INTERNATIONAL STANDARD

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Second edition
2018-10

Plastics piping systems for renovation of underground gas supply networks —

Part 3: Lining with close-fit pipes

Systèmes de canalisations en plastique pour la rénovation des réseaux enterrés de distribution de gaz —

Partie 3: Tubage par tuyau continu sans espace annulaire

Reference number
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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 of 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 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*

This second edition cancels and replaces the first edition (ISO 11299-3:2011), which has been technically revised.

The main changes compared to the previous edition are as follows:

Figure 1 and Clauses 1, 2, 3.3, 3.4, 3.6, 5.7, 5.8, 6, 8.4, 8.5, and 9.2 to 9.8 have been technically revised.

A list of all parts in the ISO 11299 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document is a part of a System Standard for plastics piping systems of various materials used for the renovation of existing pipelines in a specified application area. System Standards for renovation dealing with the following applications are either available or in preparation:

— ISO 11296, *Plastics piping systems for renovation of underground non-pressure drainage and sewerage networks*;

— ISO 11297, *Plastics piping systems for renovation of underground drainage and sewerage networks under pressure*;

— ISO 11298, *Plastics piping systems for renovation of underground water supply networks*;

— ISO 11299, *Plastics piping systems for renovation of underground gas supply networks* (this series of standards).

These System Standards are distinguished from those for conventionally installed plastics piping systems by the requirement to verify certain characteristics in the "as-installed" condition, after site processing. This is in addition to specifying requirements for plastics piping systems components "as manufactured".

This System Standard comprises a:

— *Part 1: General*

and all applicable renovation technique family-related parts, which, for gas supply networks , include or potentially include the following:

— *Part 2: Lining with continuous pipes*;

— *Part 3: Lining with close-fit pipes* (this document);

— *Part 4: Lining with cured-in-place pipes*;

— *Part 6: Lining with adhesive-backed hoses*;

— *Part 11: Lining with inserted hoses*.

The requirements for any given renovation technique family are given in Part 1, applied in conjunction with the relevant other part. For example, ISO 11299-1 and this document together specify the requirements relating to lining with close-fit pipes. For complementary information, see ISO 11295. Not all technique families are pertinent to every area of application and this is reflected in the part numbers included in each System Standard.

A consistent structure of clause headings has been adopted for all parts of ISO 11299, in order to facilitate direct comparisons across renovation technique families.

Figure 1 shows the common part and clause structure and the relationship between ISO 11299 and the System Standards for other application areas.

