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THE USE OF PE100+ MATERIALS IN TRENCHLESS TECHNOLOGY APPLICATIONS

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SHORT SUMMARY
PE100 pipes are widely used in the installation, rehabilitation and replacement of pressure systems. They can be installed using a variety of trenchless technologies and so the PE100+ Association developed an online guide to aid end users in selecting the most appropriate methods. The presentation will give an overview of methods that can be used to install PE100 pipes, along with a summary of the EN ISO 11295 family of standards and an introduction to the association's online guide.

KEYWORDS
Trenchless Technology, No-Dig, PE100, PE100-RC

ABSTRACT
PE100 pipes are the most widely used material for the installation, rehabilitation and replacement of pressure pipes for water and gas supply and for pressure sewers. Such pipes can be installed using a broad range of trenchless technologies and hence the selection of the most appropriate method and identification of the correct standards can be a challenge for end user organisations.

The PE100+ Association, working with trenchless industry experts developed an online guide to educate end users about the different technologies. The guide also aids users in selecting appropriate trenchless methods for the use of PE100 pipes in both new installation and rehabilitation works. The paper and presentation will provide an overview of the trenchless methods that can be used to install PE100 pipes, together with a summary of the EN ISO 11295 family of standards that cover these methods and an introduction to the online guide.

1. INTRODUCTION TO THE PE100+ ASSOCIATION

The PE100+ Association, which was founded in 1999 represents 14 international producers of high quality PE100 pipe resins that are located in Europe and Asia. It is supported by an Advisory Committee of non-affiliated independent experts whom all have many years of experience in different parts of the PE pipe value chain. The association works closely with other trade associations such as TEPPFA (The European Plastic Pipes and Fittings Association) and Plastics Europe.

The aims of the association are to assure consistently high quality in the production and application of PE 100+ pipe materials, thereby helping to create trust in high quality PE materials globally. They also promote the use PE pipe systems in appropriate applications, including trenchless technology and focus on providing end users with technical information and support on the use of such systems.

2. TRENCHLESS METHODS THAT CAN BE USED TO INSTALL PE100 PIPES

Underground pipelines are the arteries which enable modern cities to function, providing water for drinking, cooking and washing, gas for cooking and heating and taking away the wastewater to the treatment plants. Like all structures, these pipes deteriorate with time and ultimately require renovation or replacement. Since most cites grow outwards from the centre, the oldest pipes are likely to be in the congested central area, making replacement extremely costly and disruptive.

For example, in 2000 a survey of the water pipes in the centre of London showed that over half these pipes were over 100 years old and a third over 150 years old(1). Many of these old cast iron pipes were heavily corroded and Thames Water were repairing up to 200 leaks a day. Hence they decided that a major system overhaul was necessary as the population was expected to grow to 8.1 million by 2016.

Therefore, in 2005 Thames commenced a replacement programme using polyethylene (PE) PE100 pipes for mains and PE80 pipes for service connections. To reduce costs and disruption, the engineers were asked to use trenchless technology wherever possible and ultimately 54% of the work was carried out in this way (using mainly insertion and pipe bursting).

In 2010, the program was extended and overall over 17,000 km of water mains have so far been renovated or replaced, reducing operational costs and water losses by one third. Many cities around the world are following the same philosophy and looking at trenchless technology wherever practical to renovate their old utility networks. Also, in industrial pipework the insertion of PE liners is used to reduce the internal corrosion of steel pipes and increase abrasion resistance.

One of the advantages of PE100 pipe systems is that they can be installed using a wide variety of trenchless methods to suit different applications, installation environments and budget available. The table provides a summary of the methods that can be used to undertake the installation of new PE pipelines and those rehabilitation methods that make use of PE100 pipes.

