
**Plastics piping systems for
the trenchless replacement of
underground pipeline networks —**

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

*Systèmes de canalisations en plastique pour le remplacement sans
tranchée des réseaux de canalisations enterrés —*

*Partie 2: Remplacement hors ligne par forage horizontal dirigé et
fonçage par fusée*

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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 21225 series can be found on the ISO website.

Introduction

System standards dealing with following applications are either available or in preparation for pipeline renovation:

- The ISO 11296 series: *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks*;
- The ISO 11297 series: *Plastics piping systems for renovation of underground drainage and sewerage networks under pressure*;
- The ISO 11298 series: *Plastics piping systems for renovation of underground water supply networks*;
- The ISO 11299 series: *Plastics piping systems for renovation of underground gas supply networks*.

System standards dealing with all application areas are either available or in preparation for trenchless pipeline replacement:

- The ISO 21225 series: *Plastics piping systems for the trenchless replacement of underground pipeline networks*.

The system standard ISO 21225 comprises:

- *Part 1: Replacement on the line by pipe bursting and pipe extraction*;
- *Part 2: Replacement off the line by horizontal directional drilling and impact moling* (this document).

The requirements for technique families are given in ISO 21225-1 and ISO 21225-2 (this document) respectively. For complimentary information, see ISO 11295^[1].

A consistent structure of clause headings has been adopted for all parts to facilitate direct comparisons across replacement standards.

[Figure 1](#) shows the common part and clause structure and the relationship between ISO 21255 and the system standards for the renovation application areas.

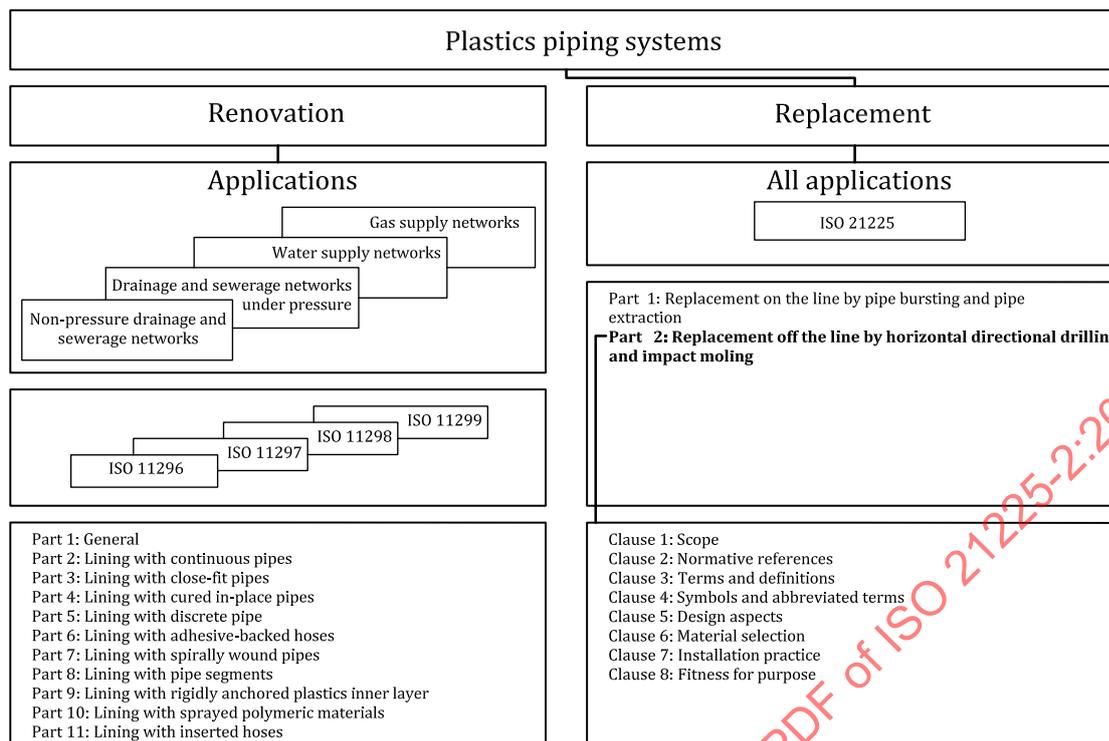


Figure 1 — Technique families and clause structure

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Plastics piping systems for the trenchless replacement of underground pipeline networks —

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

1 Scope

This document specifies requirements and test methods for pipes and fittings which are part of plastics piping systems for the trenchless replacement of various underground pipeline networks, underground non-pressure and pressure drainage and sewerage networks and underground water and gas supply networks, by means of horizontal directional drilling and impact moling.

