2021
TRENCHLESS MIDDLE EAST

# 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

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## Content

- 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



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## A brief introduction to the PE100+ Association


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## 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

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

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## Before we get down to the detail, lets define a few terms in order to avoid confusion

- **Rehabilitation**
  All measures for restoring or upgrading the performance of an existing pipeline system.
- **Renovation**
  Work incorporating all or part of the original fabric of the pipeline by means of which its current performance is improved.
- **Replacement**
  Rehabilitation of an existing pipeline system by the installation of a new pipeline system, without incorporating the original fabric.
- **Technique family**
  A group of renovation techniques which are considered to have common characteristics for standardisation purposes.

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

- 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**


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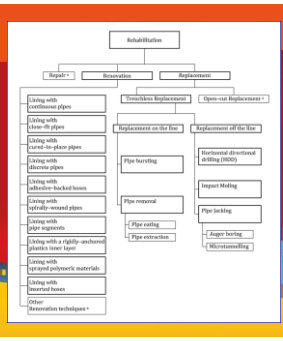
## The technique families covered by ENO ISO 11295 and related trenchless renovation and replacement standards

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## 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 | Published | |
| 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 | | | | |

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## EN ISO 11298 and 11299 parts 2 and 3 cover the renovation of water and gas pipelines using PE



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



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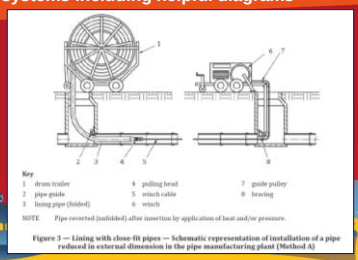
## The standards give descriptions of the different systems including helpful diagrams

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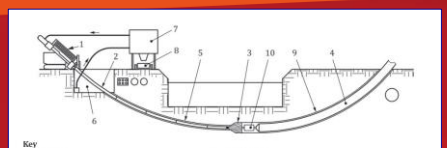
## and give guidance on their materials, applications, performance and installation



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**

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## PE100-RC materials for challenging trenchless applications

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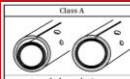
## They also provides a system for classifying the pipe or liner structural performance

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

| Class A | | Class B | Class C | Class D |
|---|---|---|---|---|
|  | |  |  |  |
| Independent | | Interactive | | |
| Fully structural | | Semi-structural | | Non-structural |
| Lining with continuous pipes | | — | | This document is not applicable |
| Lining with discrete pipes | | — | | |
| — | Lining with close-fit pipes | — | | |
| | Lining with cured-in-place pipes | | | |
| | — | Lining with adhesive-backed hoses | | |
| — | — | Lining with sprayed polymeric materials | — | |

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.

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## 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

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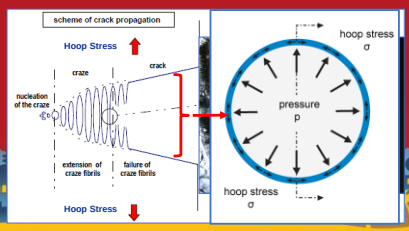
## SCG is the growth of a crack through the pipe wall as hoop stress slowly pulls the PE apart

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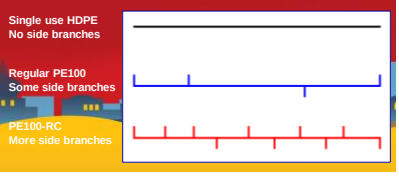
## What makes the types of High Density polyethylene (HDPE) PE100 perform differently?

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

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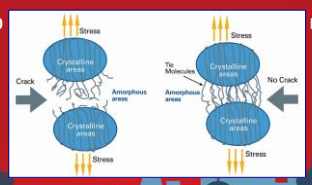
## The higher number of sides branches is the key difference

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

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

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## 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

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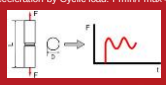
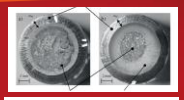
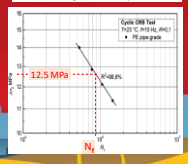
## The Cracked Round Bar (CRB) Test – ISO 18498

- 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



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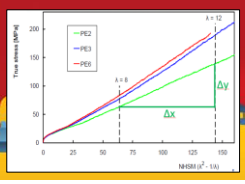
## The Strain Hardening Test – ISO 18488

- 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

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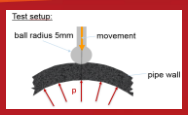
## The Point Load Test (PLT) – No standard

