TECHNICAL SPECIFICATION

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Polyethylene pipes and fittings for the supply of gaseous fuels — Code of practice for design, handling and installation

Tubes et raccords en polyéthylène pour le transport de combustibles gazeux — Code de pratique pour la conception, la manutention et l'installation

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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 4, *Plastics pipes and fittings for the supply of gaseous fuels*.

This second edition cancels and replaces the first edition (ISO/TS 10839:2000), which has been technically revised.

The main changes are as follows:

— the whole document has been redrafted in order to improve its readability;

— clauses referring to the jointing processes have been transformed into normative annexes (see Annex A, Annex B and Annex C);

— the Scope has been updated to include hydrogen;

— Clause 2 and Clause 3 have been updated;

— various additional updates and corrections have been made throughout the document to reflect the current state of the art;

— information on socket fusion jointing procedures has been deleted as this is the subject of other published documents (see Annex D).

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.

Polyethylene pipes and fittings for the supply of gaseous fuels — Code of practice for design, handling and installation

1 Scope

This document presents a code of practice dealing with polyethylene (PE) pipes and fittings for buried pipeline systems outside buildings, conforming to the ISO 4437 series, and designed to transport gaseous fuels [as defined in ISO 4437-1, e.g. methane, liquified petroleum gas (LPG), manufactured gas and hydrogen] within the temperature range –20 °C to +40 °C. This document also gives appropriate temperature-related requirements.

The code of practice covers mains and service lines whose components are prepared for fusion or mechanical jointing. It also gives instructions for the design, storage, handling, transportation, laying conditions and fusion quality control of PE pipes and fittings as well as subsequent joint testing, backfilling, pipe system testing and commissioning.

NOTE For the renovation code of practice, reference is made to the ISO 11299 series and to ISO 11295 for classification and to the ISO 21225 series for further information for trenchless replacement.

The minimal requirements for the jointing methods are given in:

— Annex A (butt fusion);

— Annex B (electrofusion); and

— Annex C (mechanical jointing).

In some countries the use of heated-tools socket and saddle fusion is permitted; information on heated-tools fusion jointing techniques is given in Annex D.

In the case of ground movement or shaking (e.g. earthquakes, etc.) it can be necessary to implement precautions mentioned in this document following guidelines provided by authorities (e.g. Eurocode 8,[7] EN 12007-1:2012, Annex A,[8] etc.),

Workers' health and safety issues are outside the scope of this document.

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

ISO 4437-2:2014, *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, *Plastics piping systems for the supply of gaseous fuels — Polyethylene (PE) — Part 5: Fitness for purpose of the system*

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 12176-3, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 3: Operator's badge*

ISO 12176-4, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 4: Traceability coding*

ISO 12176-5, *Plastics pipes and fittings — Equipment for fusion jointing polyethylene systems — Part 5: Two-dimensional data coding of components and data exchange format for PE piping systems*

ISO 13950, *Plastics pipes and fittings — Automatic recognition systems for electrofusion joints*

ISO 17885:2021, *Plastics piping systems — Mechanical fittings for pressure piping systems — Specifications*

EN 12327, *Gas infrastructure — Pressure testing, commissioning and decommissioning procedures — Functional requirements*

3 Terms, definitions and abbreviated terms

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Terms and definitions

3.1.1
butt fusion machine pressure
pressure indicated on the gauge or on a pressure display on a butt fusion machine, giving an indication of the interface force applied to the pipe and/or fitting ends

3.1.2
clearance
shortest distance between the outer limits of two objects

3.1.3
drag resistance
frictional resistance due to the weight of the length of pipe fixed in the moveable clamp at the point at which movement of the moveable clamp is initiated (peak drag), or the friction occurring during movement (dynamic drag)

3.1.4
electrofusion control unit
equipment implementing the output fusion parameters of voltage or current and time or energy to execute the fusion cycle as specified by the electrofusion fitting manufacturer

3.1.5
frictional losses in the butt fusion machine
force necessary to overcome friction in the whole mechanism of a butt fusion machine

3.1.6
fusion operator
person trained to carry out fusion jointing between polyethylene (PE) pipes and/or fittings

Note 1 to entry: Fusion jointing is based on a written procedure agreed by the pipeline operator

Note 2 to entry: The fusion operator is trained for one or more fusion–jointing procedures

3.1.7
interface force
force between the fusion surfaces of the pipe(s) and/or fitting(s) during the fusion cycle, as specified in the fusion diagram

3.1.8
operator
person authorized to build polyethylene (PE) systems from pipes and/or fittings, based on a written procedure agreed by the pipeline operator

3.1.9
overall service (design) coefficient
C
overall coefficient, with a value greater than 1, which takes into consideration service conditions as well as properties of the components of a piping system

3.1.10
pipeline operator
private or public organization authorized to design, construct and/or operate and maintain a gas supply system

3.1.11
soil cover
vertical distance between the top of a buried pipe and the normal surface after finishing work

EXAMPLE Including pavement.