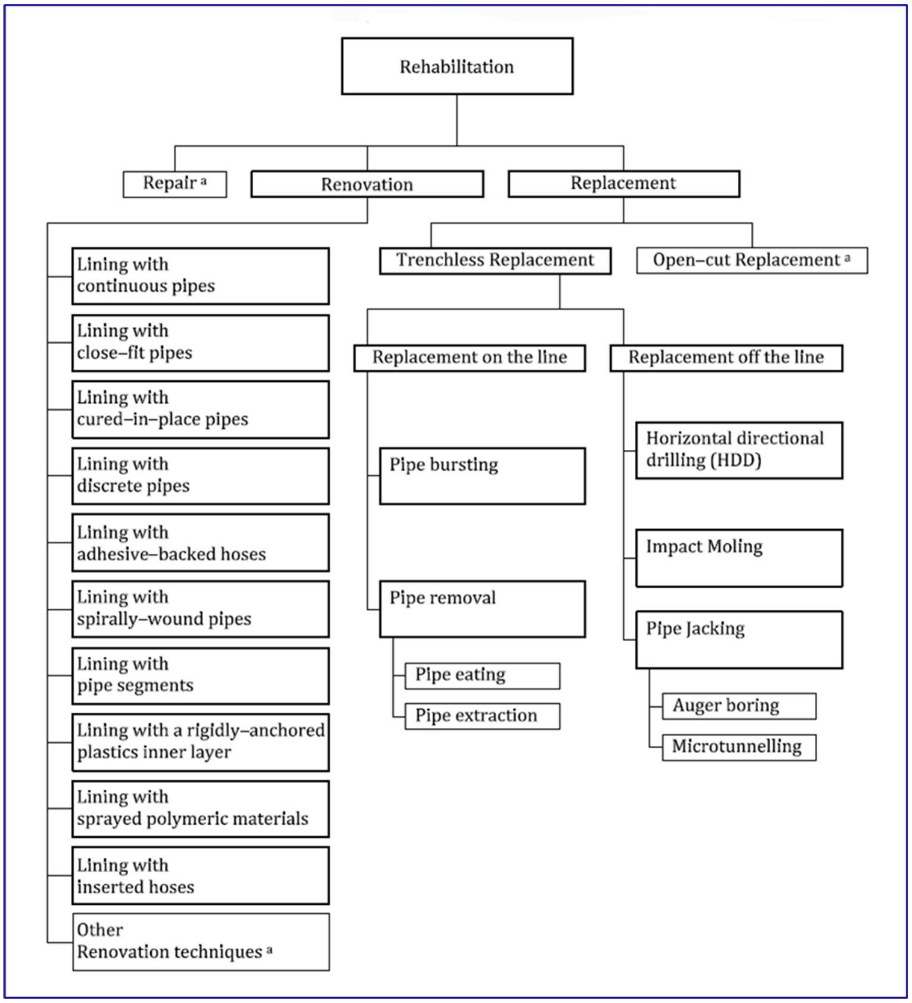
Table 1. Summary of the methods that are commonly used to install PE pipes and rehabilitate existing pipe systems using PE pipes and liners

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	

3. AN INTRODUCTION TO THE EN ISO 11295 FAMILY OF STANDARDS

Many different trenchless techniques have been developed over the last 40 years to solve different installation and rehabilitation challenges. Many of the systems are patented by the installation companies using a wide range of terminology. This has created some confusion and complicated the process of selecting and specifying the most appropriate method. Fortunately, many techniques have now been catalogued in EN ISO 11295 "Plastics piping systems used for the rehabilitation of pipelines - classification and overview of strategic, tactical and operational activities" (2), which also classifies each of them and provides a simple description of each method. The original was published in 2010, revised and expanded in 2017, and then updated in 2022. The different techniques are classified in families as shown in Figure 1.

Fig. 1. Classification of pipe rehabilitation techniques as per EN ISO 11295



A family is a group of renovation techniques that are considered to have common characteristics for standardization purposes. For example, lining with close fit pipes includes pipes that are reduced in diameter by passing them through a die or rollers prior to insertion and pipes that are formed into a U or C shape. As there is some confusion with regards to what constitutes rehabilitation, renovation, etc. the following is a brief summary:

Rehabilitation
All measures for restoring or upgrading the performance of an existing pipeline system.

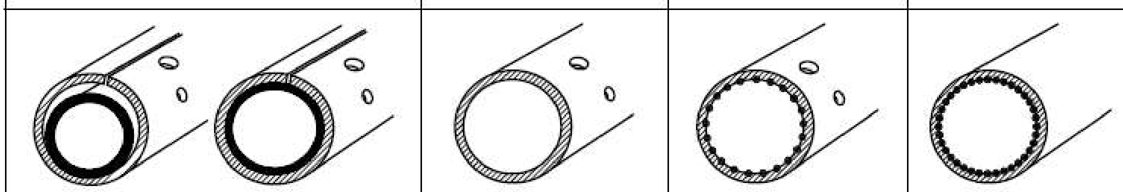
Renovation
Work incorporating all or part of the original fabric of the pipeline by means of which its current performance is improved.

