INTERNATIONAL STANDARD

ISO 16486-6

Second edition

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

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 6: Code de pratique pour la conception, la manutention et l'installation

PROOF/ÉPREUVE

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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 document 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).

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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 16486-6:2012), which has been technically revised.

The main changes are as follows:

— the structure of the document has been modified in order to generally align with the structure of ISO/TS 10839:2022;

— the normative references have been updated;

— a new subclause 4.1.2 has been added, concerning regional requirements and with reference to a new Annex F, also about regional requirements for CEN member countries;

— subclause 4.3 has been subdivided into three further subclauses: general, MOP(LTHS) and MOP(p_c);

— a more detailed definition of MOP(p_c) has been included in subclause 4.3.3 for temperatures below zero;

— a reference to Annex G has been added to subclause 4.5;

— information from subclause 5.3 for jointing procedures has been moved to the new Annexes B, C and D;

— in subclause 5.4.1, the former drag force formula for PE with fixed limiting stress (F = 14 N) has been opened for PA-U;

— a new subclause 5.4.7 for non-conventional installation has been added;

— for visual inspection of butt fusion joints, subclause 6.3.2.2.1 shows figures with the typical single bead shape, which replaces the previous double bead;

— a new informative Annex G has been added concerning the fitness of PA-U piping systems for non-conventional installation techniques;

— the Bibliography has been updated.

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

This document specifies the requirements for a piping system and its components made from unplasticized polyamide (PA-U), and which is intended to be used for the supply of gaseous fuels.

Requirements and test methods for material and components of the piping system are specified in ISO 16486-1, ISO 16486-2, ISO 16486-3 and ISO 16486-4.

Characteristics for fitness for purpose of the system and generic fusion parameters are covered in ISO 16486-5.

Recommended practice for installation is given in this document, which will not be implemented as a European Standard under the Vienna Agreement.

Assessment of conformity of the system is to form the subject of ISO/TS 16486-7.

Training and assessment of fusion operators is covered by ISO/TS 16486-8.

NOTE 1 For CEN member countries, the recommended practice for installation is given in CEN/TS 12007-6[3] and the qualification of welders is given by EN 13067.[4]

NOTE 2 A list of imperial ASTM or PPI standards related to polyamide pipes and fittings for the supply of gas is given in References [5],[6],[7][8],[9],[10] and [11].

NOTE 3 ISO 16486-1, ISO 16486-2, ISO 16486-3, ISO 16486-5 and ISO 16486-6 (this document) as well as ISO/TS 16486-7 and ISO/TS 16486-8 have been prepared by ISO/TC 138, SC 4. ISO 16486-4 has been prepared by ISO/TC 138, SC 7.

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

1 Scope

This document specifies a code of practice dealing with unplasticized polyamide (PA-U) pipes and fittings for buried pipeline systems outside buildings and designed to transport gaseous fuels (as defined in ISO 16486-1, e.g. methane, 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 and gives instructions for the design, storage, handling, transportation, laying conditions and fusion quality control of PA-U pipes and fittings as well as subsequent joint testing, backfilling, pipe system testing and commissioning.

NOTE Principal information for rehabilitation can be found in ISO 11295 for classification, ISO 11299-1 and ISO 11299-2 for renovation, and ISO 21225-1 and ISO 21225-2 for trenchless replacement.

More detailed national standards or codes of practice can exist. This document is intended to be applied in association with such national standards or codes of practice related to the above-mentioned basic principles.

The jointing methods covered by this document are:

— butt fusion jointing (see Annex A);

— electrofusion jointing (see Annex B) and

— mechanical jointing (see Annex C).

In the case of ground movement or shaking (e.g. earthquakes, etc.) precautions mentioned in this document can need to be implemented following guidelines provided by authorities (e.g. EN 1998-4,[17] EN 12007-1:2012, Annex A,[18] 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 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 13477, *Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid creack propagation (RCP) — Small-scale steady-state test (S4 test)*

ISO 13478, *Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid creack propagation (RCP) — Full-scale test (FST)*

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

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 16486-2:2020, *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 17885:2021, *Plastics piping systems — Mechanical fittings for pressure piping systems — Specifications*

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

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 16486-1, ISO 16486-5 and the following 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 unplasticized polyamide (PA-U) 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 PA-U 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 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 (e.g. including pavement)

3.2 Symbols and abbreviated terms

B	bead width
B_m	mean bead width
B_{max}	maximum bead width
B_{min}	minimum bead width
C	overall service (design) coefficient
d_e	external diameter of pipe or spigot fitting at any point
D_F	temperature derating coefficient

e_n	nominal wall thickness of pipe or fitting
F	maximum drag force, in newtons
f_s	is the safety factor
MOP	maximum operating pressure
MRS	minimum required strength
p_C	full-scale critical pressure determined in accordance with ISO 13478 at zero degrees Celsius
$p_{C,S4}$	small scale critical pressure determined in accordance with ISO 13477 at zero degrees Celsius
$p_{C,S4,REF}$	reference value of $p_{C,S4}$ to be referred to in the requirement of the S4 test specified in ISO 16486-2:2020, Table 4, footnote c.
RCP	rapid crack propagation
SDR	standard dimension ratio
T_{bz}	temperature below zero degrees Celsius
V	misalignment
σ	maximum tensile stress in MPa
σ_y	tensile stress at yield in MPa

4 Design

4.1 General and regional requirements

4.1.1 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 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 ratio (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 13.6 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.