3.2 Symbols and abbreviated terms

A	depth
a	correct bead root
B	bead width
B_m	average bead width
b	rejected bead root
C	overall service (design) coefficient
D_F	temperature derating coefficient
d_e	external diameter of pipe or spigot fitting
EF	electrofusion
e_n	pipe or fitting nominal wall thickness
F	maximum drag force (N)
L	insertion depth

MOP	maximum operating pressure
MPa	megapascal
MRS	minimum required strength
N	Newton
p	pressure
p_{RCP}	critical rapid crack propagation pressure
RCP	rapid crack propagation
SDR	standard dimension ratio
SF	safety factor
t	time
UV	ultraviolet
V	misalignment
WPS	welding procedure specification
σ	maximum tensile stress (MPa)
σ_y	tensile stress at yield (MPa)

4 Design

4.1 General

A written laying procedure, authorized by the pipeline operator, shall be made available prior to the construction of a pipeline. The laying procedure shall include specification of the jointing procedure (butt fusion, or electrofusion, or mechanical), the pipe and fitting materials to be used, the trenching and backfilling requirements, the pressure testing and commissioning requirements, and the data to be collected for the traceability system.

The selection of materials, standard dimension ration (SDR) series, dimensions and assembling techniques shall be the responsibility of the pipeline operator.

There are two SDR series in common use for gas supply systems: SDR 17 and SDR 11. Other SDR series can also be used, such as SDR 26 for renovation.

The training and the level of skill of the operator(s) shall be in accordance with the requirements of the jointing procedures.

General guidelines for supervision and quality control are given in Clause 6.

NOTE Information on the suitability of pipes made from PE100-RC for trenchless technologies is given in ISO 4437-1 and EN 1555-1.[9]

4.2 Material, components and jointing equipment

The PE materials and components used shall conform to ISO 4437-1, ISO 4437-2, ISO 4437-3, ISO 4437-4, ISO 4437-5 and ISO 17885. Other components not covered by the above-mentioned International Standards shall conform to the relevant national standards or in the absence of such documents,

the components shall meet the performance requirements of the system as demonstrated by the manufacturer.

The fusion equipment used for the construction of the pipeline shall conform to the requirements of ISO 12176-1 or ISO 12176-2. If the operation of the fusion equipment requires an operator's badge, the badge shall conform to ISO 12176-3. Traceability of PE materials shall refer to ISO 12176-4 and/or ISO 12176-5.

4.3 Maximum operating pressure

The maximum operating pressure (MOP) of the system shall be selected by the pipeline operator on the basis of the gas supply system operating requirements and the materials used. The MOP of a PE system depends on the type of resin used (the minimum required strength, MRS), the pipe SDR series and the service conditions, and is limited by the overall service (design) coefficient, C, and the rapid crack propagation (RCP) criteria.

The overall service (design) coefficient C for thermoplastics materials should be as specified in ISO 12162. This coefficient is used to calculate the MOP of the pipeline. C shall be greater than or equal to 2 for PE pipeline systems for natural gas. For other gases, a higher C value according to ISO 4437-1:2012, Annex A, can be defined.

The MOP shall be calculated using Formula (1):

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

NOTE The temperature derating coefficient, D_F, is used in the calculation of the MOP which takes into account the influence of the operating temperature.

The temperature derating coefficient, D_F, for various operating temperatures is given in Annex E.

The ratio of the critical RCP pressure, p_{RCP}, to the MOP shall be ≥ 1,5 at the minimum operating temperature. The critical RCP pressure, p_{RCP}, is dependent upon temperature, pipe size, SDR and type of PE material used. It is defined in accordance with ISO 4437-1 and ISO 4437-2, which specify a test temperature of 0 °C.

Where the pipe operating temperature decreases below 0 °C, the p_{RCP}/MOP ratio shall be recalculated using a p_{RCP} value determined from the minimum expected operating temperature of the pipe. If necessary, the value of the MOP shall be reduced so as to maintain the p_{RCP}/MOP ratio at a value ≥ 1,5.

4.4 Assembly techniques

Jointing procedures may vary depending upon the type of PE material and the pipe size used. Butt fusion and electrofusion are the preferred jointing methods. For the butt fusion jointing procedure, a reference to ISO 21307 is useful.