- 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




*Source: Kiwa Technology (PPXVII)*

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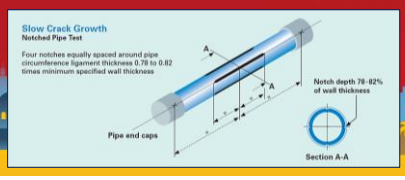
## The Notched Pipe Test (NPT) – ISO 13479

**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

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## 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 ≥ 550 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 |

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## The PE100+ Association online No-Dig Technical Guide

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## 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<br>Impact moling<br>Mole ploughing | HDD<br>Impact moling<br>Mole ploughing | Pilot tube microtunnelling | HDD<br>Impact moling<br>Mole ploughing | HDD<br>Impact moling<br>Mole ploughing |
| Rehabilitation with PE pipe | Slip lining<br>Close-fit lining*<br>Pipe bursting<br>Pipe splitting<br>Pipe extraction | Slip lining<br>Close-fit lining*<br>Pipe bursting<br>Pipe splitting<br>Pipe extraction | Pipe bursting<br>Pipe splitting<br>Pipe reaming | Slip lining<br>Close-fit lining*<br>Pipe bursting<br>Pipe splitting<br>Pipe extraction | |

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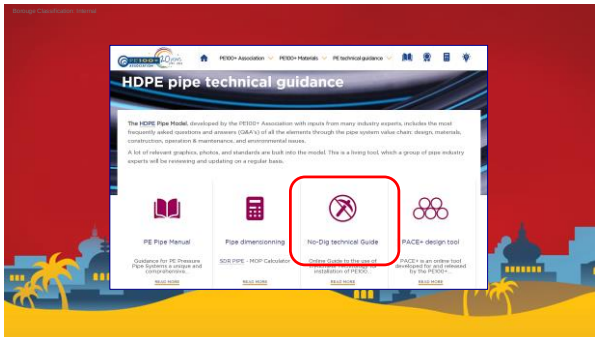
HDPE pipe technical guidance
PE Pipe Manual
Pipe dimensionning
No-Dig technical Guide
PACE+ design tool

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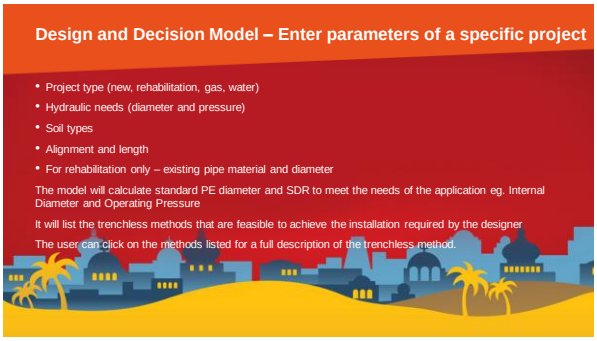
Design and Decision Model – Enter parameters of a specific project
• Project type (new, rehabilitation, gas, water)
• Hydraulic needs (diameter and pressure)
• Soil types
• Alignment and length
• For rehabilitation only – existing pipe material and diameter
The model will calculate standard PE diameter and SDR to meet the needs of the application eg. Internal Diameter and Operating Pressure
It will list the trenchless methods that are feasible to achieve the installation required by the designer
The user can click on the methods listed for a full description of the trenchless method.

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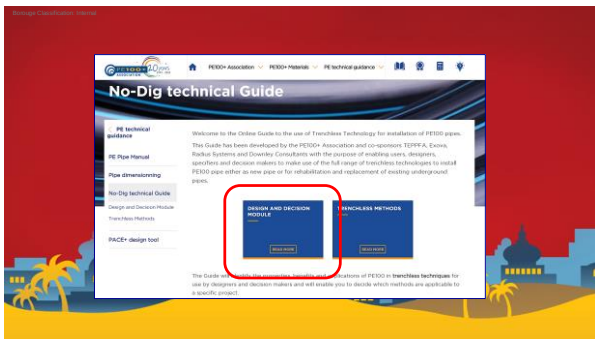
No-Dig technical Guide
DESIGN AND DECISION MODULE
TRENCHLESS METHODS