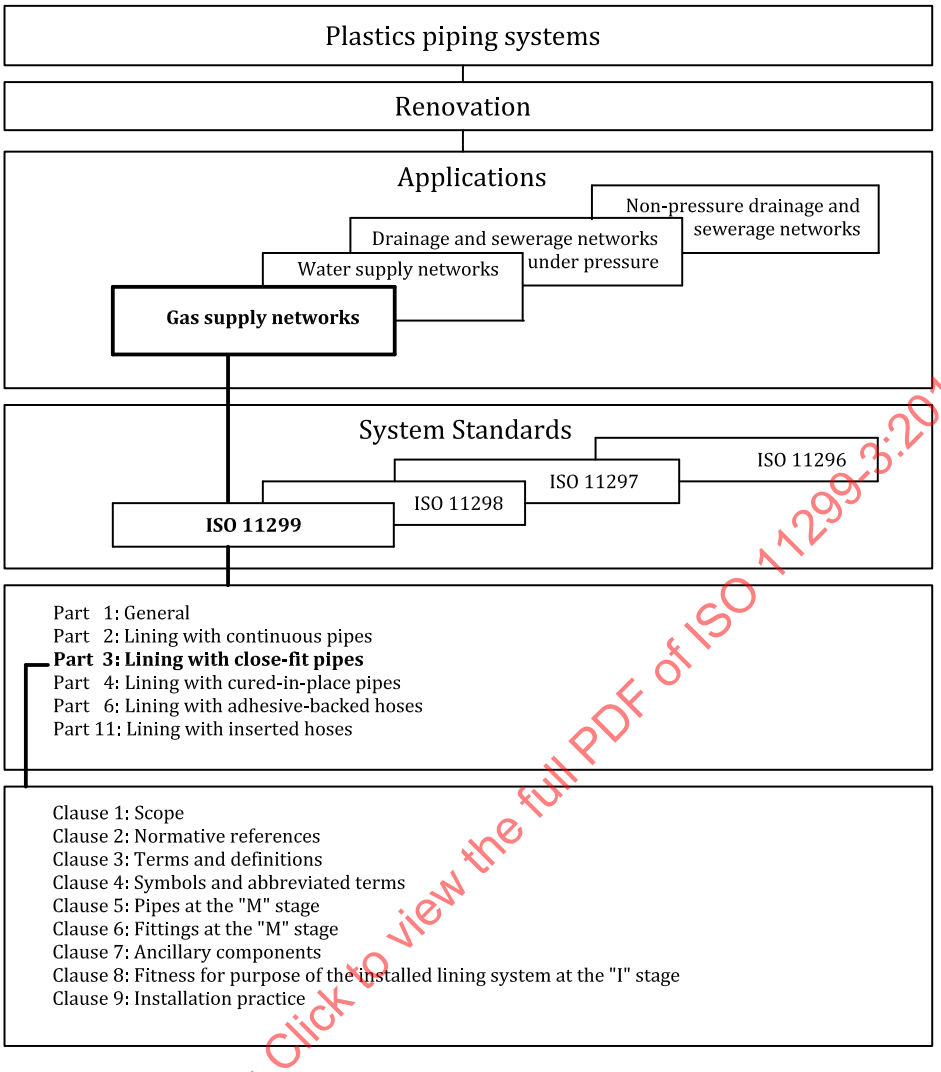

Figure 1 — Format of the renovation system standards

Plastics piping systems for renovation of underground gas supply networks —

Part 3:
Lining with close-fit pipes

1 Scope

This document, in conjunction with ISO 11299-1, specifies requirements and test methods for close-fit lining systems intended to be used for the renovation of gas supply networks.

It applies to pipes and fittings, as manufactured, as well as to the installed lining system. It is applicable to polyethylene (PE) pipe of either solid wall single layer or co-extruded layer construction, which is reduced in the factory or on site to provide a close-fitting independent or interactive pressure pipe liner, as well as associated fittings and joints for the construction of the lining system. This document is not applicable for coated PE pipes having a peelable, contiguous, thermoplastics additional layer on the outside of the pipes.

It is applicable to PE pipes, fittings and assemblies intended to be used at an operating temperature of 20 °C as the reference temperature.

NOTE For other operating temperatures, guidance is given in ISO 4437-5:2014.

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 3126, *Plastics piping systems — Plastics components — Determination of dimensions*

ISO 4437-1, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 1: General*

ISO 4437-2, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 2: Pipes*

ISO 4437-3, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 3: Fittings*

ISO 4437-4, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 4: Valves*

ISO 4437-5:2014, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 5: Fitness for purpose of the system*

ISO 11299-1:2018, *Plastics piping systems for renovation of underground gas supply networks — Part 1: General*

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*

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 1555-4, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 4: Valves*

EN 1555-5:2010, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 5: Fitness for purpose of the system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11299-1 and the following 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 https://www.iso.org/obp

3.1 General

3.1.1
compound formulation
clearly defined homogenous mixture of base polymer with additives, e.g. antioxidants, pigments, stabilizers and others, at a dosage level necessary for the processing and intended use of the final product

3.1.2
solid wall single layered pipe
pipe with smooth internal and external surface, extruded from the same compound/formulation throughout the wall

3.1.3
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

3.1.4
close fit
situation of the outside of the installed liner relative to the inside of the existing pipeline, which can either be an interference fit or include a small annular gap resulting from shrinkage and tolerances only

3.1.5
close-fit pipe
continuous lining pipe of thermoplastic material reshaped or otherwise expanded after insertion to achieve a close fit to the existing pipeline

3.2 Techniques

No additional definitions apply.

3.3 Characteristics

3.3.1
MRS
minimum required strength
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.

3.3.2
MFR
melt mass-flow rate
rate of extrusion of a molten resin through a die of specified length and diameter under prescribed conditions of temperature, load and piston position in the cylinder of an extrusion plastometer, the rate being determined as the mass extruded over a specified time

Note 1 to entry: MFR is expressed in units of grams per 10 min.

[SOURCE: ISO 1133-1:2011, 3.1]

3.4 Materials

3.4.1
crazing
microstructural phenomenon associated with the short-term application of tensile bending strain exceeding the material-related critical yield strain

3.5 Product stages

No additional definitions apply.