For electrofusion and heated-tools socket fusion processes including the operation of fusion control units, refer to the manufacturers of these components including the control units.

For fusion joints, evidence of the fusion compatibility between the jointing materials should be given.

A written jointing procedure, authorized by the pipeline operator, shall be available prior to the construction of a pipeline. The jointing procedure shall include specification of the jointing method, the fusion parameters, the fusion equipment, the jointing conditions, the level of skill of the fusion operator, and the quality control methods to be used.

4.5 Squeeze-off properties

When squeeze-off techniques are considered, the suitability of the pipe for squeeze-off shall be confirmed in accordance with ISO 4437-2:2014, Annex C.

5 Construction

5.1 Competences

Operators shall be competent in the field of the assigned job. Operators shall possess the necessary skills and required knowledge and the ability to operate with awareness.

NOTE 1 Specific courses provide training for the competencies that can be certified by a third party organization operating, for example, in accordance with ISO/IEC 17020.

NOTE 2 An example of a specific training course for fusion operators can be found in ISO/TR 19480.

5.2 Storage, handling and transport

5.2.1 General

PE pipes are available in coils, drums or straight lengths. Fittings are normally individually packed. Mishandling of the pipes and fittings shall be avoided to protect them against gouges, scratches, cuts, holes, kinks or flattening.

5.2.2 Storage

PE pipes can be stored outside and under UV radiation provided that requirements for the resin as stated in ISO 4437-1 are met. Coloured pipes (e.g. yellow or orange) can be subject to degradation if solar UV radiation exceeds values as given in ISO 4437-1:2014, Table 2. The user of this document should consider information of the pipe manufacturer for allowable UV radiation dose with determined regional UV radiation level during storage.

NOTE 1 Information on regional levels of UV radiation may be found on web pages of national authorities e.g. meteorological institutes.

NOTE 2 ISO 4437-1 resistance to weathering is based on a cumulative exposure of 3,5 GJ/m^2 UV radiation level

Coloured pipes which have been stored outdoor uncovered for longer than recommended by the manufacturer shall only be used if tested in accordance with Table 1.

Table 1 — Minimum tests for evaluating coloured pipes when over-exposed to UV radiation

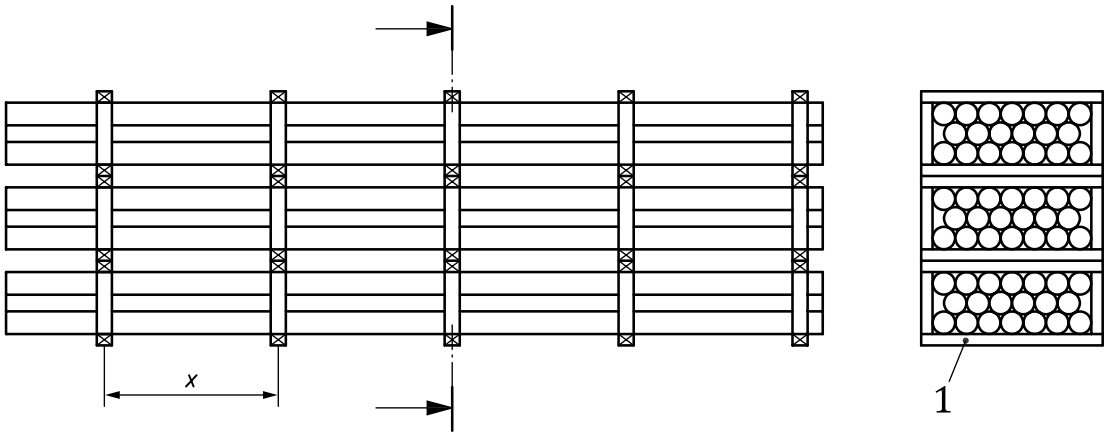
Test	Source and method
Elongation at break (all wall thicknesses)	ISO 4437-2:2014, Table 4
Hydrostatic strength (80 °C, 1 000 h)	ISO 4437-2:2014, Table 4
Decohesive resistance	ISO 4437-5:2014, Table 5

PE fittings and valves can be stored following the manufacturer's recommendation.

Straight pipes shall be stacked on a suitable surface, preferably flat and free from stones or other projections or sharp objects likely to deform or damage the pipes. Pipes and fittings shall be stored in such a way as to minimize the possibility of the material being damaged by crushing or piercing.

The distances "*x*" (Figure 1) between support frames holding packs of pipes together shall be equal in order to allow the frames to be stacked.

The support frame shall not be nailed together and should be constructed in such a way that the load is directly supported by the frame and not by the pipes.



