TECHNICAL SPECIFICATION

ISO/TS 16943

First edition
2019-12

Thermoplastic pipes for the conveyance of fluids — Inspection of polyethylene electrofusion socket joints using phased array ultrasonic testing

Tubes en matières thermoplastiques pour le transport des fluides — Contrôle des assemblages par emboîtures électrosoudables en polyéthylène au moyen de la technique pas ultrasons multi-éléments

Reference number
ISO/TS 16943:2019(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword ..... **v**

1 Scope **1**

2 Normative references **1**

3 Terms and definitions **1**

4 General **3**

5 Information required prior to testing **3**
5.1 Items to be defined for the procedure development 3
5.2 Specific information required by the operator before testing 3
5.3 Written test procedure 3

6 Personnel qualifications **4**

7 Equipment **4**
7.1 General 4
7.2 Ultrasonic instrument and display 4
7.3 Ultrasonic probes 4
7.4 Scanning mechanisms 5
7.5 Couplant 5

8 Range and sensitivity settings **5**
8.1 Settings 5
8.1.1 General 5
8.1.2 Range setting — Test volume 5
8.1.3 Sensitivity setting 6
8.2 Reference sample 7
8.2.1 General 7
8.2.2 Reference block 7
8.2.3 Electrofusion socket fitting 7
8.3 Checking of the settings 7

9 Equipment checks **7**

10 Test procedure **8**
10.1 Procedure qualification 8
10.2 Scan increment 9
10.3 Component geometry 9
10.4 Preparation of scanning surfaces 9
10.5 Component temperature 9
10.6 Testing 9
10.7 Data storage 9

11 Evaluation and analysis of test data **10**
11.1 General 10
11.2 Assessing the quality of the test data 10
11.3 Identification of relevant indications 10
11.4 Classification of relevant indications 10
11.5 Determination of location and size of indications 10
11.6 Assessment of indications 11

12 Test report **11**

Annex A (informative) **Examples of phased array images** **13**

Annex B (informative) **Example of a reference block** **15**

Annex C (informative) **Example procedures for producing imperfections in electrofusion socket joints** **16**

Annex D (informative) **Detection of melt fusion zone boundary indication** **20**

Bibliography **22**

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 on 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 the following URL: 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 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 electrofusion socket joints using phased array ultrasonic testing

1 Scope

This document describes the phased array ultrasonic testing (PAUT) of polyethylene electrofusion (EF) socket joints used for the conveyance of fluids. This document provides a test whereby the presence of imperfections such as voids, wire dislocation, misalignment, pipe under-penetration, particulate contamination, cold fusion and lack of fusion in electrofusion socket joints can be detected. The technique is only applicable to polyethylene electrofusion socket fittings without a barrier to ultrasonic waves. This document also provides requirements for procedure qualification and guidance for personnel qualifications, which are essential for the application of this test method

NOTE 1 At the time of publication, experience only exists on the use of PAUT for polyethylene (PE80 and PE100) electrofusion socket joint sizes between 90 mm and 710 mm (SDR 11 and 17)[7][8][9][10][11][12][13].

NOTE 2 Round robin testing has shown that PAUT is a viable method for enhancing the integrity assessment of electrofusion joints[16].

NOTE 3 This document does not apply to the detection of unscraped pipe. Such detection can be achieved by a simple visual inspection, provided mechanical scraping tools are employed.

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 13954, *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, *Plastics pipes and fittings — Crushing decohesion test for polyethylene (PE) electrofusion assemblies*

ISO 23243, *Non-destructive testing — Terminology — Terms used in ultrasonic testing with phased arrays*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577, ISO 23243 and the following apply.

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

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

— IEC Electropedia: available at http://www.electropedia.org/

3.1
cold fusion
insufficient joint integrity caused by the incomplete intermolecular diffusion of polymer chains for proper molecular entanglement at the joint interface due to reasons other than contamination, which does not create any non-destructive testing indication(s) at the joint interface

3.2
lack of fusion
absence of intermolecular diffusion of polymer chains for molecular entanglement at the interface, resulting in a non-destructive testing indication at the joint interface

3.3
pipe under-penetration
incomplete penetration of the pipe into the electrofusion socket

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

Note 1 to entry: The melt fusion zone is shown in Figure 1.

