BRITISH STANDARD

BS EN
13100-3:2004

Non destructive testing of welded joints in thermoplastics semi-finished products —

Part 3: Ultrasonic testing

The European Standard EN 13100-3:2004 has the status of a British Standard

ICS 25.160.40

BSI
British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee PRI/80, Welding of plastics, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Non destructive testing of welded joints in thermoplastics semi-finished products - Part 3: Ultrasonic testing

Contrôle non destructif des assemblages soudés sur produits semi-finis en thermoplastiques - Partie 3 : Contrôle par ultrasons

Zerstörungsfreie Prüfung von Schweißverbindungen thermoplastischer Kunststoffe - Teil 3: Ultraschallprüfung

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Ref. No. EN 13100-3:2004: E

Contents

Foreword

This document (EN 13100-3:2004) has been prepared by Technical Committee CEN/TC 249 “Plastics”, the secretariat of which is held by IBN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2005, and conflicting national standards shall be withdrawn at the latest by May 2005.

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1 Scope

This document specifies methods for the manual ultrasonic examination of heated tool, electrofusion, extrusion and hot gas joints in plastics materials. It applies to joints in single wall pipes and plates. The range of thicknesses covered is from 10 mm to 100 mm.

This document does not specify acceptance levels of the indications.

2 Normative references

The following referenced documents 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.

EN 473, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

EN 583-2, *Non-destructive testing — Ultrasonic examination — Part 2: Sensitivity and range setting*

EN 583-4, *Non-destructive testing — Ultrasonic examination — Part 4: Examination for discontinuities perpendicular to the surface*

EN 1330-2:1998, *Non-destructive testing — Terminology — Part 2: Terms common to the non-destructive testing methods*

EN 1330-4:2000, *Non-destructive testing — Terminology — Part 4: Terms used in ultrasonic testing*

EN 12668-1, *Non-destructive testing — Characterization and verification of ultrasonic examination equipment — Part 1: Instruments*

EN 12668-2, *Non-destructive testing — Characterization and verification of ultrasonic examination equipment — Part 2: Probes*

EN 12668-3, *Non-destructive testing — Characterization and verification of ultrasonic examination equipment — Part 3: Combined equipment*

ENV 583-6, *Non-destructive testing — Ultrasonic examination – Part 6: Time-of-flight diffraction technique as a method for detection and sizing of discontinuities*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 1330-2:1998 and EN 1330-4:2000 apply.

4 Symbols and designations

Symbols and designations are given in Table 1.

Table 1 — Symbols and designations

Symbol	Designations	Unit
t	Thickness of parent material (thinnest part)	mm
l	Length of the indication	mm
h	Extension of the indication in depth direction	mm
x	Position of the indication in the longitudinal direction	mm
y	Position of the indication in the transverse direction	mm
z	Position of the indication in depth	mm
D	Diameter of the component	mm
a	Dimension of the wedge in the direction of examination	mm

5 General

The purpose of this document is to describe general methods of ultrasonic examination for the most commonly used welded joints in thermoplastics. The specific requirements specified by this document cover the equipment, preparation, performance of the examination and reporting. Methods to be used for ultrasonic assessment of indications and acceptance criteria shall be specified.

6 Information required prior to examination

6.1 Examination procedure

The following items shall be specified:

— method for setting the reference level;

— method to be used for evaluation of indications;

— acceptance levels;

— examination level;

— manufacturing and operation stage(s) at which the examination is to be carried out;

— qualification of personnel;

— whether or not a written examination procedure is required;

— requirements for written examination procedures.

6.2 Information required by the operator

Before any examination of a welded joint can begin, the operator shall have access to the following information:

— written examination procedure, if required (see 6.3);

— type(s) of parent material;

— joint preparation and dimensions;

— welding procedure or relevant information on the welding process;

— reporting requirements.

6.3 Written examination procedure

The definitions and requirements in this document will normally satisfy the need for a written examination procedure. When this is not the case, or when the techniques described in this document are not applicable to the welded joint to be examined, additional written examination procedures shall be used.

7 Requirements for personnel and equipment

7.1 Personnel qualifications

Personnel performing examinations in accordance with this document shall be qualified to an appropriate level in accordance with the relevant document, e.g. EN 473.

In addition to a general knowledge of ultrasonic weld inspection, the personnel shall be aware of testing problems specifically associated with the thermoplastic material and type of welded joints to be examined.

7.2 Equipment

Any equipment used in conjunction with this document shall comply with the requirements of EN 12668-1 to EN 12668-3. Prior to the publication of a document related to the subject, the corresponding national documents may be used.

