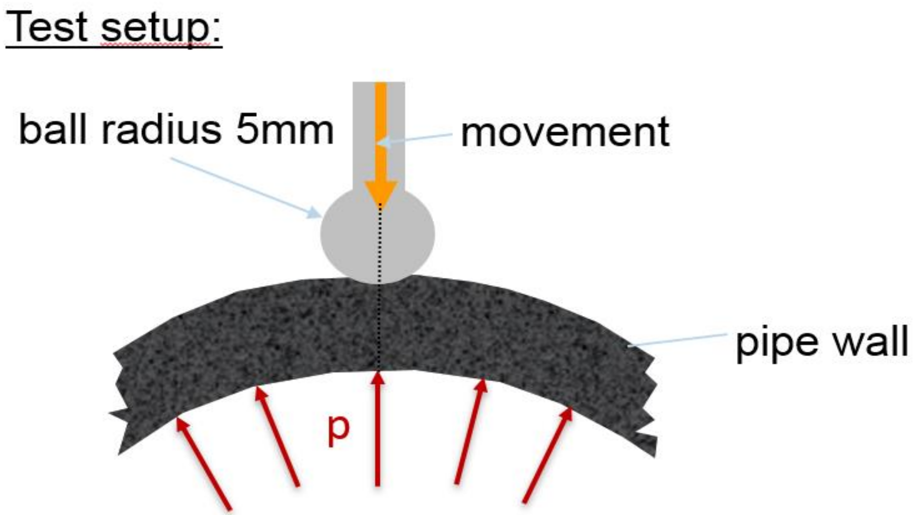
- Result:
  Nf = Failure Cycle Number
  calculated for Δ s0 = 12.5 MPa



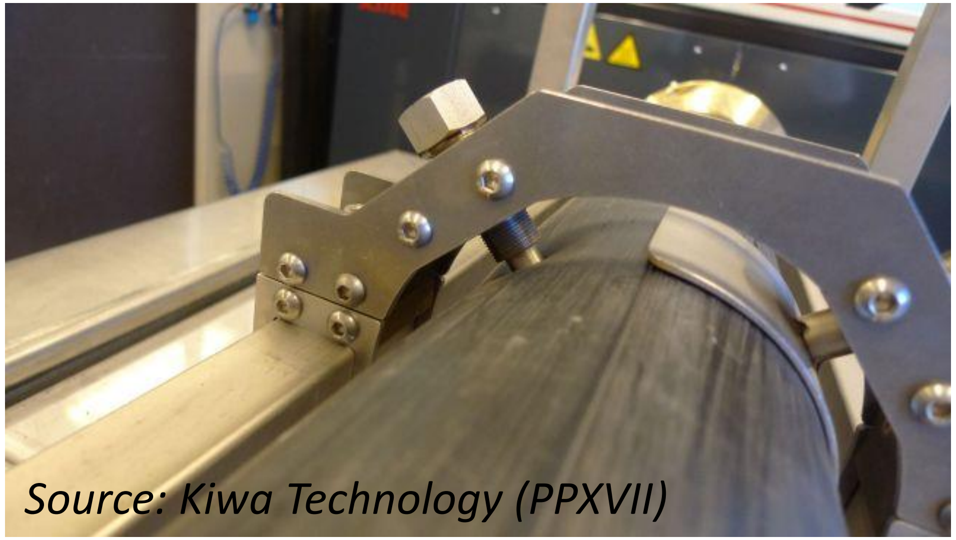


The Point Load Test (PLT) – No standard

- Static internal pressure test with a outer point load
- Acceleration by higher temp. (80 or 90°C) and surfactant solution circulated inside the pipe
- No standard test method so far, but a draft has been proposed by KIWA, TGM and SKZ
- Accelerated PLT under development within a DVGW-project at different labs



Outside wall (failure)



Inside wall (failure)

