TECHNICAL SPECIFICATION

ISO/TS 16486-8

First edition
2022-09

Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing —

Part 8: Training and assessment of fusion operators

Systèmes de canalisations en matières plastiques pour la distribution de combustibles gazeux — Systèmes de canalisations en polyamide non plastifié (PA-U) avec assemblages par soudage et assemblages mécaniques —

Partie 8: Formation et évaluation des opérateurs de soudage

Reference number
ISO/TS 16486-8:2022(E)

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Published in Switzerland

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Foreword

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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*.

A list of all parts in the ISO 16486 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

The quality of a piping system for the supply of gaseous fuels is to a large extent determined by the skills of the operators involved in installing the network. When installing unplasticized polyamide (PA-U) pipes, the quality of the fusion joints is essential for the integrity of the piping system.

Since fusion joints in PA-U 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 PA-U networks.

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

For the training and assessment or re-training and re-assessment of fusion operators in accordance with this document, a valid operator certificate in accordance with ISO/TR 19480 is required.

Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing —

Part 8: Training and assessment of fusion operators

1 Scope

This document specifies the training, assessment and approval of fusion operators, with the aim of establishing and maintaining their competency in the construction of unplasticized polyamide (PA-U) piping systems for the supply of gaseous fuels in accordance with ISO 16486-6. It covers the butt fusion and electrofusion fusion jointing techniques and considers both the theoretical and practical knowledge necessary for making high-quality fusion joints.

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 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 16486-1, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 1: General*

ISO 16486-2, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 2: Pipes*

ISO 16486-3, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 3: Fittings*

ISO 16486-4, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 4: Valves*

ISO 16486-5, *Plastics piping systems for the supply of gaseous fuels — Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 5: Fitness for purpose of the system*

ISO 16486-6, *Plastics piping systems for the supply of gaseous fuels - Unplasticized polyamide (PA-U) piping systems with fusion jointing and mechanical jointing — Part 6: Code of practice for design, handling and installation*

ISO/TR 19480, *Polyethylene pipes and fittings for the supply of gaseous fuels or water — Training and assessment of fusion operators*

3 Terms and definitions

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

3.2
drag pressure
gauge pressure required to overcome, on a given butt fusion machine, the sliding frictional drag force of the machine and pipe

Note 1 to entry: Drag pressure, if present, can be a positive or negative value.

3.3
frictional resistance
<butt fusion machine> force necessary to overcome friction in the whole mechanism of the machine

3.4
fusion operator
person trained to carry out fusion jointing between unplasticized polyamide (PA-U) pipes and/or fittings based on a *fusion procedure* (3.6)

Note 1 to entry: The fusion operator is trained for one or more fusion procedures, involving the operation of manual and/or automatic fusion-jointing machines.

3.5
valid fusion operator certificate
approval certificate issued by the examiner/assessor stating that the knowledge and skill of the *fusion operator* (3.4) is sufficient to produce fusion joints following a given *fusion procedure* (3.6)

3.6
fusion procedure
document agreed by the *pipeline operator* (3.7) providing in detail the required variables and values for a specific fusion process, in order to ensure repeatability

EXAMPLE Butt fusion procedure, electrofusion procedure.

3.7
pipeline operator
private or public organization authorized to design, construct and/or operate and maintain the supply system

3.8
training centre
establishment for the training of *fusion operators* (3.4)

4 Training organization

4.1 Training course

A valid operator certificate in accordance with ISO/TR 19480 is required prior to obtaining PA-U training in accordance with this document.

For underground PA-U systems, a trainee fusion operator shall follow a supplemental training course at a training centre. The training centre shall provide a supplemental training course under the conditions described in this document.

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

The training centre shall have a range of fusion machines and related equipment (e.g. re-rounding clamps, scraper tools, roller supports), 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 conform to ISO 12176-1 for butt fusion equipment and ISO 12176-2 for electrofusion equipment.

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

4.2 Operator assessment

A trainee fusion operator for PA-U shall own a valid operator certificate in accordance with ISO/TR 19480. The trainee shall follow a supplemental training course as described in 4.1. Then the trainee shall pass a theoretical and practical assessment in order to be qualified as a fusion operator for PA-U systems.

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

NOTE The assessor is a person accepted by the contracting parties.

5 Training

5.1 Training curriculum

The supplemental training course for PA-U shall 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 shall also be drawn to safety. The course curriculum shall address safety related to the fusion process.