7.3 Probe parameters

7.3.1 Frequency

Only longitudinal (compression) wave transducers shall be used for the inspection of thermoplastics. The frequency of the transducers shall be in the range 1 MHz to 5 MHz and shall be chosen such that flaw sensitivity is maximised without compromising signal-to-noise performance.

To improve signal-to-noise performance piezo-composite transducers may be used.

7.3.2 Angles of incidence

The probe angle(s) used shall ensure that the weld fusion face(s) are examined at, or as near as possible to, normal incidence. This means that for electrofusion joints, for example, a 0° probe angle shall be used.

7.3.3 Focusing

For the examination of electrofusion joints focusing probes should be used. These probes shall be focused to the depth of the welded interfaces, i.e. their focal distance shall be equal to the wall thickness of the socket.

Focused probes should not be used for the examination of heated tool, extrusion or hot gas welded joints unless otherwise specified.

7.3.4 Wedge material

Wedges should be made of PTFE.

7.3.5 Adoption of probes to curved scanning surfaces

The gap between the test surface and the bottom of the wedge shall not be greater than 0,5 mm. For cylindrical or spherical surfaces this requirement will normally be met when the following equation is fulfilled:

$D \geq 15\ a$

If this requirement cannot be met, the wedge shall be adapted to the surface and the sensitivity and range shall be set accordingly.

8 Examination volume

The examination volume (see Figure 1) shall include weld and parent material for at least 5 mm on each side of the weld, or the width of the heat affected zone, whichever is greater.

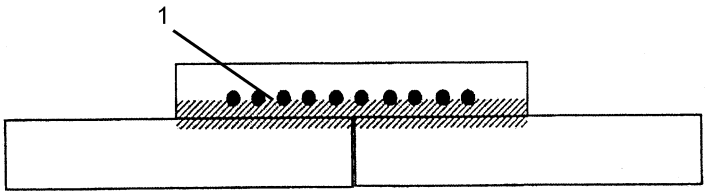
In all cases scanning shall cover the whole examination volume. If individual sections of this volume cannot be covered by a single scanning technique, alternative or supplementary ultrasonic techniques shall be used.

9 Preparation of scanning surfaces

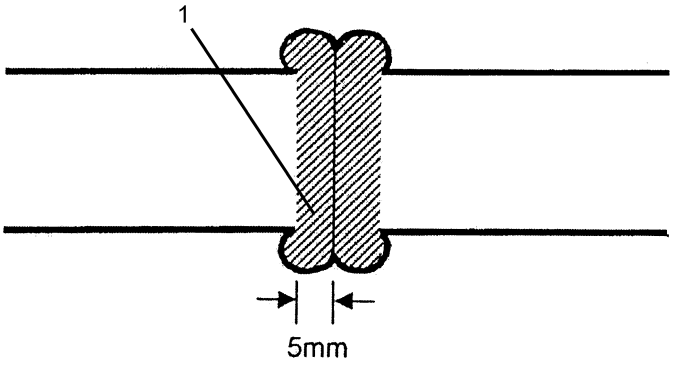
Scanning surfaces shall be wide enough to permit the examination volume to be fully covered. Alternatively, the width of the scanning surfaces may be smaller if equivalent coverage of the examination volume can be achieved by scanning either from both sides of the joint or from both the upper and the lower surface of the joint.

Scanning surfaces shall be even and free from foreign matter likely to interfere with probe coupling (e.g. soil, notches, grooves etc.). Unevenness of the test surface shall not result in a gap between the probe and test surface greater than 0,5 mm

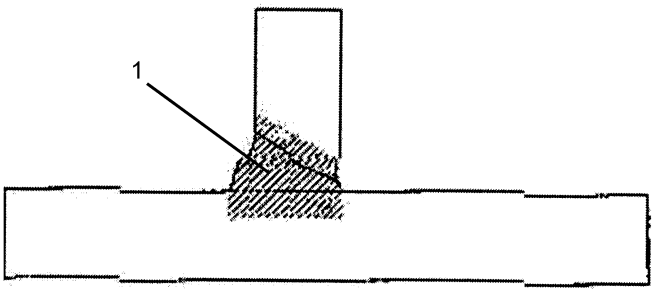
The examination can be performed with either the weld bead intact or removed.



a) Electrofusion (socket) joints



b) Heated tool joints



c) Hot-gas / extrusion joints

Key

1 Examination volume

Figure 1 — Examination volume

10 Range and sensitivity setting

10.1 General

Setting of range and sensitivity shall be carried out whenever the probe type, probe angle, weld type, material type or material thickness is changed in accordance with this document and EN 583-2. Checks to confirm these settings shall be performed at least every 4 h and on completion of the examination. Checks shall also be carried out if the operator or surface condition change, the leads are changed, a new weld (of the same

type) is examined or if changes in the equivalent settings (for example noise level, backwall echo) are suspected. If deviations are found during these checks the corrections given in Table 2 shall be carried out.