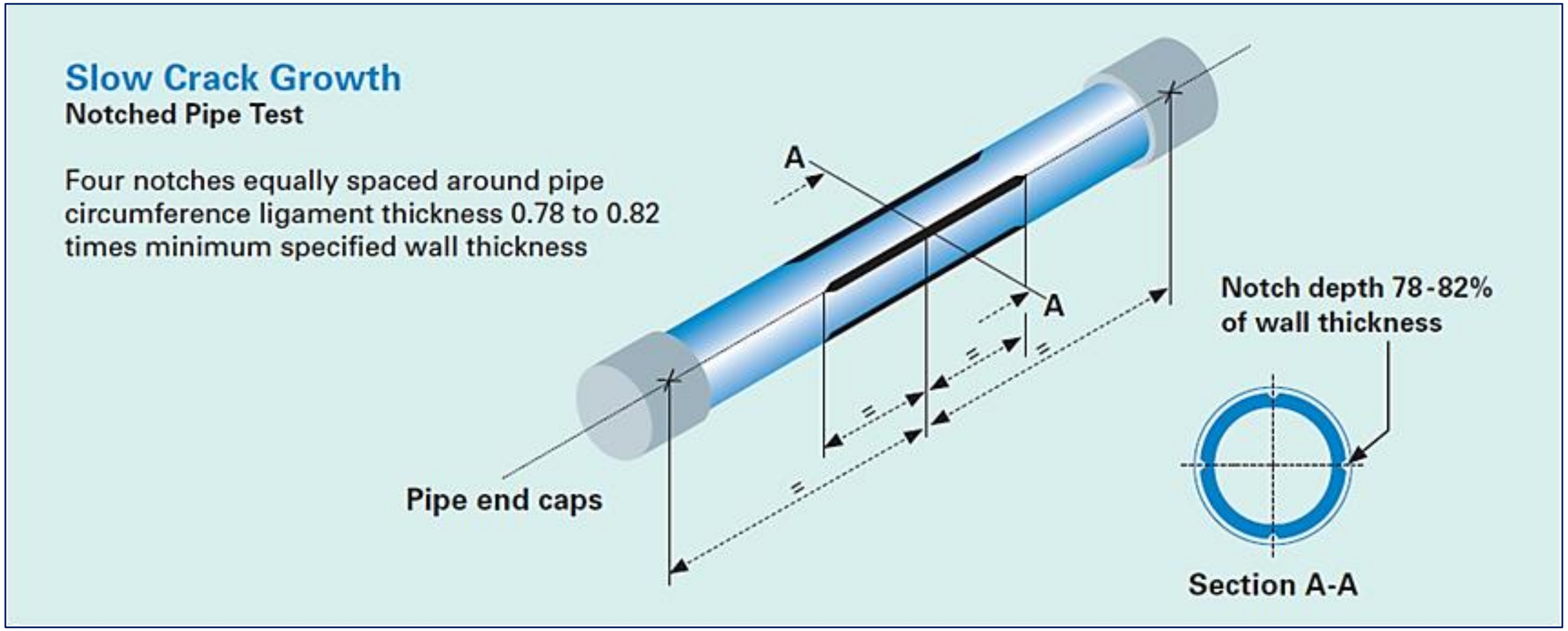
The Notched Pipe Test (NPT) – ISO 13479

Regular test in place for over 25 years

- Static internal pressure test
- Notch depth 20% of wall thickness
- Test conditions: 80°C / 9.2 bar / water-water

Accelerated version developed by TGM:

- Accelerated Notched Pipe Test (ANPT)
- 2% Arkopal N100 wetting agent in the bath
- Other test conditions as regular test



Test results classifying PE100 and PE100-RC that will be incorporated in revisions to the standards

Test Description	Relevant Standard	PE100 Minimum Value	PE100-RC Minimum Value
Full Notched Creep Test **(80°C/4MPa/2% N100)**	ISO 16770	No Requirement	t ≥ 8760 hours (Annex A, informative)
Accelerated FNCT **(90°C/4MPa/2% Lauramine oxide)**	ISO 16770	No Requirement	t ≥ 800 hours
Strain Hardening **(80°C / 0.3mm thickness)**	ISO 18488	No Requirement	<Gp> ≥ 53 MPa
Cracked Round Bar	ISO 18489	No Requirement	≥ 1.5 x 10^6 cycles
Point Load Test	No standard for test method in place		
Notched Pipe Test	ISO 13479	≥500 hours	t ≥ 8760 hours (Annex A, informative)
Accelerated NPT (ANPT)	ISO 13479 (with wetting agent)	No Requirement	t ≥ 300 hours