5.2 Courses

5.2.1 General

The training shall be provided by a trainer having the qualification described in 4.1.

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

The pipes, fittings and valves to be used shall be those in accordance with ISO 16486-2, ISO 16486-3 and ISO 16486-4 for the supply of gaseous fuels, and shall correspond to what is normally used locally for the construction of PA-U piping systems.

Operators previously certified in accordance with ISO/TR 19480 have received training to master the fusion technique and also to master the thermoplastic materials and practical problems involved in laying a pipe in a trench, with or without obstacles. The training in accordance with this document shall cover all aspects specific to PA-U.

In connection with the latter aspect, the trainee fusion operator shall construct at least one three-dimensional configuration (connection between two pipes laid in different axes).

The trainee fusion operator shall receive a written manual covering all the elements dealt with in this supplemental training for PA-U. The course shall be provided in one of the national languages.

5.2.2 Theoretical course on general information

The theoretical course shall deal with PA-U specific information in connection with raw materials, pipes and fittings, but also with theoretical knowledge on preparation, tools and devices, and joining components. It shall include PA-U specific details of the different fusion techniques (i.e. electrofusion or butt fusion) of materials (e.g. PA-U 11 or PA-U 12) and the standard dimension ratio (SDR) series, as well as on correct and incorrect parameters.

On the basis of ISO/TR 19480, the supplemental safety course in accordance with this document shall include PA-U specific differences and/or extensions of information concerning the fusion process and its raised meaning for piping systems, which potentially operate under pressures up to and including 18 bar[1)]. The main features are given in Table 1.

Table 1 — Theoretical course on general information

Characteristics of PA-U compounds	
Typical properties of thermoplastics, PA-U 11, PA-U 12, UV behaviour and typical colours. Physical and mechanical behaviour of PA-U compounds: temperature effects, strain/stress, creep, elongation/shrinkage, stress cracking, etc.	
Manufacturing of pipes and fittings	
Extrusion of pipes	Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480.[a,b]
Injection moulding of fittings	Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480.[a,b]
Standardization of PA-U 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.	
PA-U valid fusion operator certificate	
General	Requirement of valid certification in accordance with ISO/TR 19480.
Specific	Identification number, time period validity and skill.
Health and safety considerations	
General	Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480 regarding: — principle of risk management; — clothing, shoes, hard hat and gloves; — risks related to cleaning fluids, handling and storage of pipes; — use of fire extinguishers; — working in trenches and lifting equipment. Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480 and eventual extension for plastics pressure piping systems for MOP up to and including 18 bar. NOTE National regulations related to working on piping systems with pressure can apply.
[a] ISO/TR 19480 includes an overview of the manufacturing process, packaging and marking, which is also valid for PA-U.	
[b] ISO/TR 19480 includes information about transport, handling and storage of pipes, which is also valid for PA-U.	
[c] ISO/TR 19480 includes information about the use of cleaning fluid and the disposal of packaging materials, which is also valid for PA-U.	

1) 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

Table 1 *(continued)*

Butt fusion	Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480 regarding electricity safety, use of generators and heating plates.
Electrofusion	Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480 regarding electricity safety and use of generators.
Environmental aspects	
Short refresh by referencing the valid operator certificate in accordance with ISO/TR 19480.[c]	

[a] ISO/TR 19480 includes an overview of the manufacturing process, packaging and marking, which is also valid for PA-U.

[b] ISO/TR 19480 includes information about transport, handling and storage of pipes, which is also valid for PA-U.

[c] ISO/TR 19480 includes information about the use of cleaning fluid and the disposal of packaging materials, which is also valid for PA-U.

5.2.3 Theoretical and practical courses on fusion jointing techniques

5.2.3.1 Electrofusion jointing

Operators previously certified in accordance with ISO/TR 19480 have received theoretical and practical training on electrofusion jointing, including how to detect and avoid typical fusion defects, and how to assess the quality of an electrofusion joint and know the available test methods. The training in accordance with this document shall cover all aspects specific to electrofusion jointing of PA-U pipes and fittings and how to use ISO 16486-6 as a guide for a general electrofusion jointing procedure, in particular for quality control.

Additionally, the fusion procedure shall be carried out for PA-U in accordance with the PA-U specific instructions supplied by the manufacturer of the PA-U electrofusion fitting and the electrofusion equipment.

NOTE 1 The PA-U fusion parameters are laid down by the fitting manufacturer and are normally implemented automatically by the fusion machine itself (by reading in a bar code or equivalent).