Key

x distance between supports

1 support frame

Figure 1 — Support frame

The exact height to which straight pipes can be stacked depends on many factors such as material, size, wall thickness and ambient temperature. Stacking shall avoid distortion of pipes over the limits as given by the manufacturer during the storage. The manufacturer's stacking recommendations shall be followed.

PE pipes may be coiled or wound on drums. Coils of large-diameter pipes with $d_e \geq 110$ mm shall be stored vertically in purpose-built racks or cradles. Where loose straight pipes are stacked in pyramidal fashion, this shall not exceed a height of 1 m. Fittings shall be stored in their original packaging until being prepared for use. Contact with aggressive reagents or solvents shall be avoided.

The pipes with the earliest extrusion date should be used first for installation. The fittings with the earliest manufacturing date should be used first for installation. Guidance from the product manufacturer should be considered.

5.2.3 Handling

Initial handling of straight pipes shall be made with the pipes as delivered by the manufacturer (e.g. in their own packaging), thus minimizing damage during this phase. When loading, unloading or handling, it is preferable to use mechanical equipment to move or stack the packages. The pipes shall not be dragged or thrown along the ground. If handling equipment is not used, choose techniques which are not likely to damage the pipes and/or fittings.

Coils of pipe stacked on pallets are easily handled using a forklift truck. Individual coils shall not be rolled off the edge of a vehicle load platform. Coils shall be slung individually when off-loading with a crane. Before laying a pipe, ensure that the drum is positioned correctly and that its axle will remain stable during the unrolling operation. While unrolling, ensure that the pipe is not damaged.

Fittings and valves shall be handled in accordance with manufacturer instructions and left in original packaging until use.

5.2.4 Transport

When transporting straight pipes, flatbed vehicles shall be used. The bed shall be free from nails and other protuberances. The pipes shall rest uniformly on the vehicle over their whole length, and shall be securely held in place during transport.

Coiled pipes shall be transported stacked on a pallet or as individual coils, and be firmly secured to the vehicle. The height of the top of a drum when loaded on a vehicle shall take into consideration the local

regulations on the maximum height and any limitations expected on the route. Drums shall be firmly secured to the vehicle.

Fittings and valves shall be transported in accordance with manufacturer instructions.

5.3 Jointing

The jointing operation, either mechanical or fusion, shall be performed in accordance with the pipeline operator's written procedure. The minimal jointing requirements, given in Annex A, Annex B and Annex C, shall be respected.

The fusion procedure specification shall take into account the relevant fusion standards, if existing, and any recommendation from the pipe, fitting and accessory manufacturers.

NOTE 1 The relevant International Standard for butt-fusion jointing procedure is ISO 21307.

NOTE 2 In some countries "fusion procedure specification" is also defined as "welding procedure specification (WPS)"

PE pipes, fittings and accessories may be jointed either by heated-tool fusion jointing, electrofusion jointing or mechanical jointing. The jointing and quality control methods used for the construction of the gas supply system shall be appropriate to the design of the network.

Fusion operators shall possess the necessary skill and knowledge and ability to produce joints of consistently high quality. To this end, they shall receive formal training under the supervision of a qualified instructor.

The gas company can require evidence of training or qualification for fusion.

NOTE 3 An example of formal training and assessment can be found in ISO/TR 19480.

The same level of skill, knowledge and ability is required for mechanical jointing. The gas company can require evidence of training or qualification. When tightening or untightening a mechanical joint, it is essential that torsional stress is not transmitted to the pipe.

5.4 Laying

5.4.1 General

Care shall be taken to prevent damage to the pipes and fittings during the whole of the laying process.

Changes in direction of a PE pipeline when laying can be made using pre-formed bends or elbow fittings or by making use, within limits, of the natural flexibility of the pipe. Natural flexibility may be used for bend radii ≥ 25 × d_e, and also for smaller radii for certain SDR values and materials, provided that this is consistent with operational experience and good engineering practice.

NOTE 1 In general, the flexibility is a factor of SDR, environmental temperature and material. The pipe manufacturer can be consulted for additional guidance or instructions.

NOTE 2 Information on the bend radii for mechanical joints are given in Annex C.

The flexibility of PE pipes is reduced in cold weather. If the temperature falls below –15 °C for straight pipes and for fittings, or below 0 °C for coiled pipes, special handling instructions, issued by the manufacturers, shall be followed.

Machine-bending of pipes or bending after the application of heat in the fields shall not be used.

Where PE pipes, fittings and valves are allowed to be installed above ground they shall be protected against mechanical damage and, in case of non-black pipes, UV degradation.

If the gas pipeline isn't protected by the surrounding soil, special consideration should be taken to reduce any kind of risk, e.g. ignition sources, high temperatures, etc.