The PE100+ Association online No-Dig Technical Guide

The installation methods covered by the PE100+ No-Dig Guide

11 Installation Methods	Water Mains	Gas Mains	Sewage		Cable Ducts
			Gravity	Pressure (Rising Mains)	
New installation with PE pipe	HDD Impact moling Mole ploughing	HDD Impact moling Mole ploughing	Pilot tube microtunnelling	HDD Impact moling Mole ploughing	HDD Impact moling Mole ploughing
Rehabilitation with PE pipe	Slip lining Close-fit lining* Pipe bursting Pipe splitting Pipe extraction	Slip lining Close-fit lining* Pipe bursting Pipe splitting Pipe extraction	Pipe bursting Pipe splitting Pipe reaming	Slip lining Close-fit lining* Pipe bursting Pipe splitting Pipe extraction	

PE100+ Association | PE100+ Materials | PE technical guidance

HDPE pipe technical guidance

The HDPE Pipe Model, developed by the PE100+ Association with inputs from many industry experts, includes the most frequently asked questions and answers (Q&A's) of all the elements through the pipe system value chain: design, materials, construction, operation & maintenance, and environmental issues.

A lot of relevant graphics, photos, and standards are built into the model. This is a living tool, which a group of pipe industry experts will be reviewing and updating on a regular basis.

PE Pipe Manual

Guidance for PE Pressure Pipe Systems a unique and comprehensive...

READ MORE

Pipe dimensionning

SDR PIPE - MOP Calculator

READ MORE

No-Dig technical Guide

Online Guide to the use of Trenchless Technology for installation of PE100...

READ MORE

PACE+ design tool

PACE+ is an online tool developed for and released by the PE100+...

READ MORE

No-Dig technical Guide

PE technical guidance

PE Pipe Manual

Pipe dimensionning

No-Dig technical Guide

Design and Decision Module

Trenchless Methods

PACE+ design tool

Welcome to the Online Guide to the use of Trenchless Technology for installation of PE100 pipes.

This Guide has been developed by the PE100+ Association and co-sponsors TEPPFA, Exova, Radius Systems and Downley Consultants with the purpose of enabling users, designers, specifiers and decision makers to make use of the full range of trenchless technologies to install PE100 pipe either as new pipe or for rehabilitation and replacement of existing underground pipes.

DESIGN AND DECISION MODULE

READ MORE

TRENCHLESS METHODS

READ MORE

The Guide will identify the properties, benefits and applications of PE100 in **trenchless techniques** for use by designers and decision makers and will enable you to decide which methods are applicable to a specific project.

Screen Shot from the Decision Module Page

DATA INPUT

Utility Sector

Select ▾

Installation type

Select ▾

Minimum Required Internal Diameter of Pipe in mm

Existing Pipe Internal Diameter in mm - Leave blank if not applicable

PE100 Pipe Performance Requirements:

Design Factor of Safety (C) - Minimum 1.25 for water; Minimum 2.0 for gas

1.25

Minimum required Operating Pressure in bar.

6

Length of section in metres

Prevailing Conditions:

Existing Pipe Material (if applicable)

Select ▾

Tightest Bends in existing pipe (if applicable)

select ▾

Predominant ground type at pipe depth

select ▾

Are any of the following materials anticipated to be present?

☐ Coarse Gravel (>15mm)

Cobbles

Boulders

OUTPUT

Utility Sector

Installation Type

MRS

PE100 - 10MPa

Proposed PE100 pipe - SDR

Proposed PE100 pipe - Outside Diameter (mm)

Proposed PE100 pipe - Nominal Wall Thickness (mm)

Proposed PE100 pipe - Nominal Internal Diameter (mm)

Proposed PE100 pipe - Maximum Operating Pressure "MOP" (bar)

Trenchless Method(s) to Consider.

Method Notes

No-Dig technical Guide

PE technical guidance

PE Pipe Manual

Pipe dimensionning

No-Dig technical Guide

Design and Decision Module

Trenchless Methods

PACE+ design tool

Welcome to the Online Guide to the use of Trenchless Technology for installation of PE100 pipes.

