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Polyethylene pipes and fittings for the supply of gaseous fuels or water — Training and assessment of fusion operators

Tubes et raccords en polyéthylène pour le transport de combustibles gazeux — Formation et évaluation des opérateurs de soudage

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

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.

ISO/TR 19480 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*.

Introduction

The quality of a piping system for the supply of gaseous fuels or water is to a large extent determined by the skills of the operators involved in installing the network. When installing polyethylene (PE) pipes, the quality of the fusion joints is essential for the piping system.

Since fusion joints in PE piping systems can be made using various technologies, it is important that the fusion operators are trained and competent in the fusion technology employed in constructing PE networks.

Continued competence of the fusion operator is covered by periodic re-training and re-assessment.

Polyethylene pipes and fittings for the supply of gaseous fuels or water — Training and assessment of fusion operators

1 Scope

This Technical Report gives guidance and other provisions for the training, assessment and approval of fusion operators, with the aim of establishing and maintaining their competency in the construction of polyethylene (PE) piping systems for the supply of gaseous fuels in accordance with ISO 10839, for the supply of water, or in the construction of such systems used in other pressure applications. It covers the butt fusion, electrofusion and socket fusion jointing techniques and considers both the theoretical and practical knowledge necessary for making high-quality fusion joints.

2 Normative references

The following referenced documents are indispensable for the application 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, *Polyethylene (PE) pipes for water supply — Specifications*

ISO 4437, *Buried polyethylene (PE) pipes for the supply of gaseous fuels —Metric series — Specifications*

ISO 8085-1, *Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels — Metric series — Specifications — Part 1: Fittings for socket fusion using heated tools*

ISO 8085-2, *Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels — Metric series — Specifications — Part 2: Spigot fittings for butt fusion, for socket fusion using heated tools and for use with electrofusion fittings*

ISO 8085-3, *Polyethylene fittings for use with polyethylene pipes for the supply of gaseous fuels — Metric series — Specifications — Part 3: Electrofusion fittings*

ISO/TS 10839:2000, *Polyethylene pipes and fittings for the supply of gaseous fuels — Code of practice for design, handling and installation*

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 13953:2001, *Polyethylene (PE) pipes and fittings — Determination of the tensile strength and failure mode of test pieces from a butt-fused joint*

ISO 13954:1997, *Plastics pipes and fittings — Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal outside diameter greater than or equal to 90 mm*

ISO 13955:1997, *Plastics pipes and fittings — Crushing decohesion test for polyethylene (PE) electrofusion assemblies*

3 Terms and definitions

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

3.1
butt fusion cycle
pressure/time diagram for a defined fusion temperature, representing the butt fusion operation

3.2
drag resistance
⟨peak drag⟩ 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

3.3
drag resistance
⟨dynamic drag⟩ friction occurring during movement

3.4
frictional resistance
⟨butt fusion machine⟩ force necessary to overcome friction in the whole mechanism of the machine

3.5
fusion operator
person trained to carry out fusion jointing between polyethylene (PE) pipes and/or fittings based on a fusion procedure

NOTE The fusion operator is trained for one or more fusion procedures, involving the operation of manual and/or automatic fusion-jointing machines.

3.6
fusion operator certificate
approval certificate issued by the examiner/assessor stating that the knowledge and skill of the fusion operator is sufficient to produce fusion joints following a given fusion procedure

3.7
fusion procedure
document agreed by the pipeline operator providing in detail the required variables and values for a specific fusion process, in order to ensure repeatability

EXAMPLE Butt fusion procedure, electrofusion procedure.

3.8
pipeline operator
private or public organization authorized to design, construct and/or operate and maintain the supply system

3.9
training centre
establishment for training of fusion operators

4 Training organization

4.1 Training course

A trainee fusion operator for underground PE systems should follow a training course at a training centre, in order to obtain a fusion operator certificate for PE pipes. The training centre should provide the training courses under the conditions described in this Technical Report.

Where applicable, the training centre shall be as required by national authorities.

The courses should be delivered by a competent trainer having the required experience of fusion processes and mastery of the fusion technique involved.

Where applicable, the trainer shall have a level of qualification as required by national authorities.

The training centre should have a range of fusion machines representative of the equipment encountered on worksites for installing pipes, in order for the trainee fusion operator to become acquainted with the fusion equipment commonly used. The trainee fusion operator may be trained on one of these fusion machines or on a machine from his or her own company if accepted by the training centre. The fusion equipment shall comply with ISO 12176-1 for butt fusion equipment and ISO 12176-2 for electrofusion equipment.