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 standardization purposes.

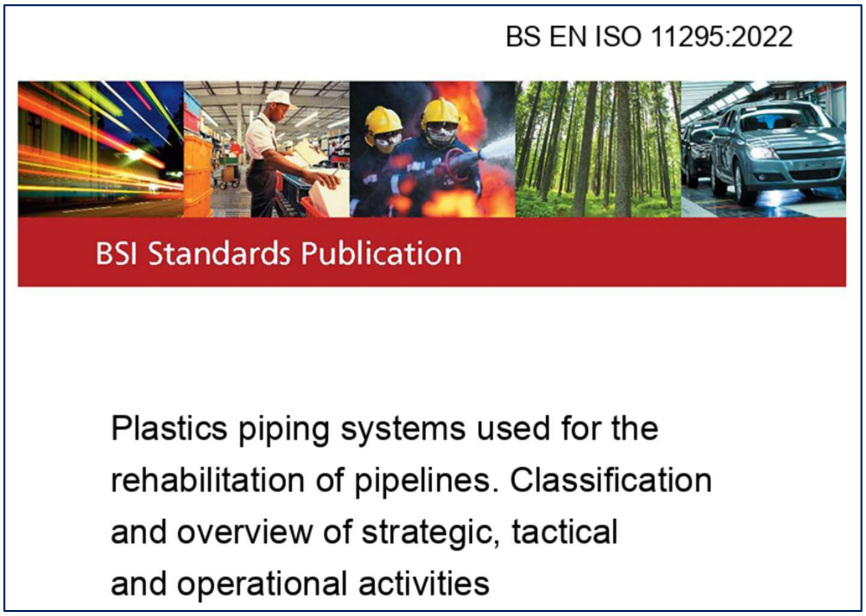
For pressure pipe lining a new classification concept with structural classes A-D has also been adopted as shown in Figure 2. A loose or a close fit lining can either be fully structural or semi structural depending upon the SDR (Standard Dimension Ratio) chosen for the PE lining pipe and the future operational pressure for the system.

Fig. 2. Schematic representation of pressure pipe liner structural classes

<table>
<tr><th colspan="2">Class A</th><th>Class B</th><th>Class C</th><th>Class D</th></tr>
<tr><td colspan="5"></td></tr>
<tr><td>loose-fit</td><td>close-fit</td><td>inherent ring stiffness</td><td>relies on adhesion</td><td>relies on adhesion</td></tr>
<tr><td colspan="2">Independent</td><td colspan="3">Interactive</td></tr>
<tr><td colspan="2">Fully structural</td><td colspan="2">Semi-structural</td><td>Non-structural</td></tr>
<tr><td>Lining with continuous pipes</td><td colspan="3"></td><td rowspan="4">This International Standard is not applicable</td></tr>
<tr><td rowspan="3"></td><td colspan="2">Lining with close-fit pipes</td><td></td></tr>
<tr><td colspan="3">Lining with cured-in-place pipes</td></tr>
<tr><td colspan="2"></td><td>Lining with adhesive-backed hoses</td></tr>
</table>

An independent pressure pipe liner as shown in Figure 2 is defined as a liner capable on its own of resisting without failure all applicable internal loads throughout its design life, whilst an interactive pressure pipe liner relies on the existing pipeline for some measure of radial support in order to resist, without failure, all applicable internal loads throughout its design life.

Fig. 3. The current edition of BS EN ISO 11295 : 2022


BS EN ISO 11295:2022

BSI Standards Publication

Plastics piping systems used for the rehabilitation of pipelines. Classification and overview of strategic, tactical and operational activities

EN ISO 11295 should be thought of as an introduction to the use of plastic piping systems in the renovation and replacement segment and as providing the framework in which a suite of subsidiary EN ISO product standards will sit. With regards to renovation, it is currently envisaged that there will be four standards that will based on the existing pipe system that is to be renovated. These will then be split down in to different parts depending on which technique families are being covered by the standard.