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

NOTE 2 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 main features of the theoretical and practical PA-U courses on the electrofusion jointing technique are given in Table 2.

5.2.3.2 Butt fusion jointing

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

According to ISO 16486-5 the butt fusion parameters are dependant to the wall thickness of PA-U pipes and fittings. The trainee fusion operator shall be familiar with the requirements of ISO 16486-5.

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

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

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

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

ISO 16486-6 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 the butt fusion jointing technique are given in Table 2.

Table 2 — Theoretical and practical courses on fusion jointing techniques

General
Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480 regarding: — fusion machines, tools (scrapers, clamps, rollers, shelters, cleaning fluid, etc.), installation instructions (aligning, scraping, clamping, etc.), and the use and installation of mechanical joints, etc. — maintenance and servicing of equipment; — overview of code of practice for installation (see ISO 16486-6); — trenchless installations; — repair and maintenance of pipelines.
Butt fusion jointing
Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480 regarding: — principle; — scope: straight/coiled pipes, service lines, main lines, etc.; — components: pipes, spigot fittings and other fittings; — butt fusion equipment: manual and automatic machines; — joint preparation: scraping, re-rounding, alignment and cleaning. Course items specific to PA-U: — 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)
Refresh by referencing the qualification represented by the valid operator certificate in accordance with ISO/TR 19480 regarding: — principle; — scope: straight/coiled pipes, service lines and main lines; — components: pipes, electrofusion fittings and other fittings; — electrofusion equipment: retrieval of fusion parameters and traceability data; — joint preparation: scraping, re-rounding, alignment and cleaning. Course items specific to PA-U: — fusion parameters as given by the PA-U electrofusion fitting supplier; — failure reasons: understanding and avoiding possible deficiencies; — test methods: visual inspection, peel test, crush test, hydrostatic test, etc.

6 Assessment

6.1 Valid fusion operator certificate

The PA-U fusion training shall end with a theoretical and practical examination (test piece). The provisions about the content of the examination, as given in Annex A, shall apply. The examination shall be taken with an assessor based on the requirements specified in 4.2.

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

— The tensile test in accordance with ISO 16486-5 with reference to ISO 13953 for butt fusion joints. The test piece shall present a ductile failure.

— The peel decohesion test in accordance with ISO 16486-5 with reference to ISO 13954 for electrofusion 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.

NOTE 1 Alternatively to ISO 13954, the strip bend test in accordance with ISO 21751 can be used to demonstrate the quality of electrofusion socket joints.

— The crushing decohesion test in accordance with ISO 16486-5 with reference to ISO 13955 for electrofusion 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 in accordance with ISO 13956. The test piece shall not present a brittle failure surface longer than 25 % of the fusion zone in the longitudinal axis.

NOTE 2 Alternatively to ISO 13956, the strip bend test in accordance with ISO 21751 can be used to demonstrate the quality of electrofusion saddle joints.

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

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

To avoid cases of dispute, laboratories meeting the requirements of ISO/IEC 17025 are recommended.

PA-U trainee fusion operators who pass the theoretical and practical examination shall receive a valid fusion operator certificate bearing the logo of the approving assessment centre.

The PA-U valid fusion operator certificate shall reference this document, i.e. ISO/TS 16486-8, and shall state the technique or techniques for which the operator is qualified: electrofusion, manual and/or automatic butt fusion. The valid fusion operator certificate shall be drawn up in one of the national languages.

NOTE The certificate issued to the qualified fusion operator can be one meeting the general requirements of ISO 12176-3.

6.2 Re-assessment

If the PA-U trainee fails one of the examinations, the trainee may retake it after a period not shorter than one week.

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

7 Periodic operator certificate renewal

A certified PA-U fusion operator shall undergo re-training and re-assessment after a period of 12 months from the date of issue of the certificate during which the operator has not produced any fusion joint of any material.

Certified PA-U fusion operators shall be re-assessed every two years, by the assessor body in accordance with 4.2, (periodic re-assessment) for their valid fusion operator certificate to be renewed. If the operator succeeds in making an acceptable test joint, the validity of the fusion certificate shall be extended.

The fusion joints shall be tested in accordance with the test criteria given in 6.1.

A PA-U fusion operator shall not be re-approved after any 12-month period without producing any fusion joint following the procedure mentioned on their operator certificate or when the tests on joints made by the fusion operator are found to be unacceptable. To this end, a PA-U fusion operator shall be subjected to spot checks in order to verify the quality of the fusion joints they make.