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Steel castings — Ultrasonic testing

Part 1: Steel castings for general purposes

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National foreword

This British Standard is the UK implementation of ISO 4992-1:2020. It supersedes BS ISO 4992-1:2006, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/111, Steel Castings and Forgings.

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Part 1: Steel castings for general purposes

Pièces moulées en acier - Contrôle par ultrasons —

Partie 1: Pièces moulées en acier pour usages généraux

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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 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 17, *Steel*, Subcommittee SC 11, *Steel castings*.

This second edition cancels and replaces the first edition (ISO 4992-1:2006), which has been technically revised. The main changes compared to the previous edition are as follows:

— New definition added for “rim zone” (3.6) and “non-measurable dimension (3.8);

— New subclause 4.3.1;

— Figure 2 was redrawn;

— Subtitles added to Figures 2, 3, 4 and Figures in Annexes A and B

— Figure A.1 Key 8 was corrected;

— Table in Figure A.1 numbered as Table A.1.

A list of all parts in the ISO 4992 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.

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Steel castings — Ultrasonic testing —

Part 1: Steel castings for general purposes

1 Scope

This document specifies the requirements for the ultrasonic testing of steel castings (with ferritic structure) for general purposes, and the methods for determining internal discontinuities by the pulse-echo technique.

This document applies to the ultrasonic testing of steel castings which have usually received a grain-refining heat treatment and which have wall thicknesses up to and including 600 mm. For greater wall thicknesses, special agreements apply with respect to the test procedure and the acceptance levels.

This document does not apply to austenitic steels and to joint welds.

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 2400, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 1*

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

ISO 7963, *Non-destructive testing — Ultrasonic testing — Specification for calibration block No. 2*

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

ISO 11971, *Steel and iron castings — Visual testing of surface quality*

ISO 16810, *Non-destructive testing — Ultrasonic testing — General principles*

ISO 16811, *Non-destructive testing — Ultrasonic testing — Sensitivity and range setting*

ISO 16827, *Non-destructive testing — Ultrasonic testing — Characterization and sizing of discontinuities*

ISO 22232-1[1)], *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 1: Instruments*

ISO 22232-2[2)], *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 2: Probes*

ISO 22232-3[3)], *Non-destructive testing — Characterization and verification of ultrasonic test equipment — Part 3: Combined equipment*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5577, ISO 16810, ISO 16811, ISO 16827 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
equivalent reference discontinuity echo size
indication to be recorded during the assessment phase of an ultrasonic test, usually expressed as an equivalent diameter of a flat-bottomed hole (FBH)

3.2
point-like discontinuity
discontinuity, the dimensions of which are smaller than or equal to the sound-beam width

Note 1 to entry: Dimensions in this document relate to length, width and/or dimension in the through-wall direction.

3.3
extended discontinuity
discontinuity, the dimensions of which are larger than the sound-beam width

Note 1 to entry: Dimensions in this document relate to length, width and/or dimension in the through-wall direction.

3.4
planar discontinuity
discontinuity having two measurable dimensions

3.5
volumetric discontinuity
discontinuity having three measurable dimensions

3.6
rim zone
1/3 the through-wall thickness from the surface with a maximum of 30 mm

3.7
special rim zone
outer *rim zone* (3.6) of the test object with special requirements

Note 1 to entry: Examples of special requirements are machined surfaces, higher stresses and sealing surfaces.

3.8
non-measurable dimension
dimension of a discontinuity that is smaller than the beam width, which depends on the probe size and the frequency used

Note 1 to entry: Current state of the industry is <3 mm.

3.9
production welding
any welding on the test object carried out during manufacturing before final delivery to the purchaser

3.10
joint welding
production welding used to assemble components together to obtain an integral unit

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3.11
finishing welding
production welding carried out in order to ensure the agreed quality of the casting

4 Requirements

4.1 Order information

The following information shall be available at the time of enquiry and order (see also ISO 16810):

a) the areas of the casting and the number or percentage of castings to which the requirements of ultrasonic testing apply (testing volume, extent of testing);

b) the acceptance levels to be applied to the various zones or areas of the casting;

c) requirements for a written test procedure;

d) whether there are any additional requirements for the test procedure, see also 5.5.1.