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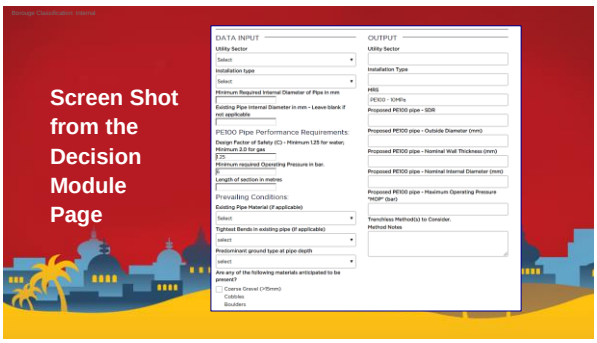
Screen Shot from the Decision Module Page
DATA INPUT
OUTPUT

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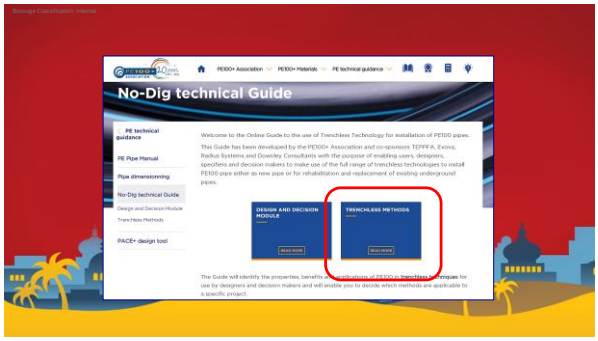
No-Dig technical Guide
PE technical guidance
PE Pipe Manual
Pipe dimensioning
No-Dig technical Guide
Design and Decision Module
Trenchless Methods
PACE+ design tool
DESIGN AND DECISION MODULE
TRENCHLESS METHODS

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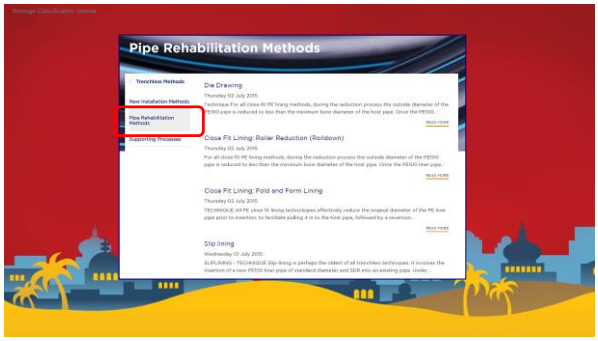
Pipe Rehabilitation Methods
Trenchless Methods
New Installation Methods
Pipe Rehabilitation Methods
Supporting Processes
Die Drawing
Close Fit Lining: Roller Reduction (Rolldown)
Close Fit Lining: Fold and Form Lining
Slip lining

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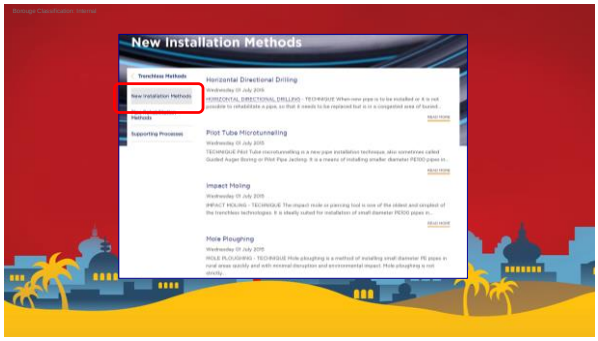
New Installation Methods
Trenchless Methods
New Installation Methods
Supporting Processes
Horizontal Directional Drilling
Pilot Tube Microtunnelling
Impact Moling
Mole Ploughing

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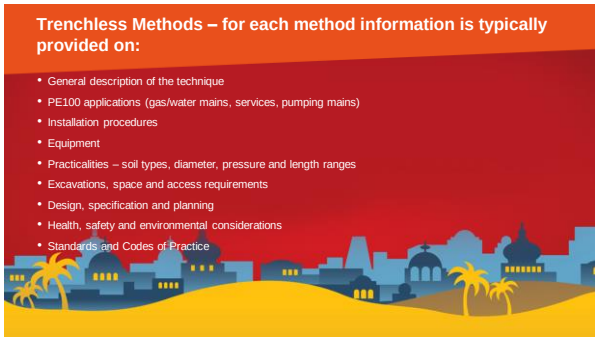
Trenchless Methods – for each method information is typically provided on:
General description of the technique
PE100 applications (gas/water mains, services, pumping mains)
Installation procedures
Equipment
Practicalities – soil types, diameter, pressure and length ranges
Excavations, space and access requirements
Design, specification and planning
Health, safety and environmental considerations
Standards and Codes of Practice

