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Thermoplastic pipes for the conveyance of fluids — Inspection of polyethylene butt fusion joints using time of flight diffraction testing

Tubes en matières thermoplastiques pour le transport des fluides — Contrôle des assemblages par soudage bout à bout en polyéthylène au moyen de la technique par diffraction des temps de vol

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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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This document was prepared by Technical Committee ISO/TC 138, *Plastics pipes, fittings and valves for the transport of fluids*, Subcommittee SC 5, *General properties of pipes, fittings and valves of plastic materials and their accessories -- Test methods and basic specifications*.

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.

Thermoplastic pipes for the conveyance of fluids — Inspection of polyethylene butt fusion joints using time of flight diffraction testing

1 Scope

This document describes the time of flight diffraction (TOFD) testing of polyethylene butt fusion (BF) joints, including pipe-to-pipe, pipe-to-fitting and fitting-to-fitting joints, used for the conveyance of fluids. This document provides a test to detect imperfections such as voids, inclusions, lack of fusions, misalignment and particulate contamination in the BF joints. The document only applies to polyethylene pipes and fittings without a barrier to ultrasonic waves.

This document also provides requirements for procedure qualification and guidance for personnel qualifications, which are essential for applying this test technique.

This document covers the equipment, the preparation and performance of the test, the indication assessment and the reporting for polyethylene BF joints.

Acceptance criteria are not covered in this document.

NOTE 1 At present, laboratory experiences exist on the use of TOFD for polyethylene butt fusion joints and/or reference blocks of wall thickness between 8 mm to 100 mm.[1][2][3][4][5][6] Field experience on butt fusion joints in high density polyethylene (HDPE) pipes has been reported.[7]

NOTE 2 Interlaboratory testing has shown that TOFD is a viable method for enhancing the integrity assessment of butt fusion joints.[13]

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 5577, *Non-destructive testing — Ultrasonic testing — Vocabulary*

ISO 9712, *Non-destructive testing — Qualification and certification of NDT personnel*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577 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
cold fusion
incomplete intermolecular diffusion of polymer chains for proper molecular entanglement at the joint interface due to reasons other than contamination

Note 1 to entry: Cold fusion results in insufficient joint integrity, including significant reduction of joint ductility.

3.2
inclusion
foreign material trapped in the fusion joint

3.3
lack of fusion
absence of intermolecular diffusion of polymer chains for molecular entanglement at the interface

Note 1 to entry: A lack of fusion flaw results in complete separation at the flaw location.

3.4
melt fusion zone
MFZ
zone containing the fusion interface and having boundaries on either side of the interface which reflect the limits of crystalline melting during the butt fusion jointing process

Note 1 to entry: The MFZ is shown in Figure 1.

3.5
misalignment
offset between the axis of the pipes/fittings to be jointed

3.6
particulate contamination
fine particles, such as airborne dust, or coarse particles, such as sand and grit, that are present at the fusion interface

3.7
surface imperfection
imperfection on the ID or OD surface of the butt fusion joint

3.8
void
empty space (or air pocket) in a butt fusion joint

3.9
time-of-flight diffraction image
TOFD image
two-dimensional image, constructed by collecting adjacent A-scans while moving the time-of-flight diffraction setup

Note 1 to entry: The signal amplitude of the A-scan is typically represented by grey-scale values.

3.10
time-of-flight diffraction setup
TOFD setup
probe arrangement defined by probe characteristics (e.g. frequency, probe element size, beam angle, wave mode), probe position, probe centre separation, and the number of probe pairs

3.11
probe centre separation
PCS
distance between the index points of the two probes

Note 1 to entry: The probe centre separation for two probes located on a curved surface is the straight-line, geometric separation between the two probe indexes and not the distance measured along the surface.

3.12
scan increment
distance between successive data collection points in the direction of scanning

3.13
false call
reporting an imperfection when none exists

4 General

This document covers the equipment, preparation and performance of the test, indication assessment, and reporting for polyethylene butt fusion joints.

This document may be used to draft a detailed procedure for TOFD testing of polyethylene butt fusion joints.

Characterization of imperfections in the parent material adjacent to the butt fusion joint is also possible.

5 Information required prior to testing

5.1 Items to be defined for the procedure development

Information on the following items shall be provided:

a) purpose and extent of testing;

b) manufacturing or operation stage of BF joints at which the testing is to be carried out;

c) reference sample;

d) requirements for getting access to the BF joints, the surface condition of the pipe; and the temperature range;

e) personnel qualifications;

f) reporting requirements.

5.2 Specific information required by the operator before testing

Before any testing of a fusion joint begins, the operator shall have access to all the information as specified in 5.1, together with the following additional information:

a) written qualified test procedure;

b) all relevant joint dimensions.

5.3 Written test procedure

For all testing, a written test procedure is required. This test procedure shall include the following information:

a) documented testing strategy or scan plan;

NOTE The testing strategy gives information on the probe placement, movement and component coverage that provides a standardized and repeatable methodology for fusion joint testing. The scan plan gives information on the volume tested for each butt fusion joint.

b) equipment requirements and settings (including but not limited to frequency, sampling rate, pitch between elements and element size);

c) evaluation of indications;

d) environmental and safety issues.

6 Personnel qualifications

Personnel performing testing in accordance with this document shall be qualified to an appropriate level in accordance with ISO 9712 or an equivalent standard in the relevant industrial sector.

In addition to a general knowledge of ultrasonic testing, the operator shall be familiar with and have practical experience in the use of TOFD systems on polyethylene butt fusion joints.

Specific theoretical and practical training and examination of personnel shall be performed on representative polyethylene butt fusion joints containing natural or artificial reflectors similar to those expected in the field.

These training and examination results shall be documented.

7 Equipment

7.1 General

The complete equipment, i.e. ultrasonic instrument, probe, cables and display monitor, shall be capable of the repetition of test results.

For selecting the system components (hardware and software), ISO/TS 16829 gives useful information.

Equipment used for TOFD testing should conform to the requirements of EN 12668[9] when applicable.

7.2 Ultrasonic instrument and display

The instrument shall be able to select an appropriate portion of the time base within which A-scans are digitized. It is recommended that the sampling rate of the A-scan should be at least six times the nominal probe frequency.

7.3 Ultrasonic probes

7.3.1 General

Only longitudinal waves are feasible for polyethylene.

7.3.2 Probe selection

Any type of ultrasonic TOFD probe can be used provided it satisfies the requirements of Clause 8 with the ultrasonic instrument.

The most suitable ultrasonic probe frequency shall be selected in accordance with the pipe wall thickness. Table 1 shows the recommended frequencies for each thickness range. However, the optimal frequency can deviate from these values depending on the attenuation and thickness of the sample to be tested.

The gap between the test surface and the bottom of the wedge shall not be greater than 0,5 mm.