Preferably, a training centre should not carry out activities related to contracting, supervision of construction work, or inspection of fusion joints.

4.2 Operator assessment

A trainee fusion operator who has followed a training course as described above should then pass a theoretical and practical assessment in order to be qualified as a fusion operator for PE systems.

The assessor should not be the trainer and should have appropriate assessment qualifications.

NOTE The assessor is a person accepted by the contracting parties or an accredited body, e.g. EN 45004 [1] or a certification body e.g. EN 45013 [2].

5 Training

5.1 Training curriculum

The training course should consist of any combination of fusion packages based on the requirements of the pipeline operators. These packages may be given as individual modules or combined to suit requirements.

During the training, attention should also be drawn to safety. The course related to safety should deal with safety related to the fusion process.

5.2 Course

5.2.1 General

The training should be provided by a trainer having the qualification according to 4.1.

All consumables and tools necessary for the training package should be available during the training session.

The pipes and fittings to be used shall be those in accordance with ISO 4437, ISO 8085-1, ISO 8085-2 and ISO 8085-3 for the supply of gaseous fuels, and ISO 4427 for the supply of water, and corresponding to what is normally used locally for the construction of PE piping systems.

The lessons should be designed so that the trainee fusion operator learns to master the fusion technique and also to master the materials and practical problems involved in laying a pipe in a trench, with or without obstacles. In connection with the latter aspect, the trainee fusion operator should construct at least one three-dimensional configuration (connection between two pipes laid in different axes).

The trainee fusion operator should receive a written manual covering all the elements dealt with in the training. The course should be drawn up in one of the national languages.

5.2.2 Theoretical course on general information

The theoretical course should deal with general information in connection with raw materials, pipes and fittings, but also with theoretical knowledge on preparation, tools and devices and joining components. It should

include details of the different fusion techniques — namely electrofusion, butt fusion or socket fusion — of materials (e.g. PE 80, PE 100) and SDR series, as well as on correct and incorrect parameters.

The safety course should include information concerning the fusion process, such as protective clothing, general safety regulations for electrical equipment, and the handling of heater plates. The main features are given in Table 1.

Table 1 — Theoretical course on general information

Characteristics of PE compounds	
Typical properties of thermoplastics, PE 80, PE 100, UV behaviour and typical colours Physical and mechanical behaviour of PE compounds: temperature effects, strain/stress, creep, elongation/shrinkage, stress cracking, etc.	
Manufacturing of pipes and fittings	
Extrusion of pipes	Overview of the manufacturing process, packaging and marking Transport, handling and storage of pipes
Injection moulding of fittings	Overview of the manufacturing process, packaging and marking
Standardization of PE piping systems	
Dimensional data: nominal outside diameter and wall thickness (SDR), out of roundness Maximum allowed pressure, standards for pipes, fittings and accessories (valves) Overview of relevant test methods with this document	
Fusion operator certificate	
Identification number, time period validity, skill	
Health and safety considerations	
General	Principle of risk management Clothing, shoes, hard hat, gloves Risks related to cleaning fluids, handling and storage of pipes Use of fire extinguishers Working in trenches, lifting equipments References to national regulations related to working on piping systems with pressure
Butt fusion	Electricity safety, use of generators, heating plates
Electrofusion	Electricity safety, use of generators
Socket fusion	Electricity safety, use of generators, heating tools
Environmental aspects	
Use of cleaning fluid Disposal of packaging materials	

5.2.3 Theoretical and practical course on fusion jointing techniques

5.2.3.1 Electrofusion jointing

The trainee should become familiar with the electrofusion jointing technique and the associated fusion procedure by making a sufficient number of electrofusion joints.

The fusion procedure shall be carried out in accordance with the instructions supplied by the manufacturer of the electrofusion fitting and the electrofusion equipment and/or as written in national specifications. The fusion parameters are laid down by the manufacturer, and are normally implemented automatically by the fusion machine itself (by reading in a bar code or equivalent).

The trainee should begin by fabricating an assembly with an electrofusion socket coupling between two pipes, and should then be taught to make joints with more specific electrofusion fittings such as T-fittings, reducers, saddles and tapping tees. Consideration should also be given to the preparation and cleanliness of the pipe, fitting and fusion equipment.

NOTE For practical reasons and if accepted by the pipeline operator, the assembly can be limited to the complete jointing procedure without starting the final fusion cycle.

The trainee should learn how to detect and to avoid typical fusion defects.