3.6 Service conditions

3.6.1
maximum operating pressure
MOP
maximum effective pressure of gas in a piping system, expressed in bar[1)], which is allowed in continuous use

Note 1 to entry: It takes into account the physical and mechanical characteristics of the components of the piping system (and the influence of the gas on these characteristics) and it is calculated using the following formula:

$$\mathrm{MOP}=\frac{20\times \mathrm{MRS}}{C\times(\mathrm{SDR}-1)}$$

[SOURCE: ISO 17885:2015, 3.1.11]

3.6.2
design coefficient
C
coefficient with a value greater than 2, which takes into consideration service conditions as well as properties of the components of a piping system other than those represented in the lower confidence limit

3.7 Joints

3.7.1
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

1) 1 bar =0,1 MPa = 0,1 N/mm^2 = 10^5·N/m^2.

3.7.2
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

3.7.3
mechanical joint
joint made by assembling a PE pipe to another PE pipe, or any other element of the piping system, using a fitting that generally includes a compression part, to provide for pressure integrity, leaktightness and a gripping part to provide resistance to end loads

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.

3.7.4
fusion compatibility
ability of two similar or dissimilar PE materials to be fused together to form a joint which conforms to the performance requirements of this document.

4 Symbols and abbreviated terms

4.1 Symbols

For the purposes of this document, the symbols given in ISO 11299-1 and the following apply.

C	design coefficient
d_e	outside diameter (at any point)
d_{manuf}	original circular outside diameter of the pipe (before processing for insertion)
$e_{m,\,max}$	maximum mean wall thickness
σ_{LPL}	quantity with the dimensions of stress, which represents the 97,5 % lower confidence limit of the predicted hydrostatic strength at temperature T, and time t
T	temperature at which stress rupture data have been determined
t	time to occurrence of a leak in the pipe

4.2 Abbreviated terms

For the purposes of this document the following abbreviated terms apply:

LPL	lower confidence limit of the predicted hydrostatic strength
MFR	melt mass-flow rate
MOP	maximum operating pressure
MRS	minimum required strength
PE	polyethylene
R	series of preferred numbers, conforming to the Renard series

5 Pipes at the "M" stage

5.1 Materials

The compound(s) from which the pipes are made shall conform to ISO 4437-1 and ISO 4437-2.

5.2 General characteristics

General characteristics of solid wall single layered pipes and pipes with co-extruded layers shall conform to the requirements of ISO 4437-2.

5.2.1 Appearance

When viewed without magnification, the internal and external surfaces of the pipe shall be smooth, clean and free from scoring, cavities and other defects, which would prevent conformity to this document.

5.2.2 Colour

Pipes shall be black (PE 80 or PE 100), yellow (PE 80), or orange (PE 100). In addition, black PE 80 pipes can be identified by yellow stripes and black PE 100 pipes can be identified by yellow or orange stripes, according to national preference.

5.3 Material characteristics

The material from which the pipes are made shall conform to the requirements specified in ISO 4437-2. The requirements for OIT and MFR shall apply to each individual layer.

5.4 Geometric characteristics

The pipe diameter, wall thickness and shape in the "M" stage depend on the specific close-fit lining technique. "M" stage dimensions needed to obtain specified "I" stage dimensions (see 8.4) shall be declared, with their tolerances, by the manufacturer.

In the case of factory-folded pipes, variations in wall thickness in one cross-section can be present at the "M" stage. This is acceptable, as long as the folded pipe has the property to obtain a wall thickness in accordance with 8.4 when installation is complete.

5.5 Mechanical characteristics

When tested in accordance with the method given in Table 2, the pipe shall conform to the requirements in the table.

Table 2 — Mechanical characteristics of pipes

Characteristic	Requirement	Test parameters		Test method
		Parameter	Value	
Hydrostatic strength at 80 °C (165 h)	ISO 4437-2[a]			
[a] The pipe shall be reverted in the case of factory-folded pipes.				

5.6 Physical characteristics

Physical characteristics shall conform to those specified in ISO 4437-2.

Longitudinal heat reversion shall be applicable to the pipe, inclusive of any coloured identification layer.

In the case of factory-folded heat-reverted pipes, the pipe shall additionally conform to the requirement for memory ability specified in Annex A.

5.7 Jointing

Butt fusion joints shall conform to ISO 4437-2 and ISO 4437-5. All butt fusion joints shall be externally, and if required by the client, internally de-beaded.

Butt fusion joints shall not be made between folded pipes prior to reversion.

NOTE The joining of circular pipes to form a string prior to site processing is considered as part of the "M" stage.

5.8 Marking

Pipes shall be marked in accordance with ISO 11299-1.