4.2 Extent of testing

The casting shall be tested so that the agreed areas are covered (insofar as this is possible from the shape of the casting) by the use of the best applicable test technique.

For wall thicknesses greater than 600 mm, agreement shall be made between the purchaser and manufacturer on the acceptance levels, test procedure, and the recording of the test results.

4.3 Maximum acceptable size of discontinuities

4.3.1 General

Single discontinuities extending into the rim zone and core zone shall be evaluated as rim zone.

4.3.2 Acceptance levels for planar discontinuities mainly orientated perpendicular to the surface

The acceptance levels for planar discontinuities are given in Figure 1.

Discontinuities exceeding 3 mm FBH shall not be acceptable in class 1.

The largest dimension of a discontinuity in the through-wall direction shall not exceed 10 % of the wall thickness, except discontinuities with a length ≤10 mm. Discontinuities with a length ≤10 mm shall not exceed a dimension in the through-wall direction of 25 % of the wall thickness.

The greatest distance between discontinuities, as a criterion for evaluation as a single discontinuity or a discontinuity area perpendicular or lateral to the surface, shall be 10 mm.

For a discontinuity with more than 3 mm in length and non-measurable dimension in the through-wall direction, this non-measurable dimension shall be taken as 3 mm and the discontinuity area shall be calculated as follows:

$$A = 3L \tag{1}$$

where

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A is the area of discontinuity, in square millimetres;

3 is the width taken, in millimetres;

L is the length, in millimetres.

4.3.3 Acceptance levels for volumetric discontinuities

The acceptance levels for volumetric discontinuities are given in Table 1. Any discontinuity exceeding one of the levels shall not be acceptable.

4.3.4 Maximum acceptable discontinuities when radiographic testing (RT) of the casting is carried out as a supplement to ultrasonic testing (UT)

Unless otherwise agreed at the time of enquiry and order, when conducting radiographic and ultrasonic testing in combination it was proven that if a discontinuity indicated by radiographic testing is situated in the core zone, the discontinuity is acceptable at one level lower, e.g. in class 3 instead of class 2 for radiographic testing. For further information, see EN 1559-2.

4.4 Qualification of personnel

Ultrasonic testing shall be performed by qualified personnel. Qualification of personnel may be according to ISO 9712 or other equivalent recognised standards.

4.5 Wall-section zones

The wall section shall be divided into core and rim zones as shown in Figure 2. These zones relate to the dimensions of the casting ready for assembly (finish-machined).

4.6 Classes

If the purchaser specifies different classes in different areas of the same casting, all of these areas shall be clearly identified and shall include:

a) all necessary dimensions for accurate location of zones;

b) the full extent of all weld preparations and the thickness of any special rim zone.

Class 1 is only applied to weld preparations and special rim zones.

Unless other requirements have been agreed at the time of acceptance of the order, for finishing welds, the requirements for the parent metal shall apply.

5 Testing

5.1 Principles

The principles of ultrasonic testing given in ISO 16810, ISO 16811 and ISO 16827 shall apply.

5.2 Material

The suitability of material for ultrasonic testing is assessed by comparison with the echo height of a reference reflector (usually the first back-wall echo) and the noise level. This assessment shall be carried out on selected casting areas which are representative of the surface finish and of the total thickness range of the objects to be tested. The assessment areas shall have parallel surfaces.

The reference echo height according to Table 2 shall be at least 6 dB above the noise level.

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If the echo height of the smallest detectable flat-bottomed or equivalent side-drilled hole at the far end of the test range to be assessed is less than 6 dB above the noise level, then ultrasonic testing has reduced performance. In this case, the diameter of the flat-bottomed or side-drilled hole which can be detected with a signal-to-noise ratio of at least 6 dB shall be noted in the test report, and the additional procedure shall be agreed between the manufacturer and the purchaser.

