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

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~~The committee responsible for this document is~~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*.

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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, whereby the presence of imperfections such as voids, inclusions, lack of fusions, misalignment and particulate contamination in the BF joints can be detected. The document is only applicable to polyethylene pipes and fittings without a barrier to ultrasonic waves.

This document also provides requirement for procedure qualification and guidance for personnel qualifications which are essential for the application of this test method.

This document also covers the equipment, the preparation and performance of the test, the indication assessment and the reporting for polyethylene BF joints. The acceptance criteria are not covered in this document.

NOTE 1 At the present time 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]. Recently field experience on butt fusion joints in HDPE pipes has been reported [7].

NOTE 2 Round robin testing has shown that TOFD is a viable method for enhancing the integrity assessment of butt-fusion joints [14].

NOTE 3 TOFD techniques for cold fusion detection are known to be available. However further research, verification and experience are needed to transfer the technique into an ISO Standard. This document does not provide any information regarding the detection of cold fusions [14].

2 Normative references

The following referenced standards 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 5577, *Non-destructive testing — Ultrasonic ~~inspection —~~ 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 terms and definitions apply.

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

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

— IEC Electropedia: available at ~~http://www.electropedia.org/~~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 (e.g. airborne dust) or coarse particles (e.g. 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 set-up/ TOFD setup
probe arrangement defined by probe characteristics (e.g. frequency, probe element size, beam angle, wave mode), probe position, *probe centre separation* (3.11) and the number of probe pairs

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

~~NOTE~~ 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 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 TOFD equipment, the preparation and performance of the test, the indication assessment and the reporting for polyethylene butt fusion joints. The acceptance criteria are not covered in this document.

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

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

5 Information required prior to testing

5.1 Items required for test procedure development

Information on the following items is required:

— purpose and extent of testing;

— reference sample;

— requirements for getting access to the butt fusion joints, the surface condition of the pipe; and the temperature range

— personnel qualifications;

— reporting requirements;

— manufacturing or operation stage of butt fusion joints at which the testing is to be carried out.

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)~~ a) written test procedure, qualified in accordance with Clause 10;

~~b)~~ b) all relevant joint dimensions.

5.3 Written qualified test procedure

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

~~a)~~ a) purpose and extent of testing;

~~b)~~ b) reference sample;

~~c)~~ c) requirements for access to the butt fusion joints and surface conditions and temperature;

~~d)~~ d) personnel qualifications;

~~e)~~ e) reporting requirements;

~~f)~~ f) equipment requirements and settings (including but not limited to frequency, sampling rate and element size, probe centre separation);

~~g)~~ g) evaluation of indications;

~~h)~~ h) environmental and safety issues;

~~i)~~ i) 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.

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. These training and examination results shall be documented.