Where marked in accordance with ISO 11299-1:

— Under item c) specified in ISO 11299-1:2018, 5.8, the nominal size marked shall be DN/OD;

— Under item d) specified in ISO 11299-1:2018, 5.8, the dimension marked shall be SDR.

In addition, the pipe can be marked with the following optional information: MFR.

5.9 Regional requirements for pipes

In countries of the Single European Market, the parts of ISO 4437 (e.g. ISO 4437-1, ISO 4437-2, ISO 4437-5) specified as normative references in 5.1 to 5.8 are replaced by the corresponding parts of EN 1555 (EN 1555-1, EN 1555-2, EN 1555-5).

6 Fittings at the "M" stage

6.1 Requirements

Fittings shall conform to the requirements of ISO 4437-3. Where required for compatibility with pipe dimensions in accordance with Table 3, fittings with other geometric characteristics are acceptable.

6.2 Marking

Each fitting shall be marked either in accordance with ISO 11299-1 or in accordance with ISO 4437-3.

6.3 Regional requirements for fittings

In countries of the Single European Market, ISO 4437-3 specified as normative reference in 6.1 to 6.2 is replaced by EN 1555-3.

7 Ancillary components

7.1 Requirements

Plastic bodied valves shall conform to the requirements of ISO 4437-4. If valves constructed of other materials are specified, full details including reference standards shall be documented in the installation manual.

NOTE Interactive pressure pipe liners can rely on the use of technique-dependent, mechanical fittings for end connections and service connections. The mechanical fittings provide the connection between the liner, which is generally thin walled, and the rest of the pipeline system, by clamping the liner wall inside/outside. By means of a compression part, the fitting provides pressure integrity, leaktightness and resistance to end loads. The fitting generally includes a support sleeve, either inserted into or assembled around the liner, and can also include a grip ring. The mechanical fitting can be supplied for field assembly. See also ISO 17885.

7.2 Regional requirements for ancillary components

In countries of the Single European Market, ISO 4437-4 specified as normative reference in 7.1 is replaced by EN 1555-4.

8 Fitness for purpose of the installed lining system at the "I" stage

8.1 Materials

Any combination of pipes, fittings and valves for heat fusion conforming to Clauses 5, 6 and 7 respectively, may be used, provided that fusion compatibility has been demonstrated in accordance with ISO 4437-5:2014, Clause 4.

8.2 General characteristics

The internal surface of the pipe shall be smooth, and free from scoring and other defects which could impair the functionality.

NOTE A feature of close-fit pipes is that the lining can conform to the surface characteristics of the existing pipe.

8.3 Material characteristics

There are no additional requirements for material characteristics.

8.4 Geometric characteristics

Samples of pipes taken from actual or simulated installations shall have wall thicknesses conforming to the requirements of Table 3, whereby relevant dimensions shall be measured in accordance with ISO 3126 at a temperature of (23 ± 2) °C.

Table 3 — Pipe wall thicknesses as installed

Dimensions in millimetres

Nominal outside diameter[a]	Standard dimension ratio[a]							
	SDR 11		SDR 17		SDR 17,6		SDR 26	
	Wall thickness[b]							
d_n	e_{min}	$e_{m,max}$	e_{min}	$e_{m,max}$	e_{min}	$e_{m,max}$	e_{min}	$e_{m,max}$
100	9,1	10,7	5,9	7,1	5,7	6,9	3,9	4,9
125	11,4	13,3	7,4	8,8	7,1	8,5	4,8	5,9
150	13,7	15,9	8,9	10,5	8,6	10,2	5,8	7,0
200	18,2	20,9	11,9	13,9	11,4	13,3	7,7	9,2
225	20,5	23,5	13,4	15,6	12,8	14,9	8,6	10,2
250	22,7	26,0	14,8	17,1	14,2	16,4	9,6	11,3
300	27,3	31,1	17,7	20,4	17,1	19,7	11,6	13,5
350	31,9	36,3	20,6	23,6	19,9	22,8	13,5	15,6
400			23,7	27,1	22,8	26,1	15,3	17,7
500			29,7	33,5	28,3	32,2	19,1	21,9
600							23,1	26,4

[a] Outside diameters and SDRs are examples; other sizes and SDRs are acceptable.

[b] Wall thickness requirements calculated as installed, both rounded up to the next greater 0,1 mm:

— $e_{min} = d_n/SDR$;

— $e_{m,max} = 1{,}12e_{min} + 0{,}5$ mm.