In these product standards, tools are provided to demonstrate and assure the long-term quality of the liners. In order to review performance in the installed state, two distinct stages are recognised: stage M – as manufactured and stage I – as installed. System manufacturers should carry out tests to ensure that products conform to all requirements for the characteristic given in the respective standard.

For example, EN ISO 11298[3] covers plastic pipe systems for renovation of underground water supply networks. The standard is in several parts with EN ISO 11298 Part 1 defining the general requirements common to all relevant renovation techniques and Part 2 the specific requirements for lining with continuous pipes, for example. By selecting the appropriate parts of the standard, engineers will be able to clearly define the requirements of the PE lining pipe for the chosen trenchless technique.

The following table summarises the different standards and parts that had been published up to 2021. It should be noted that none of the standards will comprise all eleven parts as many of the techniques not suitable for use in all four areas of application. For example, Spirally-Wound pipe systems are only suitable for renovating gravity pipe systems and therefore EN ISO 11296[4] will have only a Part 7.

Table 2. Summary of renovation standards published up to 2023

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	Published			
10: Sprayed Polymeric Mats.				
11: Inserted Hoses				

Whilst the original version of EN ISO 11295 only concerned itself with renovation techniques, the 2017 edition was expanded to also include the classification of trenchless replacement techniques such as horizontal directional drilling, impact moling, pipe bursting and micro-tunnelling. These are covered by a variety of subsidiary product standards, with four of the most commonly used techniques being covered by Parts 1 and 2 of EN ISO 21225(5), both of which were published in 2018.

Fig. 4. EN ISO 21225 parts 1 and 2 covering the classification of four techniques for the trenchless replacement of underground pipelines

4. THE PE100+ NO-DIG TECHNICAL GUIDE

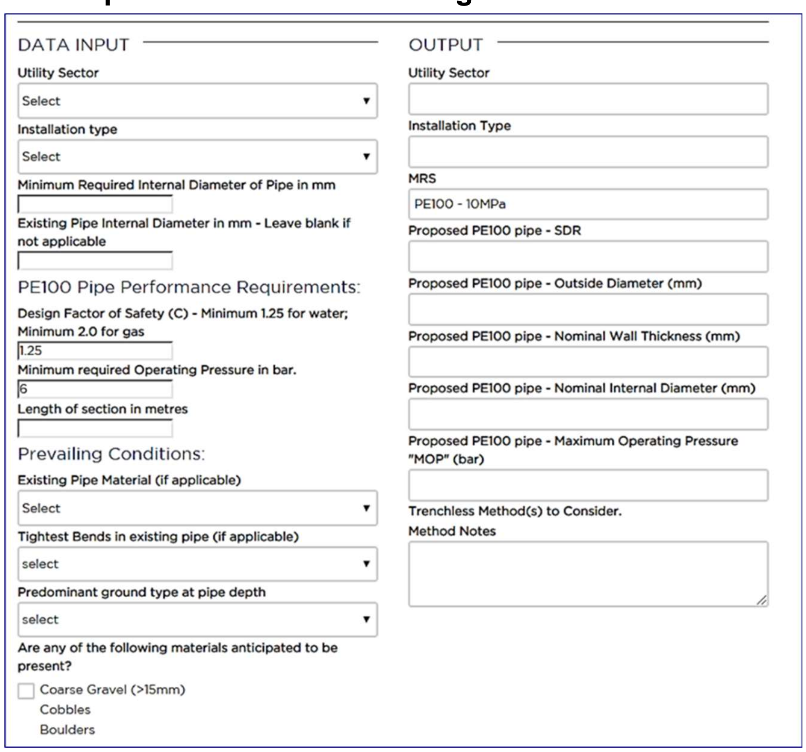
PE100 and trenchless technology make a perfect match; a combination of method and material that complement each other, resulting in economic, cost-effective and non-disruptive installation and rehabilitation works. The range of trenchless methods in which PE100 is used was shown in Table 1.