It is applicable to polyethylene (PE) pipes and fittings, as manufactured, as well as to the installed replacement system.

This document is intended to be used in conjunction with standards applicable for the construction of PE pipeline systems where available.

Regarding manufactured pipes it is applicable to three different PE pipe types:

- PE solid wall single layered pipes (nominal outside diameter, d_n), including any identification stripes;
- PE pipes with co-extruded layers on either or both the outside and inside of the pipe (total outside diameter, d_n), as specified in [Annex A](#), where all layers have the same MRS rating;
- PE pipes (outside diameter, d_n) having a peelable, contiguous, thermoplastics additional layer on the outside of the pipe (“coated pipe”), see [Annex A](#).

In addition it is applicable to:

- jointing of pipe lengths by means of butt fusion joint to form continuous strings prior to installation;
- fabricated and injection-moulded fittings made of PE.

Pipes made from other plastics, e.g. polypropylene (PP) are outside the scope of this document.

This document is not applicable to push-fit jointed discrete pipes assembled as part of the trenchless installation process.

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 4427 (all parts), *Plastics piping systems — Polyethylene (PE) pipes and fittings for water supply*

ISO 4437 (all parts), *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE)*

ISO 4633, *Rubber seals — Joint rings for water supply, drainage and sewerage pipelines — Specification for materials*

ISO 21225-2:2018(E)

ISO 8772, *Plastics piping systems for non-pressure underground drainage and sewerage — Polyethylene (PE)*

ISO 12176-1, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 1: Butt fusion*

ISO 12176-2, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 2: Electrofusion*

ISO 16010, *Elastomeric seals — Material requirements for seals used in pipes and fittings carrying gaseous fuels and hydrocarbon fluids*

EN 681-1, *Elastomeric seals — Material requirements for pipe joint seals used in water and drainage applications — Part 1: Vulcanized rubber*

EN 681-2, *Elastomeric seals — Material requirements for pipe joint seals used in water and drainage applications — Part 2: Thermoplastic elastomers*

EN 681-3, *Elastomeric seals — Material requirements for pipe joint seals used in water and drainage applications — Part 3: Cellular materials of vulcanized rubber*

EN 681-4, *Elastomeric seals — Material requirements for pipe joint seals used in water and drainage applications — Part 4: Cast polyurethane sealing elements*

EN 682, *Elastomeric seals — Material requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids*

EN 1555-1, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 1: General*

EN 1555-2, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 2: Pipes*

EN 1555-3, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 3: Fittings*

EN 1555-5, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 5: Fitness for purpose of the system*

EN 12201-1, *Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 1: General*

EN 12201-2, *Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 2: Pipes*

EN 12201-3, *Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 3: Fittings*

EN 12201-5, *Plastics piping systems for water supply, and for drainage and sewerage under pressure — Polyethylene (PE) — Part 5: Fitness for purpose of the system*

EN 12666-1, *Plastics piping systems for non-pressure underground drainage and sewerage — Polyethylene (PE) — Part 1: Specifications for pipes, fittings and the system*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply.

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 General

3.1.1**CCTV system**

system comprised of cameras, recorders, interconnections and displays that are used to inspect pipelines

3.1.2**characteristic**

property, dimension or other feature of a material or component

3.1.3**coated pipe**

pipe with a peelable, contiguous thermoplastic additional layer on the outside of the pipe

3.1.4**installed pipe**

replacement pipe after installation

3.1.5**maintenance**

routine work undertaken to ensure the continuing performance of an asset

3.1.6**pipe with co-extruded layers**

pipe with smooth internal and external surface, having co-extruded layers on either or both the outside and inside of the pipe, where all layers have the same MRS rating

3.1.7**pipeline system**

interconnecting pipe network for the conveyance of fluids

3.1.8**rehabilitation**

measures for restoring or upgrading the performance of existing pipeline systems, including renovation, repair and replacement