4.1.2 Regional requirements

For CEN member countries, this document is substituted by CEN/TS 12007-6,[3] where the MOP is limited to up and to including 16 bar[1)] for the whole piping system with all components. CEN/TS 12007-6[3] references several functional standards prepared by CEN/TC 234. More detailed information about regional requirements for CEN member countries is given in Annex F.

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

In addition to CEN member countries, there are also other regions for which this document is not suitable. These other regions follow individual solutions.

EXAMPLE India, Egypt, Indonesia and some other countries besides the US and Canada follow North American ASME B 31.8[19] while using the ISO 16486 series as the product standard.

4.2 Materials, components and jointing equipment

The PA-U materials and components used shall conform to the relevant ISO International Standards: the ISO 16486 series and ISO 17885. Other components not covered by the ISO 16486 series or ISO 17885 shall conform to relevant standards or in the absence of such documents, the components shall meet the performance requirements of the system as demonstrated by the manufacturer.

As specified by ISO 16486-5, 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 PA-U materials should refer to ISO 12176-4 and/or ISO 12176-5.

4.3 Maximum operating pressure

4.3.1 General

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 PA-U system depends upon the type of resin used (the MRS), the pipe SDR series and the service conditions. It is limited by the overall service (design) coefficient, C, and the rapid crack propagation (RCP) criteria.

The MOP is the lower value when calculated using Formula (1) and Formula (2) with the critical pressure calculated from Formula (4).

4.3.2 Maximum operation pressure based on long-term hydrostatic strength

The overall service (design) coefficient C for thermoplastics materials is specified in ISO 12162. This coefficient is used to calculate the MOP of the pipeline. C shall be ≥ 2 for PA-U pipeline systems for natural gas. For other gases, a higher overall service (design) coefficient C according to ISO 16486-5:2021, Clause 6, can be defined.

The MOP shall be calculated using Formula (1):

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

where D_F is the temperature derating coefficient.

The temperature derating coefficient D_F for various operating temperatures shall be in accordance with Annex E.

4.3.3 Maximum operation pressure based on rapid crack propagation

The critical RCP pressure, p_c, is dependent upon the temperature, pipe diameter, SDR and type of PA-U material used.

For design temperatures ≥ 0 °C, the rules for the MOP pressure are given by ISO 16486-1 and ISO 16486-2.

In case of design temperatures < 0 °C, the MOP pressure shall be determined by following equivalent Formula (2):

$$MOP = \frac{p_{c,T(bz)}}{1,5} \tag{2}$$

The full-scale critical pressure for temperatures < 0 °C, $p_{c,T(bz)}$ shall be determined in accordance with ISO 16486-1 and ISO 16486-2. The lab-scale critical pressure for temperatures shall be defined by RCP-S4 testing according to ISO 13477 at the < 0 °C design temperature.

Where $p_{c,S4,T(bz)} \geq 0,9 * p_{c,S4,REF}$, the critical reference pressure from full-scale testing, p_c, shall be used as the critical full-scale pressure for < 0 °C as shown by Formula (3):

$$p_{c,T(bz)} = p_c \tag{3}$$

where $p_{c,S4,T(bz)} < 0,9 * p_{c,S4,REF}$.

The MOP shall be determined by Formula (4):

$$\frac{p_c + 1}{p_{c,S4,REF} + 1} = const = \frac{p_{c,T(bz)} + 1}{p_{c,S4,T(bz)} + 1} \tag{4}$$

This RCP Formula (4) converts to Formula (5), where the result shall be used for calculating Formula (2).

$$p_{c,T(bz)} = \frac{p_{c,REF} + 1}{p_{c,S4,REF} + 1} * (p_{c,S4,T(bz)} + 1) - 1 \tag{5}$$

4.4 Assembly techniques

Jointing procedures may vary depending upon the pipe size used. Butt fusion and electrofusion are the preferred jointing methods. Butt fusion jointing shall be in accordance with Annex A and electrofusion in accordance with Annex B.

For electro-fusion processing, including the operation of fusion control units, reference is made to the manufacturers.

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

Components made from PA-U 11 shall be fusion jointed only to components made from PA-U 11.

Components made from PA-U 12 shall be fusion jointed only to components made from PA-U 12.

Components made from PA-U are not fusion-compatible with components made from other polymers.

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 16486-2:2020, Annex A.

Further information can be taken from Annex D.