After installation and reversion, the liner shall have attained a cross-section within the host pipe such that the curvature is positive at all points around the circumference.

This is to limit the size of shape memory imperfection affecting resistance of the liner to buckling under net external hydrostatic pressure, and, where applicable, to enable connections to be made. Design considerations shall also provide that in the long term, the positive curvature is maintained under the normal operating pressure regime.

Full details of installation and future connection methodologies shall be included in the installation manual. If required by the client, the maximum degree of deformation remaining after reversion shall be agreed on and included in the project-specific installation manual.

NOTE If appropriate, a higher pressure than the operating pressure can be applied to achieve complete reversion.

If the installation of connections requires the use of dedicated fittings and assembly equipment, the installation manual should provide details of these.

8.5 Mechanical characteristics

When tested in accordance with the methods given in Table 4, pipes taken from actual or simulated installations in accordance with 8.8 shall have mechanical characteristics conforming to Table 4.

Table 4 — Mechanical characteristics of pipes

Characteristic	Requirement	Test parameters[a,b]		Test method
		Parameters	Value	
Hydrostatic strength at 20 °C (100 h)	ISO 4437-2			
Hydrostatic strength at 80 °C (1 000 h)				
Resistance to rapid crack propagation[c]				
Resistance to slow crack growth[c]				
Elongation at break				

[a] Where the test parameters cannot be met with a particular technique (e.g. limited product range, not including SDR 11), the test parameters shall be re-calculated accordingly.

[b] Where electrofusion saddles are offered as part of the lining system, the long-term integrity of the saddle/reverted pipe assembly shall be demonstrated in accordance with ISO 4437-5.

[c] The technique supplier shall demonstrate that the technique's own reduction/reforming process does not adversely affect this property; the test shall be done at least once on "I"-stage pipe samples.

Where liners are folded/unfolded (either in the factory or on site), there is a risk that crazing may occur at the tips of the folds, which, in the long term, can result in through-wall cracks and thus leakage. The possible occurrence of crazing depends on pipe material, folding technique, wall thickness and temperature. The risk of cracks increases with increasing wall thickness and decreasing temperature. The technique supplier should demonstrate that crazing would not occur with the pipe proposed to be applied with its technique under the prevailing ambient conditions.

Mechanical characteristics of the assembly, including all electrofusion joints, butt fusion joints and mechanical joints between pipes, fittings and ancillary components, shall conform to those specified in ISO 4437-5.

Where a mechanical joint applies radial compression, a cylindrical metal sleeve shall be inserted into the pipe end, providing permanent internal support to prevent creep.

8.6 Physical characteristics

There are no requirements for physical characteristics of the installed lining system.

8.7 Additional characteristics

There are no requirements for additional characteristics of the installed lining system.

8.8 Sampling

The sampling of the installed pipe shall conform to ISO 11299-1:2018, 8.8.

NOTE For process verification testing, samples can conveniently be taken either from the exposed end of an installed liner where this emerges from the host pipe or from a section of the liner installed in a length of simulated host pipe; see ISO 11299-1:2018, 9.4.3.

8.9 Regional requirements for the installed lining system

In countries of the Single European Market, the parts of ISO 4437 (e.g. ISO 4437-2 and ISO 4437-5) specified as normative references in 8.1 and 8.5 are replaced by the corresponding parts of EN 1555 (EN 1555-2 and EN 1555-5).

9 Installation practice

9.1 Preparatory work

There are no additional requirements for preparatory work.

9.2 Storage, handling and transport of pipes and fittings

Precautions shall be taken to ensure that no excessive damage is caused to the lining pipe during unloading, site handling and storage. 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.

Storing the lining pipe on reasonably level ground, free of large sharp stones, debris or litter, helps avoid potentially damaging point-loading.

When assessing damage to the pipe wall caused by scratches, the installer should be aware that further scratch damage may occur during installation.

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 lining 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 lining pipe as a free-standing coil or wound onto a drum. Before being loaded onto a trailer, the lining 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 ovalization or other deformation, is recommended.

Pipes that do not meet the above stated specifications shall be rejected, clearly marked and removed to a separate stock.

9.3 Equipment

9.3.1 Butt fusion and debeading 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 clamping, re-rounding and trimming systems to ensure alignment and matching of the pipe ends, and an external debeader capable of removing the bead cleanly in one continuous strip without damage to the pipe. If an internal debeader is used, this shall not cause damage to the internal pipe surface.

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

9.3.2 Reduction equipment

Depending on the lining technique, a reduction of the lining pipe may take place at the site. The reduction equipment shall be operated in accordance with the technique's specification.