Unfortunately, one major obstacle to greater use of trenchless technology is a lack of knowledge among designers and asset owners about how the techniques can be applied to their projects in order to achieve the maximum benefit. Hence the PE100+ Association, working with TEPPFA, Exova, Radius Systems and Downley Consultants have developed an online No-Dig Guide. The guide is designed to help decision makers learn about and select from a wide range of trenchless technologies that can be used to install new PE100 pipelines or rehabilitate existing pipelines using PE100 pipes and liners. It is freely available online through the PE100+ Association website.

The Guide includes mole ploughing which, although not strictly a trenchless method, uses PE100 in the same way. In total the guide covers 11 different trenchless techniques, if the three close-fit lining methods are considered separately, in addition to mole ploughing. The benefit of the combination is clear: the pipe material that water and gas utilities in most regions of the world want in their distribution networks can be installed using the state-of-the-art trenchless installation and renovation techniques.

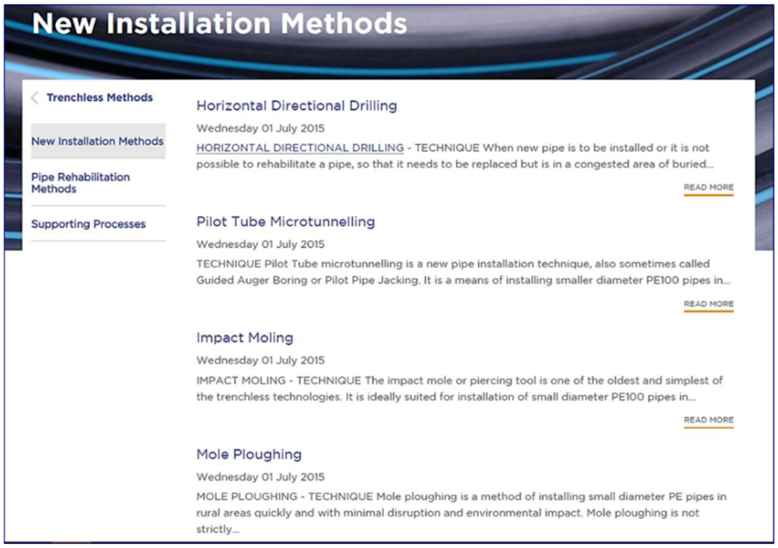
The first part of the Guide is a decision process in which users can enter the parameters of a specific project: project type (new, rehabilitation, gas, water, etc.), diameter and pressure needs, soil types, alignment, length, and for rehabilitation projects, existing pipe material and diameter. Based on the user inputs, the Guide calculates the standard PE diameter and SDR that is suitable and shows this to the user along with a list of trenchless methods that are feasible to achieve what is required. The following is a screen shot taken from the guide's design and decision module input and output page.

Fig. 5. Screen print taken from the design and decision module webpage



The second part of the Guide is aimed at providing end users with a good introduction to the different new installation and rehabilitation methodologies.

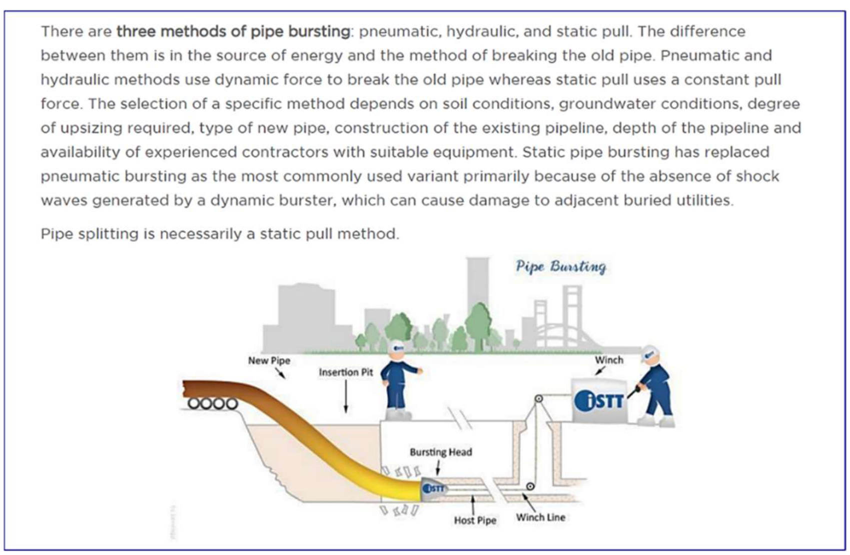
Fig. 6. Screen print of the installation methods webpage