Table 2 — Sensitivity and range corrections

Sensitivity		
1	Deviations ≤ 4 dB	The setting shall be corrected before the examination is continued
2	Reduction of the sensitivity > 4 dB	Setting shall be corrected and all examinations carried out with the equipment over the previous period shall be repeated
3	Increase in sensitivity > 4 dB	Setting shall be corrected and all recorded indications shall be re-examined
Range		
1	Deviations ≤ 2 % of the range	The setting shall be corrected before examination is continued
2	Deviations > 2 % of the range	Setting shall be corrected and examinations carried out with the equipment over the previous period shall be repeated

10.2 Reference level

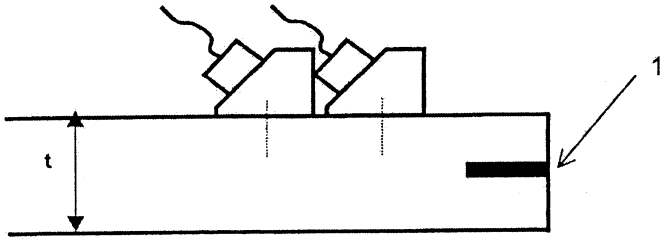
The following methods for setting reference levels shall be used, dependent on which ultrasonic technique has been selected:

— Normal incidence and angled longitudinal (compression) wave inspection: the reference level shall be set using a distance amplitude correction (DAC) curve for a 3 mm diameter side-drilled hole in accordance with EN 583-2;

— Tandem examination: The reference level shall be set using a 3 mm diameter end-drilled flat bottomed hole, inserted at mid-thickness in a test block of similar thickness and material to the component under examination, [see Figure 2a)];

— Time-of-flight diffraction (TOFD) examination: The reference level shall be set using a 3 mm side-drilled hole inserted at 2/3 thickness in a test block of similar thickness and material to the component under examination, [see Figure 2b)];

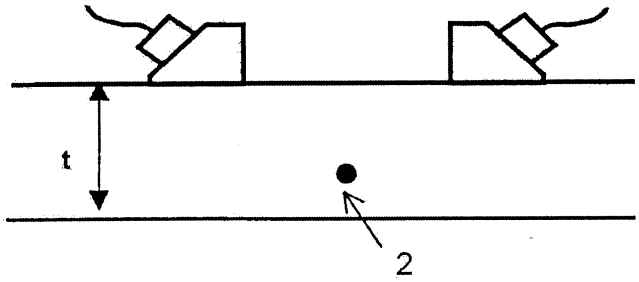
— Creeping wave examination: The reference level shall be set using a 2 mm deep rectangular notch at the surface of a test block of similar material to the component under examination, [see Figure 2c)].



Key

1 3 mm diameter end-drilled flat bottomed hole

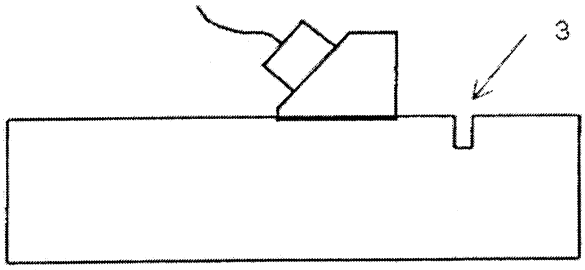
a) Tandem examination



Key

2 3 mm diameter side-drilled hole

b) TOFD examination



Key

3 2 mm deep rectangular notch

c) Creeping wave examination

Figure 2 — Reference blocks

10.3 Evaluation levels

An appropriate evaluation level shall be agreed between the contracting parties for each of the techniques used.

10.4 Transfer correction

If the reference block used for establishing reference levels, is not of identical material to that of the test object then a measurement shall be made of the transfer differences between test object and block at a representative number of locations. Only measurements made using a 0°, normal incidence, compression wave probe shall be used, as described in EN 583-2.

If the differences are less than 2 dB, correction is not required.