Reduction or deformation equipment for use on site shall be free from sharp edges which could damage the internal or external surfaces of the pipe during deformation.

NOTE Damage can also be caused by debris passing undetected into the reduction equipment. This can be avoided by continuous inspection of the liner pipe immediately before and after it passes through reduction equipment, and before it enters the host pipe.

Any lubricant used in the reduction process shall be compatible with the lining material.

9.3.3 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.

9.3.4 Winching and rod-pulling equipment

Winching equipment consists of a winch connected to the replacement pipe by a winch cable and appropriate nose cone connection.

Rod pulling equipment consists of a hydraulic ram driven carriage, connected to the replacement pipe by a string of rods which screw or hook together, and an appropriate nose cone connection.

All pulling equipment shall have a means of displaying in real time, and recording graphically or numerically, the force applied to the pipe during installation. In the case of a winch, this shall be by directly measuring the load on the winch wire. In the case of a rod puller, this shall be by directly measuring either the load applied to the rods or the load applied to the nose cone.

For site reduced pipes a swivel shall be incorporated between the winch wire or rods and the nose cone. To achieve direct measurement of the force on the pipe a load cell is also generally required.

WARNING — All pulling operations are potentially dangerous and any exposed winch cable or puller rods should be guarded.

9.3.5 Pipe entry guides

Pipe entry guides shall be designed to prevent damage to the lining pipe during insertion in such a way that no part of the guide can become detached and pass accidentally into the host pipe.

9.3.6 Reforming equipment

Any equipment used to carry out the reforming or rerounding process shall be capable of providing the required conditions of pressure and temperature and shall be in accordance with the technique's specification.

9.3.7 Electrofusion equipment

Electrofusion equipment shall conform to ISO 12176-2. The power supply/controller and associated alignment and fixing clamps shall be such as to ensure fusion when following the manufacturer's guidelines for surface preparation and fusion.

9.3.8 Inspection equipment

Inspection equipment [closed-circuit television (CCTV)] shall provide a full colour picture and recording/replay facilities complete with slow motion and frame by frame replay, and shall provide a clear picture of all parts of the installed pipe. The recording shall be labelled on screen with full location, metreage, lining type and size and date information.

Inspection equipment (profiling) shall additionally provide calibrated profiles of the liner at any required location, and shall be capable of automatically identifying and recording all locations where

the liner profile exhibits a negative curvature and/or exceeds a preset deformation agreed between the client and the installer. Each profile shall be labelled on screen with location and degree of deformation.

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

The equipment shall conform to all relevant safety standards.

9.3.9 Lifting equipment

All lifting equipment shall be covered by current test certification and shall be operated only by trained personnel.

9.4 Installation

Installation shall follow the procedures detailed in the installation manual.

The installation manual shall specify all necessary parameters and details of the method of reforming the lining pipe to achieve a close fit. If applicable, the description of the reforming method and the installation parameters shall specify, according to the requirements of the technique concerned:

a) maximum and/or minimum values of any internal pressure to be applied;

b) maximum and/or minimum values of temperatures to be reached on the inside and/or outside surfaces of the pipe;

c) maximum pulling forces; minimum installation bending radii;

d) permitted ambient temperature range.

The manual shall also include details of the methods of jointing and of the type of fittings to be used, together with any special requirements.

Where pipes are jointed to form one string on site using butt fusion, the method of external debeading shall be specified. The method statement shall specify at least:

— how the bead is removed;

— how the bead and the related joint are identified;

— how the bead should be examined for quality control purposes and stored for future reference.

Where squeeze-off is used during the installation process, the squeezed-off section shall, if instructed by the client, be removed before the liner is put into service. Otherwise, the squeezed-off section shall be re-rounded and marked to prevent repeat squeezing of the same section.

NOTE Stainless steel support bands can be fitted to permanently reinforce squeezed-off positions, where appropriate.

For pipes expanded to fit an electrofusion coupler, a stiff internal supporting sleeve shall be installed to maintain melt pressure during fusion. The supporting sleeve shall have a design and dimensions which have been proven to give satisfactory joints, in accordance with ISO 4437-3, with the make and type of electrofusion couplers used.

9.5 Process-related inspection and testing

The lining pipe shall be inspected at the leading end, and where possible, at other places along the installed lengths where the pipe is exposed (e.g. at service connection windows), to verify that the external surface of the pipe is not scratched to a depth greater than 10 % of the wall thickness.