The trainee should learn how to assess the quality of an electrofusion joint and to know the available test methods.

ISO/TS 10839 may be used as a guide for a general electrofusion jointing procedure, in particular for quality control.

The main features of the theoretical and practical courses on electrofusion jointing technique are given in Table 2.

5.2.3.2 Butt fusion jointing

The trainee fusion operator should become familiar with the butt fusion jointing technique and associated fusion procedure by making a sufficient number of butt fusion joints.

In some cases, the butt fusion cycle can vary according to the diameter, e.g. with double fusion pressure being used for larger diameters. In such cases, the fusion operator should also be made familiar with this technique.

Attention should also be paid to the differences between automatic and manual fusion machines, as regards, among other things, drag resistance and frictional resistance in the butt fusion machine.

The trainee should start by making a butt joint between two pipes, and then learn to make butt fusion joints with pipes and fittings such as tees, reductions, etc.

The trainee should learn how to detect and to avoid typical fusion defects.

The trainee should learn how to assess the quality of a butt fusion joint, and know the available test methods.

ISO/TS 10839 may be used as a guide for a general butt fusion jointing procedure, in particular for quality control.

The main features of the theoretical and practical courses on butt fusion jointing technique are given in Table 2.

5.2.3.3 Socket fusion jointing

The trainee fusion operator should become familiar with the socket fusion jointing technique and the associated fusion procedure by making a sufficient number of socket fusion joints.

The fusion procedure shall be carried out in accordance with the instructions supplied by the manufacturer of the socket fusion fitting. The fusion operator should be made familiar with type A and B fittings, and with the fact that these two systems are not compatible with each other. The fusion parameters should be as laid down by the manufacturer of the socket fusion fitting.

The trainee should start by making a socket fusion joint between two pipes, and then learn to make joints with more specific socket fusion fittings.

The trainee should learn how to detect and to avoid typical fusion defects.

The trainee should learn how to assess the quality of a butt fusion joint, and know the available test methods.

ISO/TS 10839 may be used as a guide for a general socket fusion jointing procedure, in particular for quality control.

The main features of the theoretical and practical courses on socket fusion jointing technique are given in Table 2.

Table 2 — Theoretical and practical courses on fusion jointing techniques

General
Fusion machines, tools (scrapers, clamps, rollers, shelters, cleaning fluid, etc.), installation instructions (aligning, scraping, clamping, etc.), the use and installation of mechanical joints, etc.
Maintenance and servicing of equipment
Overview of code of practice for installation (ISO/TS 10839)
Trenchless installations
Repair and maintenance of pipelines
Butt fusion jointing
Principle
Scope: straight/coiled pipes, service lines, main lines, etc.
Components: pipes, spigot fittings, other fittings
Butt fusion equipment: manual and automatic machines
Joint preparation: scraping, re-rounding, alignment, cleaning
Butt fusion cycle: pressure, time and temperature diagram
Failure reasons: understanding and avoiding possible deficiencies
Test methods: visual inspection, tensile test, bending test, hydrostatic test, etc.
Electrofusion jointing (sockets and saddles)
Principle
Scope: straight/coiled pipes, service lines, main lines
Components: pipes, electrofusion fittings, other fittings
Electrofusion equipment: retrieval of fusion parameters, traceability data
Joint preparation: scraping, re-rounding, alignment, cleaning
Fusion parameters
Failure reasons: understanding and avoiding possible deficiencies
Test methods: visual inspection, peel test, crush test, hydrostatic test, etc.
Socket fusion jointing
Principle
Scope: service lines, main lines
Components: pipes, socket fittings, other fittings
Socket fusion equipment
Joint preparation: scraping, re-rounding, alignment, cleaning
Fusion parameters
Failure reasons: understanding and avoiding possible deficiencies
Test methods: visual inspection, hydrostatic test, etc.

6 Assessment

6.1 Fusion operator certificate

The fusion training should end with a theoretical and practical examination (test piece). The content of the examination is given in Annex A, and the examination should be taken with an assessor based on the assessment to be obtained as specified in 4.2.

The assessor should visually observe the making of test pieces: any failure to comply with the jointing specification should constitute a failure of the practical test. The assessor may select test pieces for the following destructive tests.