3.1.9**renovation**

work incorporating all or part of the original fabric of the pipeline, by means of which its current performance is improved

3.1.10**repair**

rectification of local damage

3.1.11**replacement**

construction of a new pipeline, on or off the line of an existing pipeline, where the function of the new pipeline system incorporates that of the old

3.1.12**replacement pipe**

new pipe installed for rehabilitation purposes

3.1.13**replacement system**

replacement pipe and all relevant fittings for trenchless replacement on or off an existing pipeline for the purposes of rehabilitation

3.1.14

solid wall single layered pipe

pipe with smooth internal and external surface, extruded from the same compound/formulation throughout the wall

3.1.15

system test pressure

STP

pressure applied to the installed pipeline system in order to ensure its integrity and leaktightness

3.1.16

technique family

group of renovation or trenchless replacement techniques which are considered to have common characteristics for standardization purposes

3.1.17

trenchless replacement

replacement without opening trenches other than small excavations to provide access for the particular technique

3.2 Techniques

The various techniques for trenchless replacement of underground networks, within the scope of pipeline rehabilitation techniques generally, are shown schematically in [Figure 2](#).

Definitions of technique families outside the scope of this document are given in ISO 11295.

The technique families within the scope of this document are defined as follows.

3.2.1

horizontal directional drilling

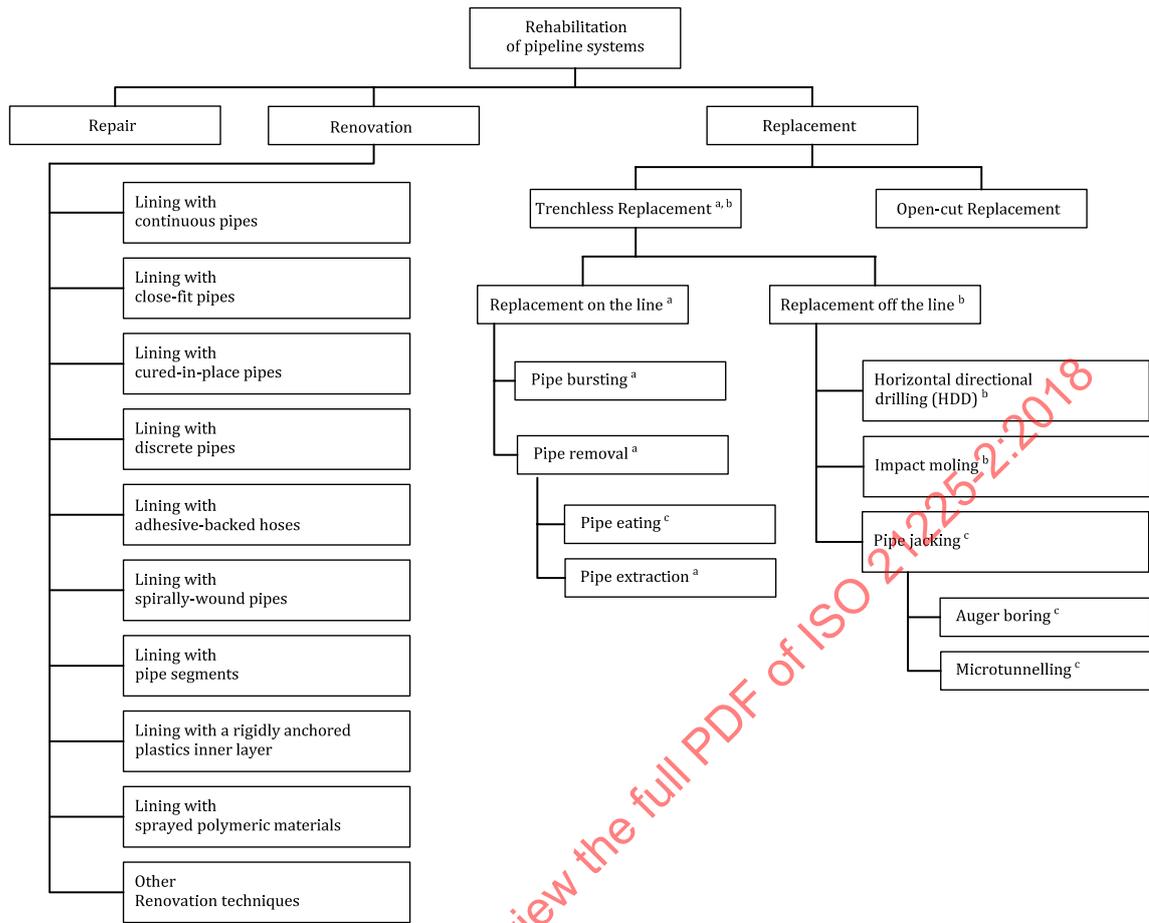
HDD

off the line replacement method in which a pilot bore is drilled using a steerable drilling head connected to flexible rods and then the bore is enlarged by reamers up to the diameter required for the pipe or pipes to be subsequently pulled/pushed into place

3.2.2

impact moling

off the line replacement method in which pipes are pulled in behind a pneumatically powered soil displacement hammer



- a This document is applicable.
- b In scope of ISO 21225-2.
- c Outside scope of ISO 21225, see ISO 11295[1].

Figure 2 — Technique families for trenchless replacement of underground pipeline networks using plastics pipes, within the scope of pipeline rehabilitation techniques

3.3 Geometrics

3.3.1

minimum bending radius

minimum radius at any point throughout the length of the pipeline, measured to the longitudinal axis of the pipe

Note 1 to entry: This is usually expressed as a multiple of the pipe diameter.

3.3.2

minimum mean outside diameter

$d_{em,min}$

minimum value of the mean outside diameter as specified for a given nominal size

[SOURCE: ISO 4427-1:2007, 3.1.1.6]