This Guide has been developed by the PE100+ Association and co-sponsors TEPPFA, Exova, Radius Systems and Downley Consultants with the purpose of enabling users, designers, specifiers and decision makers to make use of the full range of trenchless technologies to install PE100 pipe either as new pipe or for rehabilitation and replacement of existing underground pipes.

DESIGN AND DECISION MODULE

READ MORE

TRENCHLESS METHODS

READ MORE

The Guide will identify the properties, benefits and applications of PE100 in **trenchless techniques** for use by designers and decision makers and will enable you to decide which methods are applicable to a specific project.

New Installation Methods

< Trenchless Methods

New Installation Methods

Pipe Rehabilitation Methods

Supporting Processes

Horizontal Directional Drilling

Wednesday 01 July 2015

HORIZONTAL DIRECTIONAL DRILLING - TECHNIQUE When new pipe is to be installed or it is not possible to rehabilitate a pipe, so that it needs to be replaced but is in a congested area of buried...

READ MORE

Pilot Tube Microtunnelling

Wednesday 01 July 2015

TECHNIQUE Pilot Tube microtunnelling is a new pipe installation technique, also sometimes called Guided Auger Boring or Pilot Pipe Jacking. It is a means of installing smaller diameter PE100 pipes in...

READ MORE

Impact Moling

Wednesday 01 July 2015

IMPACT MOLING - TECHNIQUE The impact mole or piercing tool is one of the oldest and simplest of the trenchless technologies. It is ideally suited for installation of small diameter PE100 pipes in...

READ MORE

Mole Ploughing

Wednesday 01 July 2015

MOLE PLOUGHING - TECHNIQUE Mole ploughing is a method of installing small diameter PE pipes in rural areas quickly and with minimal disruption and environmental impact. Mole ploughing is not strictly...

Pipe Rehabilitation Methods

Die Drawing

Thursday 02 July 2015

Technique For all close-fit PE lining methods, during the reduction process the outside diameter of the PE100 pipe is reduced to less than the minimum bore diameter of the host pipe. Once the PE100...

READ MORE

Close Fit Lining: Roller Reduction (Rolldown)

Thursday 02 July 2015

For all close-fit PE lining methods, during the reduction process the outside diameter of the PE100 pipe is reduced to less than the minimum bore diameter of the host pipe. Once the PE100 liner pipe...

READ MORE

Close Fit Lining: Fold and Form Lining

Thursday 02 July 2015

TECHNIQUE All PE close fit lining technologies effectively reduce the original diameter of the PE liner pipe prior to insertion, to facilitate pulling it in to the host pipe, followed by a reversion...