NOTE For the definition of an adequate diameter of a flat-bottomed hole, the distance-gain-size system (DGS) or a test block of identical material, heat treatment, and thickness containing flat-bottomed holes with a diameter according to Table 2 or equivalent side-drilled holes, can be used. The following formula can be used for converting a flat-bottomed hole diameter into an equivalent side-drilled hole diameter:

$$D_{\mathrm{SDH}} = \frac{4{,}935 D_{\mathrm{FBH}}^{4}}{\lambda^{2} s} \tag{2}$$

where

D_{SDH} is the side-drilled hole diameter, in millimetres;

D_{FBH} is the flat-bottomed hole diameter, in millimetres;

λ is the wavelength, in millimetres;

s is the path length, in millimetres.

Formula (2) is applicable for $D_{\mathrm{SDH}} \geq 2\lambda$ and $s \geq 5$ times the near-field length and is only defined for single-element probes.

5.3 Test equipment and coupling fluid

5.3.1 Ultrasonic instrument

The ultrasonic instrument shall meet the requirements given in ISO 22232-1 and shall have the following characteristics:

a) range setting capability, from at least 10 mm to 2 m, continuously selectable, for longitudinal and transverse waves in steel;

b) gain span, adjustable in 2 dB maximum steps over a range of at least 80 dB with an accuracy of 1 dB;

c) time-base and vertical linearities less than 5 % of the adjustment range of the screen;

d) operating in combined transmitter-receiver mode or in separate transmitter-receiver mode;

e) suitability, at least for nominal frequencies from 1 MHz up to and including 5 MHz, for the pulse-echo technique with single-element and dual-element probes.

5.3.2 Probes

The probes shall meet the requirements given in ISO 22232-2 and ISO 22232-3 with the following exceptions:

a) nominal frequencies shall be in the range 1 MHz to 5 MHz;

b) for oblique incidence, angle-beam probes with angles between 35° and 70° shall be used.

NOTE Normal-beam or angle-beam probes can be used for the testing of steel castings. The suited probe type depends on the geometry of the casting and the type of discontinuity to be detected.

For test zones close to the surface, dual-element probes (normal-beam or angle-beam) should be preferred.

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5.3.3 Checking of the ultrasonic test equipment

The ultrasonic test equipment shall be checked regularly by the operator in accordance with ISO 22232-3.

5.3.4 Coupling fluid

A coupling fluid in accordance with ISO 16810 shall be used. The coupling fluid shall wet the test surface to ensure satisfactory sound transmission. The same coupling fluid shall be used for the calibration and all subsequent test operations.

NOTE The sound transmission can be checked by one or more stable back-wall echoes in areas with parallel surfaces.

5.4 Preparation of casting surfaces for testing

For the preparation of casting surfaces for ultrasonic testing, see ISO 16810.

The casting surfaces to be tested shall be such that satisfactory coupling with the probe can be achieved.

With single-element probes, satisfactory coupling can be achieved if the surfaces correspond at least to the limit comparator 4 S1 or 4 S2 according to ISO 11971.

The roughness of any machined surface used for testing shall be $R_a \leq 12{,}5$ µm.

For special test techniques, higher surface qualities such as 2 S1 or 2 S2 (see ISO 11971) and $R_a \leq 6{,}3$ µm may be necessary.

5.5 Test procedure

5.5.1 General

Because the choice of both the direction of incidence and suitable probes largely depends on the shape of the casting, or on the possible discontinuities in the casting or on the possible discontinuities from finishing welding, the applicable test procedure shall be specified by the manufacturer of the casting.

If possible, the areas to be tested shall be tested from both sides. When testing from one side only, short-range resolving probes shall be used additionally for the detection of discontinuities close to the surface. Testing with dual-element probes is only adequate for wall thicknesses up to 50 mm.

Additionally, when not otherwise agreed between the purchaser and the manufacturer, for all castings, dual-element normal-beam and/or angle-beam probes shall be used to test the following areas up to a depth of 50 mm:

a) critical areas, e.g. fillets, changes in cross-section, areas with external chills;

b) finishing welds;

c) weld preparation areas, as specified in the order;

d) special rim zones, as specified in the order, critical for the performance of the casting.

Finishing welds which are deeper than 50 mm shall be subject to supplementary testing with other suitable angle-beam probes.

For angle-beam probes with angles over 60°, the sound path shall not exceed 150 mm.

Complete coverage of all areas specified for testing shall be performed by carrying out systematically overlapping scans.

The scanning speed shall not exceed 150 mm/s.

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