**3.3.3
minimum wall thickness at any point**

e_{\min}
minimum value of the wall thickness at any point around the circumference of a component as specified

[SOURCE: ISO 4427-1:2007, 3.1.1.11]

**3.3.4
nominal outside diameter**

d_n
specified outside diameter, in millimetres, assigned to a nominal size DN/OD

Note 1 to entry: For thermoplastics solid-wall components, the value of nominal outside diameter, is identical to the minimum mean outside diameter, $d_{em,\min}$.

[SOURCE: ISO 4427-1:2007, 3.1.1.3, modified by addition of Note 1 to entry.]

**3.3.5
nominal thickness of the coating**

e_{coating}
arithmetic mean of a number of measurements of the coating thickness around the circumference and in the same cross-section of a component

**3.3.6
nominal wall thickness**

e_n
numerical designation of the wall thickness of a component, which is a convenient round number, approximately equal to the manufacturing dimension in millimetres

Note 1 to entry: For thermoplastics solid-wall components, the value of nominal wall thickness, e_n , is identical to the specified minimum wall thickness at any point, e_{\min} .

[SOURCE: ISO 4427-1:2007, 3.1.1.9, modified by addition of Note 1 to entry.]

**3.3.7
out-of-roundness**

difference between the measured maximum and the measured minimum outside diameter in the same cross-sectional plane of the pipe

**3.3.8
standard dimension ratio
SDR**

ratio of the nominal outside diameter, d_n , to its nominal wall thickness, e_n

**3.3.9
wall thickness**

e
value of the measurement of the wall thickness at any point around the circumference of a component

3.4 Materials

**3.4.1
compound/formulation**

clearly defined homogenous mixture of base polymer with additives, e.g. anti-oxidants, pigments, stabilisers and others, at a dosage level necessary for the processing and intended use of the final product

**3.4.2
drilling mud**

fluid created by mixing water and additives to facilitate drilling and transport of drill cuttings from the drill bit to the surface

3.4.3**lower confidence limit of the predicted hydrostatic strength** σ_{LPL}

quantity, with the dimensions of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength at a temperature θ and time t

Note 1 to entry: It is expressed in megapascals.

3.4.4**melt mass-flow rate****MFR**

value relating to the viscosity of the molten material at a specified temperature and load

Note 1 to entry: It is expressed in grams per 10 min (g/10 min).

3.4.5**minimum required strength****MRS**

value of σ_{LPL} , rounded down to the next smaller value of the R10 series or R20 series, depending on the value of σ_{LPL}

Note 1 to entry: R10 and R20 series are the Renard number series according to ISO 3 and ISO 497.