If the differences are greater than 2 dB, but less than 12 dB, they shall be compensated for.

If the transfer difference exceeds 12 dB the reason(s) for such a large difference shall be investigated and corrective actions undertaken, i.e. by selecting a reference block which more closely matches the material under test.

10.5 Signal-to-noise ratio

During examination of the weld the noise level, excluding spurious surface indications, shall remain at least 12 dB below the evaluation level. This requirement may be relaxed subject to agreement between the contracting parties.

11 Examination technique

11.1 Ultrasonic techniques

11.1.1 Normal incidence longitudinal (compression) wave examination

This examination technique is normally used to inspect electrofusion and lap joints. Testing involves using a single, 0° longitudinal wave probe operating in pulse-echo mode, focused to the depth of the weld line (see Figure 3).

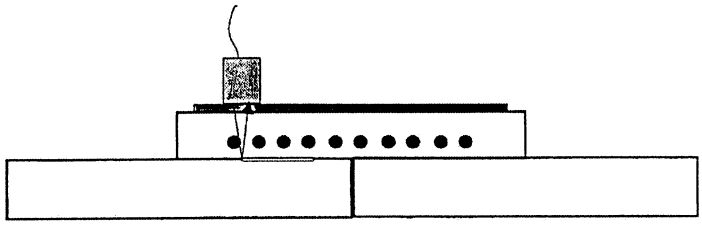


Figure 3 — Principle of normal incidence longitudinal (compression) wave examination

11.1.2 Angled longitudinal (compression) wave examination

This examination technique is normally used to inspect hot gas or extrusion welded joints and involves selecting an appropriate probe angle in accordance with 6.3.2 (see Figure 4).

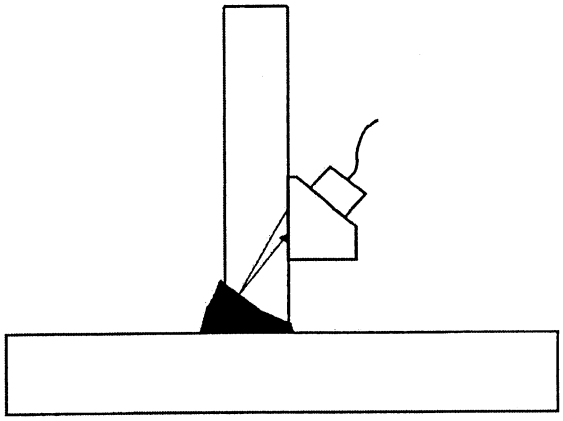
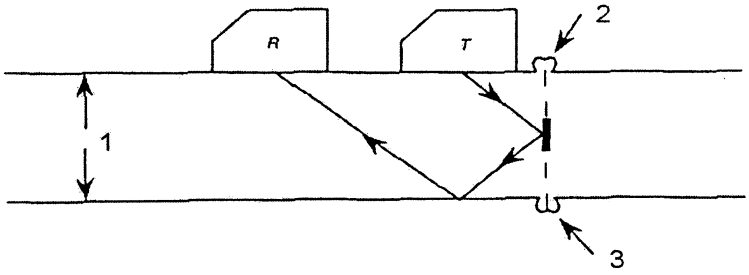


Figure 4 — Principle of angled longitudinal (compression) wave examination

11.1.3 Tandem examination

This examination technique is normally used to inspect heated tool welds and involves using two similar angle probes (normally 45 ° or 60 °), one probe operating as the transmitter and the other probe as the receiver. The probes are located in a line with their beam axes facing in the same direction as shown in Figure 5. Tandem examination shall be carried out in accordance with EN 583-4.



Key

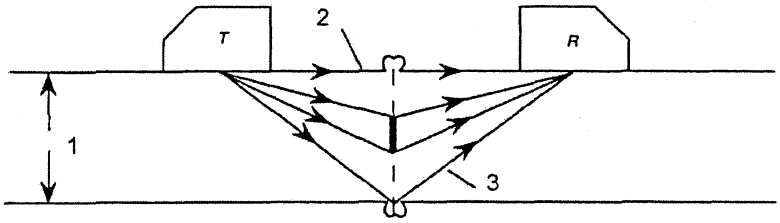
1 Pipe wall
2 Outer weld bead
3 Inner weld bead

Figure 5 — Principle of tandem examination

11.1.4 Time-of-flight diffraction (TOFD) examination

This examination technique is normally used to inspect heated tool welds and involves using two similar probes (normally 45 ° or 60 °), positioned facing each other across the weld as shown in Figure 6. One probe operates as the transmitter and the other probe as the receiver.