— The tensile test according to ISO 13953 for butt fusion joints. The test piece shall present a ductile failure;

— The peel decohesion test according to ISO 13954 for electrofusion joints or socket fusion joints with a nominal outside diameter greater than or equal to 90 mm. The test piece shall not present a brittle failure zone longer than 33 % of the fusion zone in the longitudinal axis;

— The crushing decohesion test according to ISO 13955 for electrofusion joints or socket fusion joints with a nominal outside diameter smaller than 90 mm. The test piece shall not present a brittle failure zone longer than 33 % of the fusion zone in the longitudinal axis;

— The tear test for fusion saddles according to Annex B. The test piece shall not present a brittle failure surface longer than 25 % of the fusion zone in the longitudinal axis.

Where the test piece fails to meet the requirements of a test, this should be considered as constituting failure of the practical test.

The testing of test pieces should be performed in a laboratory chosen by the assessor.

To avoid cases of dispute, accredited laboratories according to ISO/IEC 17025 [3] are recommended.

Trainee fusion operators who pass the theoretical and practical examination should receive a fusion operator certificate bearing the logo of the approving assessment centre.

The fusion operator certificate should state the technique or techniques for which the operator is qualified: electrofusion, manual and/or automatic butt fusion or socket fusion. The fusion operator certificate should be drawn up in one of the national languages.

The certificate issued to the qualified fusion operator may be one meeting the requirements of ISO 12176-3 [4].

6.2 Re-assessment

If the trainee fails one of the examinations, he/she should retake it after a period not shorter than one week.

If the result is negative once more, the trainee should repeat the training course.

7 Periodic operator certificate renewal

A fusion operator should retake assessment training after a period of 12 months from the date of issue of the certificate — unless another time period is prescribed by national regulations — during which he/she has not produced any fusion joint.

Approved fusion operators should be re-assessed every two years, by the assessor body according to 4.2, (periodic re-assessment) for their fusion operator certificate to be renewed. If the operator succeeds in making an acceptable test joint, the validity of the fusion certificate should be extended.

The test joint should be a fusion joint, which shall then be tested according to ISO 13953 for butt fusion joints, ISO 13954 for electrofusion joints, ISO 13955 for electrofusion and heated tool socket fusion joints, and according to Annex B for saddles. The test criteria are given in 6.1.

A fusion operator should not be re-approved after any 12-month period without producing any fusion joint following the procedure mentioned on its operator certificate or when the tests on joints made by the fusion operator are found to be unacceptable. To this end, a fusion operator should be subjected to spot checks in order to verify the quality of the fusion joints he/she makes.

Annex A
(normative)

Examination

A.1 Contents of theoretical examination

The theoretical examination should consist of a list of multiple-choice questions that have to be answered by the trainee fusion operator within a set time.

The questions should cover the entire field of the theoretical course. The number of questions should be at least 20.

There should be a sufficiently wide range of questions, so that the same questions do not constantly recur in successive training cycles.

The fusion operator should be able to reply to at least 80 % of the questions correctly.

A.2 Contents of practical examination

The practical examination should consist of a test joint on a PE pipe with a diameter representative of the intended field. According to the required skill, the fusion operator may carry out two or three electrofusion joints, butt fusion joints and/or socket fusion joints.

The test pieces should then be visually inspected. If a failure is observed, the test piece shall be refused. Otherwise, one of the test pieces of each fusion method shall be tested according to ISO 13953, ISO 13954, ISO 13955, and Annex B, as applicable. The test criteria are given in 6.1.

If the fusion operator does not pass the practical examination, the reason for this should be stated in the examination report.

Annex B
(normative)

Tear test for polyethylene (PE) saddle assemblies

B.1 Principle

The method given in this annex tests the cohesive resistance of an electrofusion or heated tool saddle fused onto a pipe by applying a load along the centreline of the saddle. The test is conducted at an ambient temperature of (23 ± 2) °C.