3.4.6**oxidation induction time****OIT**

relative measure of a stabilized material's resistance to oxidative decomposition, determined by the calorimetric measurement of the time interval to the onset of exothermic oxidation of the material at a specified temperature in an oxygen or air atmosphere, under atmospheric pressure

3.5 Joints**3.5.1****butt fusion joint**

joint made by heating the planed ends of matching surfaces by holding them against a flat heating plate until the PE material reaches fusion temperature, quickly removing the heating plate and pushing the two softened ends against one another

3.5.2**electrofusion joint**

joint between a PE socket or saddle electrofusion fitting and a pipe or fitting with spigotted ends, made by heating the electrofusion fittings by the Joule effect of the heating element incorporated at their jointing surfaces, causing the material adjacent to them to melt and pipe and fitting surfaces to fuse

Note 1 to entry: A support sleeve inserted into the pipe bore can be used to provide a permanent support for the PE pipe to prevent creep in the pipe wall under radial compressive forces.

4 Symbols and abbreviated terms**4.1 Symbols**

For the purposes of this document the following symbols apply:

d_{em} mean outside diameter

$d_{em,min}$ minimum mean outside diameter

d_n nominal outside diameter

e	wall thickness
e_{\min}	minimum wall thickness at any point
e_n	nominal wall thickness
e_{coating}	nominal thickness of the coating

4.2 Abbreviated terms

CCTV	closed-circuit television
DN/OD	nominal size, related to the outside diameter
HDD	horizontal directional drilling
MFR	melt mass-flow rate
MRS	minimum required strength
OIT	oxidation induction time
SDR	standard dimension ratio
STP	system test pressure

5 Design aspects

For general information on design, including specific design parameters relevant to the technique families covered by this document refer to ISO 11295[1]. Further information particular to HDD is provided in [Annex B](#).

6 Material selection

6.1 Pipes and fittings

The characteristics of pipes and fittings shall conform to the requirements of all parts of the relevant application area standard from the following list:

- ISO 8772 for non-pressure drainage and sewerage networks;
- EN 12201 (Parts 1, 2, 3 and 5), for drainage and sewerage networks under pressure;
- ISO 4427 (all parts) for water supply under pressure;
- ISO 4437 (all parts) for networks supplying gaseous fuels.

In addition, any nominal diameter shall be permitted.

NOTE Developments are ongoing to amend these standards to include PE100 materials with a significantly enhanced resistance to slow crack growth.

Elastomeric sealing rings shall conform to the performance requirements:

- ISO 4633, for water and drainage;
- ISO 16010, for gas.

6.2 Regional requirements for pipes and fittings

In countries of the Single European Market, the applicable normative references indicated in 6.1 are replaced by the following.

For the characteristics of pipes and fittings:

- EN 12666-1 for non-pressure drainage and sewerage networks;
- EN 12201 (Parts 1, 2, 3 and 5) for drainage and sewerage networks under pressure;
- EN 12201 (Parts 1, 2, 3 and 5) for water supply under pressure;
- EN 1555 (Parts 1, 2, 3 and 5) for networks supplying gaseous fuels.

For the performance requirements of elastomeric sealing rings:

- EN 681 (Parts 1, 2, 3 or 4, as applicable) for water and drainage;
- EN 682 for gas.

6.3 Ancillary components

All materials used for ancillary components intended for water supply systems shall be suitable for such an application. They shall not cause any unacceptable deterioration of the quality of water with which they come into contact.

For valves including hydrants, the relevant pressure capability shall be specified in the open position and in the closed position so that the valve function and its tightness are assured under this pressure.

Certain replacement systems require mechanical, end-load-bearing fittings for service connections and pipe terminations. If applicable, full details of these shall be included in the installation manual.

7 Installation practice

7.1 Preparatory work

A comprehensive planning of the work shall be carried out, including:

- Route investigation by checking infrastructure maps;
- Site surveys to detect underground infrastructure;
- Ground/subsoil investigation by sampling and/or test drillings.

The location of underground infrastructure shall be decisive in determining the route and selecting the appropriate method of installation.

NOTE An example of guidance on the surveying and location of buried utilities is provided by BS PAS 128 [8].

7.2 Storage, handling and transport

The manufacturer's prescribed procedures for storage, handling and transport of all replacement system components shall be adhered to.