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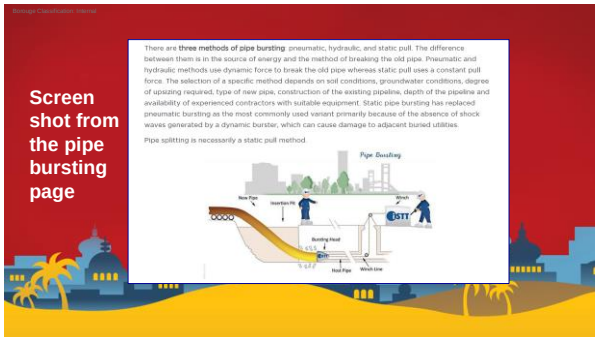
Screen shot from the pipe bursting page
There are three methods of pipe bursting: pneumatic, hydraulic, and static pull. The difference between them is in the source of energy and the method of breaking the old pipe. Pneumatic and hydraulic methods use dynamic force to break the old pipe whereas static 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.
Pipe Bursting
New Pipe
Insertion Pit
Winch
Bursting Head
Old Pipe
Head Pipe
Winch line

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

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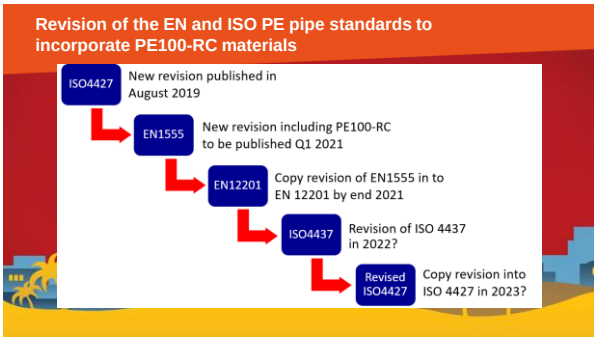
Revision of the EN and ISO PE pipe standards to incorporate PE100-RC materials
ISO4427
New revision published in August 2019
EN1555
New revision including PE100-RC to be published Q1 2021
EN12201
Copy revision of EN1555 in to EN 12201 by end 2021
ISO4437
Revision of ISO 4437 in 2022?
Revised ISO4427
Copy revision into ISO 4427 in 2023?

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Conclusions

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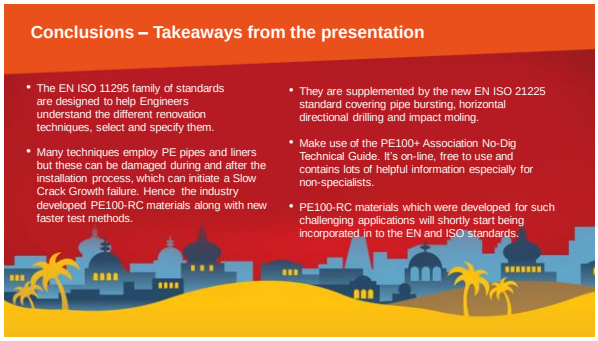
Conclusions – Takeaways from the presentation
• The EN ISO 11295 family of standards are designed to help Engineers understand the different renovation techniques, select and specify them.
• Many techniques employ PE pipes and liners but these can be damaged during and after the installation process, which can initiate a Slow Crack Growth failure. Hence the industry developed PE100-RC materials along with new faster test methods.
• They are supplemented by the new EN ISO 21225 standard covering pipe bursting, horizontal directional drilling and impact moling.
• 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.

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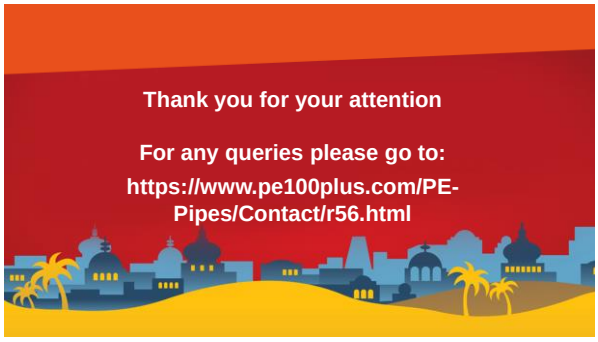
Thank you for your attention
For any queries please go to:
https://www.pe100plus.com/PE-Pipes/Contact/r56.html

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