READ MORE

Slip lining

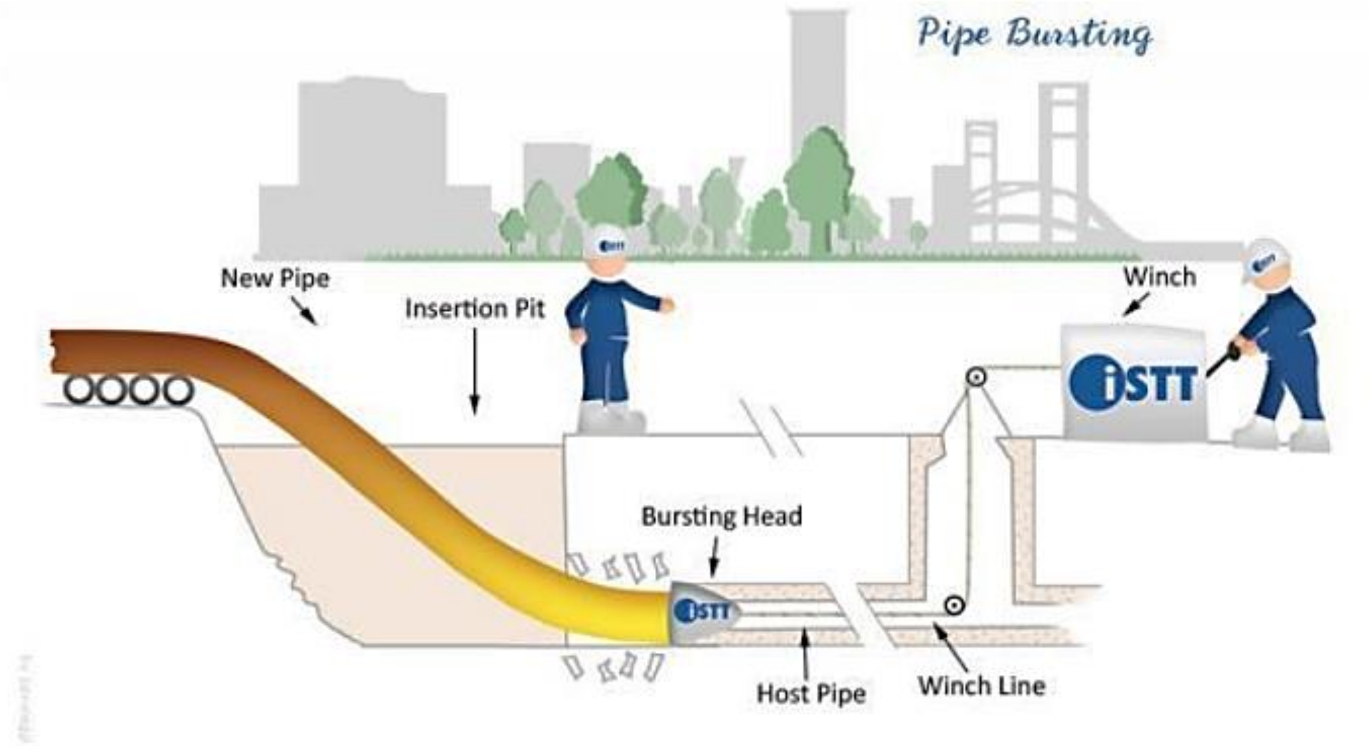
Wednesday 01 July 2015

SLIPLINING - TECHNIQUE Slip-lining is perhaps the oldest of all trenchless techniques. It involves the insertion of a new PE100 liner pipe of standard diameter and SDR into an existing pipe. Under...

There are **three methods of pipe bursting**: pneumatic, hydraulic, and static pull. The difference between them is in the source of energy and the method of breaking the old pipe. Pneumatic and hydraulic methods use dynamic force to break the old pipe whereas static pull uses a constant pull force. The selection of a specific method depends on soil conditions, groundwater conditions, degree of upsizing required, type of new pipe, construction of the existing pipeline, depth of the pipeline and availability of experienced contractors with suitable equipment. Static pipe bursting has replaced pneumatic bursting as the most commonly used variant primarily because of the absence of shock waves generated by a dynamic burster, which can cause damage to adjacent buried utilities.

Pipe splitting is necessarily a static pull method.

Screen shot from the pipe bursting page



Incorporation of PE100-RC materials in the ISO and EN standards

Revision of the EN and ISO PE pipe standards to incorporate PE100-RC materials

ISO4427 – Too late. New revision already published in August 2019

EN1555 – PE100-RC draft revisions published in September 2019

EN12201 – Copy revision of EN1555 in to EN 12201 by end of 2020

ISO4437 – Revision of ISO 4437 in 2021?

Revised ISO4427 – Copy revision into ISO 4427 in 2022?

Conclusions

Conclusions – Takeaways from the presentation

- The EN ISO 11295 family of standards are designed to help Engineers understand the different renovation techniques, select and specify them.
- They are supplemented by the new EN ISO 21225 standard covering pipe bursting, horizontal directional drilling and impact moling.
- Many techniques employ PE pipes and liners but these can be damaged during and after the installation process, which can initiate a Slow Crack Growth failure. Hence the industry developed PE100-RC materials along with new faster test methods.
- Make use of the PE100+ Association No-Dig Technical Guide. It's on-line, free to use and contains lots of helpful information especially for non-specialists.
- PE100-RC materials which were developed for such challenging applications will shortly start being incorporated in to the EN and ISO standards.

Thank you for your attention

For any queries please go to:

https://www.pe100plus.com/PE-Pipes/Contact/r56.html