Precautions shall be taken to ensure that no excessive damage is caused to the replacement pipe during unloading, site handling, storage and installation. In this context, excessive damage shall mean any scratch which is more than 10 % of the wall thickness in depth or the imposition of any severe bending operation, which results in a permanent kink, crease or fold.

The replacement pipe shall be stored on reasonably level ground, free of large sharp stones, debris or litter, to avoid potentially damaging point-loading.

In general, and in the absence of any specific handling requirements, these precautions shall include the use of webbing slings in place of wire rope or chains, and the use of spreader beams for pipe lengths in excess of 12 m. Where the system designer specifies handling requirements, these shall prevail.

The replacement pipe shall be transported on a flat-bed vehicle, free of nails or other projections or on a purpose-built trailer designed to carry the rehabilitation pipe as a free-standing coil or wound on to a drum. Before being loaded, the replacement pipe shall be visually checked for any damage.

Pipe ends shall be securely sealed to prevent contamination of the pipe by moisture and/or dirt under storage, handling and transport.

For pipes of 600 mm diameter or larger, a suitable plug or other closure, which also prevents ovality or other deformation is recommended.

7.3 Equipment

7.3.1 General

All equipment shall be as specified by the system designer and/or installer.

All equipment introduced into the installed pipe shall be constructed and maintained so as to prevent any damage or contamination to the installed pipe.

Schematic representations of the equipment used for the techniques described in this document are provided in ISO 11295.

7.3.2 Inspection equipment

Inspection equipment (CCTV system) shall provide a clear picture of all parts of the installed pipe. This shall include a full colour picture and recording/replay facilities complete with slow motion and frame by frame replay. The recording shall be labelled on screen with full location, meterage, pipe type and size and date information.

7.3.3 Lifting equipment

All lifting equipment shall be covered by current test certification.

7.3.4 Butt fusion equipment and debanding equipment

Butt fusion equipment shall be capable of producing joints between PE pipes or PE pipes and fittings under site conditions and shall comply with ISO 12176-1. In addition to the heater plate, the equipment shall include such clamping, re-rounding and trimming systems as to ensure alignment and matching of the pipe ends.

If an external debander is used, this shall be capable of removing the bead cleanly in one continuous strip without damage to the pipe surface. If an internal debander is used, this shall not cause damage to the internal pipe surface.

A shelter shall be provided to avoid fusion joint contamination from water and dust and to generally maintain a clean and warm working environment. The ends of the pipe string shall be plugged to prevent cold air blowing through, which could otherwise adversely affect the fusion joint.

7.3.5 Pipe skids/rollers

Depending on the technique, pipe skids or rollers shall be used. These shall minimize frictional loads and prevent damage to the pipe as it is moved during the butt fusion and installation processes.

7.3.6 HDD equipment

The equipment required for HDD comprises:

- A drilling machine with hollow flexible rods and a drilling head, of which there are several types for different ground conditions.
- Tracking equipment providing information on the location and depth of the drilling head, as well as operating parameters, such as drilling head pitch angle, clock face orientation, and temperature.
- A back reamer or series of back reamers for enlarging the bore, of which there are several types for different ground conditions.
- A unit for mixing, pumping, and recycling the drilling mud (also named drilling fluid).
- For large diameter installations where the volume of drilling mud is considerable, additional facilities as necessary for material storage, lagoon settlement and spoil disposal.

The first operation is to create a small diameter pilot bore, in which the drilling machine pushes and rotates the flexible rods fitted with a suitable drilling head, along the selected path. This operation shall be steerable, generally using a slant head drill in soft ground, or a tri-cone mud motor drill in rock.

A proportion of the drilled material is flushed from the bore by the drilling mud, which is pumped in through the hollow drill rods to the drilling head, and also serves to lubricate and cool the drilling head and support the bore. The drilling mud can also be used to power the drill head by means of a mud motor. The remaining material is compacted into the surrounding ground except when drilling in rock. This is pre-determined by assessment of the ground conditions and selection of drilling head.

Next, when the drilling head emerges at the end of the bore, it is removed from the drilling rods and replaced by a back reamer. This is of a larger diameter than the drilling head, and as it is pulled back and rotated by the drilling machine, it enlarges the bore through a mix of cutting and compaction except when drilling in rock – again pre-determined based on the ground conditions encountered and the desired effect of the process. This operation is repeated as necessary using bigger reamers until the bore is large enough for the pipe to be installed.