3.5
misalignment
angular offset between the axis of the electrofusion socket fitting and the axis of the pipe

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
void
empty space (or air pocket) in an electrofusion socket joint

3.8
wire dislocation
displacement of heating wires from their original position in the fitting

3.9
phased array image
one-, two-, or three-dimensional display, constructed from the phased array data

3.10
phased array set-up
probe arrangement defined by probe characteristics (e.g. frequency, probe element size, beam angle, wave mode), probe position and the number of probes

3.11
probe position
axial and radial position of the probe with respect to the heating wire coil in the electrofusion socket joint

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

3.14
electrofusion socket fitting
part containing one or more integral heating elements that are capable of converting electrical energy to heat to make a joint between pipes

3.15
electrofusion socket joint
fused combination of one or more pipe components using an electrofusion socket fitting

3.16
fusion zone
one side of an electrofusion socket joint

Note 1 to entry: There are two fusion zones in a straight joint.

4 General

This document covers the equipment, the preparation and performance of the test and the reporting for polyethylene electrofusion socket joints. The assessment of ultrasonic indications and acceptance criteria are not covered in this document.

This document can be used to draft a detailed procedure for phased array ultrasonic testing of polyethylene electrofusion socket joints.

5 Information required prior to testing

5.1 Items to be defined for the procedure development

Information on the following items is required:

a) purpose and extent of testing;

b) reference sample;

c) requirements for getting access to the electrofusion socket joints, the surface condition of the pipe and the temperature range;

d) personnel qualifications;

e) reporting requirements;

f) manufacturing or operation stage of electrofusion socket joints at which the testing is to be carried out.

5.2 Specific information required by the operator before testing

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

a) written test procedure;

b) all relevant pipe and fitting dimensions.

5.3 Written test procedure

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

a) purpose and extent of testing;

b) reference sample;

c) requirements for access to the electrofusion socket joints, surface conditions and temperature;

d) personnel qualifications;

e) reporting requirements;

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

g) evaluation of indications;

h) environmental and safety issues;

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 electrofusion socket 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 operators shall be familiar with and have practical experience in the use of phased array systems. Specific theoretical and practical training and examination of personnel shall be performed on representative polyethylene electrofusion socket 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

In selecting the system components (hardware and software), ISO 13588 and ISO/TS 16829 provide useful information.

Ultrasonic equipment used for phased array testing should comply with the requirements of ISO 18563-1, ISO 18563-2 and ISO 18563-3 when applicable.

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

7.2 Ultrasonic instrument and display

The instrument shall be capable of selecting 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. The instrument and display shall achieve a resolution capable of identifying each heating wire individually.

7.3 Ultrasonic probes

Only longitudinal wave modes are feasible for polyethylene.

Any type of phased array probe can be used if it satisfies the requirements of Clause 8 with the phased array equipment.

The most suitable ultrasonic probe frequency should be selected in accordance with the thickness of the electrofusion socket fitting. Table 1 shows recommended frequencies for each thickness range of the electrofusion socket fitting. However, the optimal frequency can be shifted up or down depending on the attenuation and thickness of the sample to be tested.

Table 1 — Selection of probe frequency

Recommended frequency MHz	Fitting wall thickness mm
3,5	30 - 50
5,0	10 - 50
7,5	10 – 30

NOTE In general, higher frequencies provide better resolution and lower frequencies provide better penetration.

7.4 Scanning mechanisms

To achieve consistency of the images (collected data), guiding mechanisms and scan encoder(s) shall be used.

NOTE Space and accessibility conditions can require specialty encoded scanners to facilitate the inspection.

7.5 Couplant

In order to generate proper images, a couplant should be used which provides a constant transmission of ultrasound between the probe and the material. The same couplant used for calibration shall be used for the testing.

NOTE Any couplant used needs to be cleaned off after testing.

8 Range and sensitivity settings

8.1 Settings

8.1.1 General

Setting of range and sensitivity shall be carried out prior to each testing period in accordance with this document. Any change of the phased array set-up (e.g. probe position and steering parameters) will require a new setting. The set-up should be optimized on the reference reflectors to give a minimum signal-to-noise ratio minimum of 6 dB.

8.1.2 Range setting — Test volume

The range in the depth direction shall cover at least the melt fusion zone above the plane of the heating wires and the same distance below. If the position of the melt fusion zone is unknown, at least half of the thickness of the electrofusion socket fitting above and below the plane of the heating wires shall be used (See Figure 2). When feasible, the range monitored may be extended from the probe-fitting interface and include the inside surface of the pipe.

The range in the axial direction shall cover the nominal length of the fusion zone, which is the expected fusion length indicated by the aligned heating wires.

The range in the circumferential direction shall include the full circumference. Areas not tested due to obstacles (e.g. fusion indicators and connectors) shall be reported.