Clicking on any of the methods listed takes the user to the page describing that method in more detail. For each method, the Guide provides clear information on the key aspects of the method:

- Technique – general description
- Applications of PE100 (gas/water mains, services, sewer force mains)
- Installation Procedure
- Equipment
- Practicalities – range of soil types, diameter, pressure and length ranges
- Excavations, space and access requirements
- Design, Specification and Planning
- Health, Safety and Environment
- Standards and Codes of Practice

Fig. 7. Screen print showing part of the pipe bursting method webpage



The Guide also includes several common modules to provide information about related works before, during and after the trenchless works themselves. These are:

- Pipe Assembly & Handling
- Installation Manual
- Host pipe cleaning & inspection (for the rehabilitation methods)
- Isolation
- End Fittings
- Inspection & Testing

5 EXAMPLES OF PIPELINE REHABILITATION USING PE PIPES AND LINERS

A HDD twin pipeline river crossing in demanding geological conditions

The renovation of a pressure sewer pipeline between two wastewater treatment plants in Prague, included the installation of twin 400 mm OD, SDR 17 PE100 pipelines. Two sections of the twin pipeline were installed using Horizontal Directional Drilling (HDD), one crossed the Vitava River, whilst the other was beneath an area of mature trees.

The river crossing was relatively short at 160m long, but had to be installed in a continuous arc as shown below and through complicated geological conditions that included slate rock in various states of weathering. Installing a pipeline through bedrock in which the strength varies and which involve unstable conditions around the borehole can cause problems when pulling in the pipes. Therefore, due to the longitudinal profile of the pipe and the demanding geology it was decided to use a pipe which allowed for an integrity check after installation.

Fig. 8. Route of the twin pipeline river crossing using 400 mm OD pipes

Prazska vodohospodarska spolecnost (PVS) the system owner and the designers selected the Egeplast SLM DCT system. This comprises a PE 100-RC pipe with an additional protective outer layer and integrated conductive strips. The strips enable testing of the piping system for integrity directly after installation. In addition, they offer the possibility of permanent detection of the installed line. Both 160 m long HDD river crossings were installed in less than three weeks and the pipe integrity test confirmed the full functionality of the new pressure pipe.

Close fit lining of a DN300 Ductile Iron Pipeline in Finland

Drinking water supplier of Puijo, a utility located in central Finland needed to replace an existing 130 m long, DN 300 ductile iron pipeline that was laid up a very steep 45º hillside, through a heavily forested area.

Rather than replace the pipeline, the utility, working with their engineering consultant Johan Lundberg OY, decided to renovate the pipeline using a fully structural liner that would be capable of taking the full operating pressure of the pipeline.

After reviewing the options, it was decided to opt for the Wavin Compact Pipe system and the new liner was installed in June 2022 by Pollex AB, based in Gothenborg, Sweden, working under the supervision of Jukka Huusko.

One interesting point is that calculations undertaken by the project team estimated that using a liner system, rather than the open trenching replacement of the pipeline saved 16 tonnes of CO2 emissions.

Fig. 9. The winch unit that pulled through the pipe liner

6. CONCLUSIONS

Installing new pipe systems and extending the life of existing water, gas and sewage pipelines using plastic pipes and modern trenchless techniques provides utilities with major benefits compared to conventional replacement using open trench installation. Excavation and reinstatement costs can be significantly reduced, major disruption to urban life can be avoided and the environmental of the rehabilitation process significantly reduced.

It is hoped that the PE100+ Association's online No-Dig Guide, when used in conjunction the EN ISO 11295 family of standards, will help bridge the gap between the PE pipe system end users and the trenchless technology community, each of which has their respective areas of knowledge. The association's aim is to support the increased use of both trenchless technology and PE100 pipe systems especially in newer markets where experience is limited. The Guide can be found at: www.pe100plus.com.

7. REFERENCES

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3. EN ISO 11298, "Plastic piping systems for renovation of underground water supply networks." 2018.
4. EN ISO 11296, "Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks", 2018
5. EN ISO 21225, "Plastics piping systems for the trenchless replacement of underground pipeline networks" 2018