To ensure that the bore is clear for insertion of the pipe a reamer or proving piece may be pulled back and forces monitored from the drill rig to ensure these are low and consistent, indicating a clear bore path. After this the pipe is generally attached to the final reamer, via a swivel to prevent the pipe being rotated, and then pulled back to the drilling machine. To ensure that the pipe is not over stressed during pulling in, a load cell shall be inserted between the swivel and the pipe. The load applied to the pipe shall be displayed and recorded throughout the installation.

Throughout the entire operation the bore shall be kept completely filled with drilling mud. This is generally a bentonite mixture which shall be available in appropriate quantity and maintained at the correct consistency to fulfil its three functions of a) creating a filter cake to keep the hole open when drilling stops, b) continuously flowing through the bore when drilling is in progress to suspend and extract the drill cuttings, and c) providing lubrication to drilling and back reaming operations.

NOTE On projects where large volumes of drilling mud are required, a recycling system to separate out the cuttings and maintain the correct drilling mud consistency for re-use can be provided.

7.3.7 Impact moling equipment

This generally comprises a percussive displacement hammer, which is pneumatically driven together with a compressor as appropriate, connection hoses, an oil lubricator, as well as a launch and aiming cradle.

The impact mole has a slim torpedo-shaped steel body containing a heavy sliding piston system or 'hammer' which, when air pressure is applied, moves rapidly back and forth. At the end of each forward stroke the piston impinges on the back of a sliding or fixed head in the nose of the mole, causing this to impact upon and displace the ground immediately in front of it. Friction between the mole body and the surrounding ground prevents the mole moving back during this impact or the return stroke of the

hammer, and the overall effect is for the mole to proceed through displaceable ground in a straight line, providing there are no substantial obstacles to deflect it. Bore speeds vary depending on the ground density.

NOTE Impact moles are generally unguided but steerable variants are also available.

The impact mole is aligned along the intended bore path from a launch pit, using the launch and aiming cradle, at a depth of cover no less than 10 times the diameter of the impact mole, to minimize the possibility of creating surface heave. On operation the impact mole displaces the ground creating a hole from the launch pit to the reception pit. It should be noted that obstructions along the bore path may cause the impact mole to deviate from its intended line and that the effect of poor alignment of the mole at start of the operation is exacerbated the further the bore proceeds.

The common method of installing the product pipe is to simultaneously pull it behind the mole while creating the borehole, as this reduces the risk of the borehole collapsing. However, due to the risk of contamination from the oil mist in the exhaust of a pneumatic mole, this method is expressly excluded for drinking water applications, and the product pipe must be pulled through after the bore is completed, either attached to the air hose, or attached to the nose of the mole which is then reversed, or by pulling in a protective duct behind the mole and installing the product pipe through this duct afterwards.

An impact mole of diameter some 15 % to 20 % greater than the diameter of the product pipe should be used to allow for ground shrinkage in standard ground conditions.

During installation by any of these means, the product pipe shall be fitted with a sealed pulling head or nose cone to prevent ingress of dirt or other contamination.

In some circumstances the impact mole can be reversed along the original bore path with the product pipe attached to the front end. This procedure is used for cable and sewerage lateral installation.

7.3.8 Electrofusion equipment

The electrofusion control box shall conform to ISO 12176-2. In addition:

- Pipe preparation shall be carried out using a mechanical scraper, wherever possible.
- Robust alignment and re-rounding clamps shall be used.
- Where requested by the client, fusion parameters and joint location details shall be recorded by a data logging system.

7.4 Installation

The installer shall ensure that the rehabilitation process shall not damage any adjacent infrastructure.

The installer shall employ competent, trained staff with appropriate certification, where applicable, to carry out the work.

The installer shall prepare an installation manual detailing all the procedures required to carry out the work.

Attention is drawn to the need to assess the risk and methods of mitigation to avoid contamination of the environment by dust, sand or slurry contamination. Dust suppression is particularly important in the vicinity of fusion welding.

The installation manual shall specify the method of installation, including the equipment, new pipe termination and reconnection to existing network and customer service pipes, inspection and testing, and all necessary parameters according to the requirements of the method described.

