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Steel castings — Ultrasonic testing

Part 2: Steel castings for highly stressed components

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National foreword

This British Standard is the UK implementation of ISO 4992-2:2020. It supersedes BS ISO 4992-2:2006, which is withdrawn.

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Second edition
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Steel castings — Ultrasonic testing —

Part 2: Steel castings for highly stressed components

Pièces moulées en acier - Contrôle par ultrasons —

Partie 2: Pièces moulées en acier pour composants fortement sollicités

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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).

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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 4992-2:2006), 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 4.3.3.1;

— Figure 1 was redrawn;

— Text in Figure 2 moved to 4.3.3.2 and text in Figures 3 and 4 moved to 4.3.3.3;

— Figure referenced in 5.5.3.3 was corrected (new Figure 5 added);

— Figure 5 was renumbered as Figure 6;

— Subtitles added to Figure 1, Figure 6, and Figures in Annex C;

— Figure B.1 Key 8 was corrected;

— Table in Figure B.1 numbered as Table B.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 2: Steel castings for highly stressed components

1 Scope

This document specifies the requirements for the ultrasonic testing of steel castings (with ferritic structure) for highly stressed components, and the methods for determining internal discontinuities by the pulse-echo technique. Purchasers determine if components are highly stressed based on the need for performance or safety.

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 16827:2012, *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*

1) Under preparation. Stage at the time of publication: ISO/DIS 22322-1.

2) Under preparation. Stage at the time of publication: ISO/DIS 22322-2.

3) Under preparation. Stage at the time of publication: ISO/DIS 22322-3.

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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 diameter

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 diameter

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 discontinuity
dimension of the discontinuity that cannot be determined, non-measurable, by scanning (dB-drop) when the dimension 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;

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

The purchaser shall specify the acceptance level according to the required class for planar and volumetric discontinuities within each zone and in each specified area of the casting.

The wall section shall be divided into core and rim zones as shown in Figure 1. These sections relate to the sizes of castings ready for assembly (finish-machined).

4.3.2 Indications without measurable dimensions

In special rim zones and at weld preparation ends, indications without measurable dimensions are limited to a maximum number of indications.

These indications shall not exceed the limits given in Table 1.

4.3.3 Indications with measurable dimensions

4.3.3.1 General

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

4.3.3.2 Planar discontinuities

Planar discontinuities shall not exceed the limits given in Figure 2.

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

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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 criterion for evaluation as an individual discontinuity or a discontinuity area in the through-wall direction 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 area shall be calculated as follows:

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

where

A is the area of discontinuity, in square millimetres;

3 is the width taken, in millimetres;

L is the length, in millimetres.

The sizing of small planar discontinuities, as given in Figure 2, becomes more difficult with increasing beam-path length and sound-beam diameter. As a guide, these sizings are normally applied to a rim zone of 30 mm. This makes the use of probes with focused beams, such as dual-transducer probes, necessary.

4.3.3.3 Volumetric discontinuities

Volumetric discontinuities shall not exceed the sizes given in Figure 3 for the rim zone and Figure 4 for the core zone.

Indications exceeding 3 mm FBH shall not be acceptable as class 1.

The maximum acceptable dimensions of discontinuity areas in the through-wall direction in the rim zone shall be 15 % of the rim zone thickness. The maximum acceptable dimensions of discontinuity areas in the through-wall direction in the core zone shall be 15 % of the wall thickness.

The maximum distance between discontinuities, as a criterion for evaluation as an individual indication in the through-wall direction or lateral to the surface, shall be 10 mm in the rim zone and 20 mm in the core zone.

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 area shall be calculated as follows:

$$A = 3L \tag{2}$$

where

A is the area of discontinuity, in square millimetres;

3 is the width taken, in millimetres;

L is the length, in millimetres.

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.

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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 1. These sections 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.

If the echo height of the smallest detectable flat-bottomed or equivalent side-drilled hole diameter at the far end of the test range to be assessed is less than 6 dB above the noise level, then the 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 condition and section 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:

$$D_{\mathrm{SDH}} = \frac{4{,}935 D_{\mathrm{FBH}}^{4}}{\lambda^{2} s} \tag{3}$$

where

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

5.3 Test equipment, coupling fluid, test sensitivity and resolution of detection

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 transmitted 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) suitability, at least for nominal frequencies from 1 MHz up to and including 6 MHz, in the pulse-echo technique with single-transducer and dual-transducer probes.

5.3.2 Probes and transducer frequencies

The probes and transducer frequencies shall be as given in ISO 22232-2, ISO 22232-2 and ISO 22232-3 with the following exceptions:

a) nominal frequencies shall be in the range 1 MHz to 6 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 for highly stressed components. The type of probe used 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.

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.

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