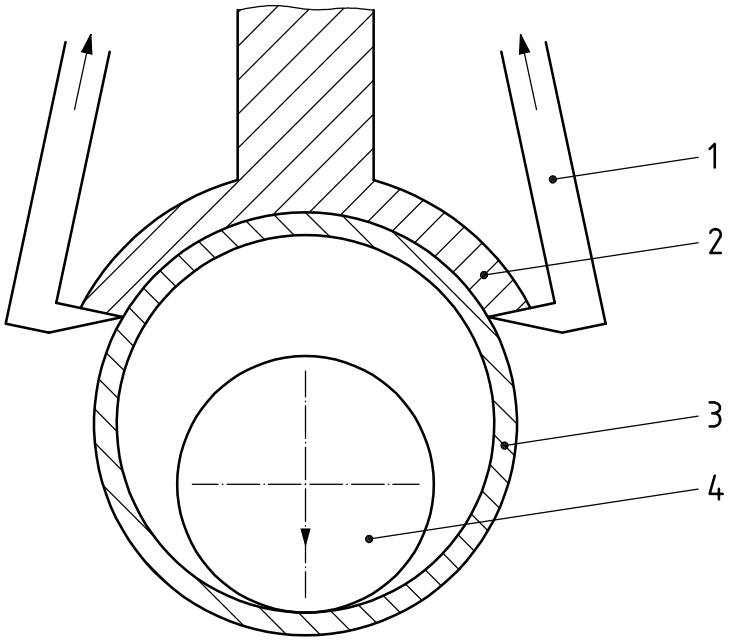
The cohesive resistance of the assembly is characterized by the nature of the failure in the fusion plane and by a percentage of decohesion, where the appearance and location of the failure is taken into account in interpreting the quality of the assembly.

B.2 Apparatus

B.2.1 Tensile testing machine, capable of maintaining a speed of (100 ± 10) mm/min and having sufficient force to separate the saddle from the pipe.

B.2.2 Loading pin (see Figure 1), with an outside diameter equal to (66,6 ± 2) % the nominal outside diameter of the pipe.

B.2.3 Clamping device, of an appropriate form to allow the saddle to be gripped and separated from the pipe (see Figure 1).



Key

1 clamping device
2 PE saddle
3 PE pipe
4 loading pin

Figure B.1 — Example of tear test assembly

B.3 Test piece

B.3.1 Preparation of test pieces

Test pieces shall be assembled in accordance with the manufacturer's instructions.

Unless otherwise specified, the main pipe shall not be perforated.

The free length on both sides of the saddle shall be minimum $0{,}1 d_n$ (nominal outside pipe diameter).

Any attached under-clamp shall be removed.

For practical reasons, the branch outlet of the saddle may be removed.

NOTE The pipe wall thickness could influence the magnitude of applied peel stress.

B.3.2 Number of test pieces

The number of test pieces shall be as specified in the product standard.

Testing of at least three test pieces is recommended.

B.4 Conditioning

The testing shall not be carried out within a period of time of 24 h after completion of jointing.

Condition the test piece at an ambient temperature of (23 ± 2) °C for at least 6 h before carrying out the procedure given in Clause 7.

B.5 Test procedure

Carry out the following procedure at an ambient test temperature of (23 ± 2) °C.

a) Insert the loading pin inside the pipe.

b) Position the test piece and the clamping device such that the saddle is separated from the pipe at a speed of (100 ± 10) mm/min. An example of the tear test assembly, using a tensile test, is given in Figure 1. Alternatively, the saddle may be separated from the pipe by a compression test assembly.

c) Continue the loading until complete separation or rupture of one of the parts of the test piece occurs, and record the maximum applied force.

d) Inspect the test piece for, and record the location of, any rupture (in the pipe or the saddle, between the wires or the fusion interface, etc.), also recording the type of rupture, and whether or not a brittle fracture surface is observed.

e) Measure and record the maximum brittle fracture length in radial direction of the fusion zone (d_2) and the overall length between the first and last wire in the fusion zone at the same location (y).

f) Calculate the percentage decohesion C_c, using the following equation:

$$C_c = \frac{d_2}{y} \times 100$$

B.6 Test report

The test report shall include the following information:

a) a reference to this Technical Report, i.e. ISO/TR 19480;

b) full identification of the components tested;

c) nature of the material for each of the assembly components tested;

d) nominal size of the saddle;

e) dimensions of the pipes, including nominal diameter, thickness or SDR;

f) fusion conditions of the test pieces;

g) test temperature;

h) number of test pieces subjected to testing;

i) time between fusion of test piece and test, conditioning period;

j) maximum separation force;

k) in case of failure — type of failure, i.e. brittle or ductile, and details of its appearance including, as applicable, decohesion at interface, tearing between wires, yielding of the pipe or saddle;

l) the percentage decohesion, C_c;

m) observations made during and after the test;

n) any factors which could have affected the results, such as any incidents noted or any operational details not specified in this Technical Report;

o) identification of test laboratory;

p) date of test.

Bibliography

[1] EN 45004:1995, *General criteria for the operation of various types of bodies performing inspection*

[2] EN 45013:1989, *General criteria for certification bodies operating certification of personnel*

[3] ISO/IEC 17025:1999, *General requirements for the competence of testing and calibration laboratories*

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

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