This manual shall also include:

- a) For HDD, calculation of pulling forces required to advance a reaming tool and pull in the new pipe, as a function of pipe diameter, soil type and depth of burial;
- b) Maximum outside diameter of replacement pipe relative to diameter of reaming tool or impact mole, as applicable;
- c) Maximum allowable pulling force on the replacement pipe as declared by the pipe manufacturer as a function of temperature;

NOTE The maximum pulling force is usually calculated to limit the maximum stress to not more than 50 % of the tensile yield stress of the material.

- d) Minimum bending radius during installation, as declared by the pipe manufacturer as a function of SDR and temperature, and the associated minimum length of access pit as a function of excavation depth;
- e) Details of the type of fittings to be used.

The installer shall provide a detailed record of the as-installed bore path. The accuracy to which this information is provided shall be stated by the installer. This information shall be provided in a format agreed between the installer and the client.

Where pipes are jointed to form one pipe string on site using butt-fusion, a method statement for internal de-beading, where required, and for external de-beading shall be provided and shall specify at least:

- 1) how the bead is removed;
- 2) how the bead and related joint are identified;
- 3) how the bead is to be examined for quality control purposes, and stored for future reference.

7.5 Process-related inspection and testing

The required measurements and tests relating to the installation process and the methods by which the measurements shall be taken or the tests conducted, shall be documented in the installation manual.

7.6 Finishing off

On completion of the rehabilitation process, the installation equipment shall be dismantled, any corrosion protection facilities disrupted by the installation of the new pipe shall be reinstated and the ends of the installed replacement pipe prepared for subsequent reconnection.

7.7 Connection to the existing pipeline system

In the case of pressure applications, where applicable, the ends of the replacement pipe shall be anchored and sealed in such a way as to provide a leak tight connection to the existing pipeline network. The method of anchoring the replacement pipe ends shall be such that no longitudinal forces are transmitted onto the existing network pipes. Any service connections, bends, valves, branches and laterals shall be transferred via local excavations, in a manner to be documented as specified by the client (man-entry access).

8 Fitness for purpose

8.1 General

All elements of the installed replacement system shall be able to withstand without leakage, and for the full design life, all stresses arising from operation within the system parameters and any residual stresses caused by the installation or thermal effects.

The system supplier shall document compliance with all relevant mechanical requirements.

The installed replacement system shall have a minimum free bore in accordance with the design requirements (e.g. flow capacity and routine maintenance).

NOTE Free bore has two aspects. The first (cross-sectional) free bore is to ensure that adequate cross-section is retained for flow capacity. The second (dimensional) free bore is to ensure that adequate clearance is retained for routine maintenance equipment to be used or for access to be maintained in the installed pipeline system.

Out-of-roundness of the replacement system after installation (including any caused by the installation of the replacement pipe) shall not exceed any maximum value specified by design or otherwise agreed between the client and installer.

For drinking water applications, the installed system shall ensure that there is no unacceptable deterioration of water quality.

IMPORTANT — Attention is drawn to the need for care in respect of the potential for any residues of materials, lubricants or other chemical agents from the installation process to damage the surrounding environment.

8.2 Final inspection

If specified by the client, the finished replacement pipe shall be inspected internally.

NOTE Where specified, testing to verify leaktightness of the installed replacement system in accordance with 8.4 can take place in stages. For example, in order to verify leaktightness of the installed pipe, including any integral joints only, testing of leaktightness can be carried out before the reconnection of any service or lateral connections.

External inspection shall be carried out of the leading replacement pipe end, and where possible, at other places along the installed lengths where the pipe is exposed (e.g. at service connection excavations), to verify that the external surface of the pipe is not scratched to a depth greater than 10 % of the wall thickness. Where the pipe wall has scratches greater than 10 % of the wall thickness, the installed length affected shall be replaced.

8.3 Pressure testing

In the case of pressurized applications, the installed replacement system shall meet the STP to ensure the integrity of pipes, joints, fittings and other components, such as anchor blocks.

The STP methodology and the pass/fail criteria shall be agreed on between the client and the system installer and documented in the installation manual.

8.4 Disinfection

In the case of water supply pipelines, the measures taken to disinfect the installed replacement system after final inspection shall be specified by the client and documented in the installation manual.