TOFD inspection shall be carried out in accordance with ENV 583-6.



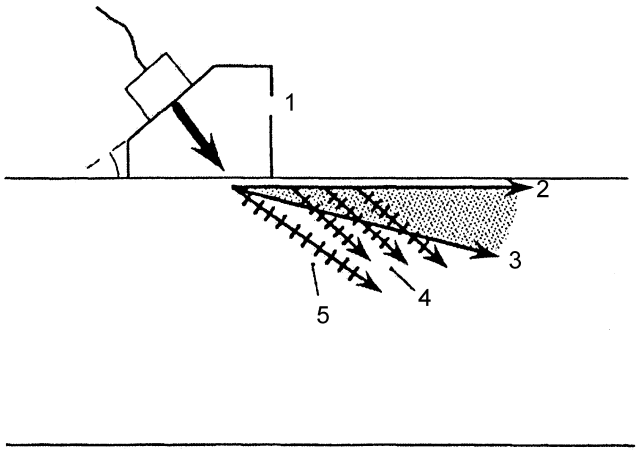
Key

1 Pipe wall
2 Lateral wave
3 Back wall echo

Figure 6 — Principle of time-of-flight diffraction (TOFD) examination

11.1.5 Creeping wave examination

This examination technique is normally used to inspect the first few millimetres immediately beneath the surface. Testing involves using a single creeping wave probe normally 85 ° to 90 ° operating in pulse-echo mode, as shown in Figure 7.



Key

1 Incident compression waves
2 Creeping wave
3 Refracted compression waves
4 Secondary shear waves
5 Mode converted shear wave

Figure 7 — Principle of creeping wave examination

11.2 Location of indications

The location of all indications shall be defined by reference to a co-ordinate system. A point on the examination surface shall be selected as the origin for these measurements.

Where examination is carried out from more than one surface, reference points shall be established on each surface. In this case care shall be taken to establish a positional relationship between all reference points used, so that the absolute location of all indications can be established from any nominated reference point.

11.3 Evaluation of indications

11.3.1 General

All indications above the evaluation level shall be assessed in accordance with 11.3.2 to 11.3.4.

11.3.2 Maximum echo amplitude

The echo amplitude shall be maximised by probe movement and recorded in relation to the agreed reference level.

11.3.3 Indication length

The length of the indication shall, where possible, be determined using the 6 dB drop tip location technique, unless otherwise agreed.

11.3.4 Indication height

Indication height measurement shall be carried out by agreement only.

11.3.5 Characterisation of discontinuities

Discontinuities shall be characterised only by agreement between the contracting parties, or if required by the specified acceptance criteria.

12 Examination report

12.1 General

The examination report shall include a reference to this document and give, as a minimum, the following information.

12.2 General data

a) Identification of the object under examination:

   1) material and product form;

   2) dimensions;

   3) location of weld/welded joint examined;

   4) sketch showing geometrical configuration (if necessary);

   5) reference to the welding procedure;

   6) state of manufacture;

   7) surface conditions;

b) contract requirements, e.g. specifications, guidelines, special agreements etc.;

c) place and date of examination;

d) identification of examination organisations and identification and qualification of operator;

e) identification of inspection authority.

12.3 Information relating to equipment

a) Manufacturer and type of ultrasonic instrument with identification number, if required;

b) manufacturer, type, nominal frequency and actual angle of incidence of probes used with identification number, if required;

c) identification of reference blocks used, with a sketch, if necessary;

d) couplant medium.

12.4 Information relating to examination technique

a) Examination level(s) and reference to written procedure, when used;

b) extent of examination;

c) location of the scanning areas;

d) reference points and details of co-ordinate system used, as specified in 11.2;

e) time base range;

f) method and values used for sensitivity setting (gain setting for reference levels and values used for transfer corrections);

g) reference levels;

h) acceptance levels;

i) deviations from this document, or contract requirements.

12.5 Results of the examination

Tabular summary (or sketches) providing the following information for recorded indications:

a) co-ordinate of the indication, as specified in 11.2, with details of associated probes and corresponding probe positions;

b) maximum echo amplitude, as specified in 11.3.2, and information, if required, on the type and size of indication;

c) lengths of indications, as specified in 11.3.3;

d) heights of indications, if required (11.3.4);

e) results of evaluation, according to specified acceptance levels.

Bibliography

[1] EN 583-1, *Non-destructive testing — Ultrasonic examination — Part 1: General principles*

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