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Livarstvo - Ultrazvočna preiskava - 3. del: Ulitki iz sive litine s kroglastim grafitom

Founding - Ultrasonic examination - Part 3: Spheroidal graphite cast iron castings

Gießereiwesen - Ultraschallprüfung - Teil 3: Gussstücke aus Gusseisen mit Kugelgraphit

Fonderie - Contrôle par ultrasons - Partie 3: Pièces moulées en fonte à graphite sphéroidal

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This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 190.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Contents

Foreword

This document (prEN 12680-3:2010) has been prepared by Technical Committee CEN/TC 190 “Foundry Technology”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 12680-3:2003.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 4.10 "Inner defects" to revise EN 12680-3:2003:

EN 12680-3, *Founding — Ultrasonic examination — Part 3: Spheroidal graphite cast iron castings.*

This is one of three European Standards for ultrasonic examination. The other standards are:

EN 12680-1, *Founding — Ultrasonic examination — Part 1: Steel castings for general purposes.*

EN 12680-2, *Founding — Ultrasonic examination — Part 2: Steel castings for highly stressed components.*

Annex A provides details of significant technical changes between this European Standard and the previous edition.

1 Scope

This European Standard specifies the requirements for the ultrasonic examination of spheroidal graphite cast iron castings and the methods for determining internal discontinuities by the pulse-echo technique.

This European Standard does not deal with the ultrasonic examination of the nodularity of spheroidal graphite cast irons.

This European Standard does not cover the transmission technique.

NOTE The transmission technique has insufficient sensitivity to detect the discontinuities found in spheroidal graphite cast iron castings and is used in exceptional cases only.

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

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

EN 583-5, *Non-destructive testing — Ultrasonic examination — Part 5: Characterization and sizing of discontinuities*

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

EN 12223, *Non-destructive testing — Ultrasonic examination — Specification for calibration block No. 1*

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*

EN 27963, *Welds in steel — Calibration block No. 2 for ultrasonic examination of welds (ISO 7963:1985)*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 1330-4 and the following apply.

3.1
dross
accumulation of fine slag particles (oxides, sulphides ….) in the rim zone of castings

NOTE In smaller castings dross is usually not detected by ultrasonic testing.

4 Requirements

4.1 Order information

The following information shall be available at the time of enquiry and order (see also EN 583-1):

— the areas of the casting and the number or percentage of castings to which the ultrasonic examination requirements apply;

— the severity levels for small castings in accordance with Table 1 and if applicable Table 3, or for large castings Table 2 and if applicable Table 4, to be applied to the various areas of the casting;

— requirements for a written examination procedure.

NOTE 1 Severity levels in Tables 1 and 3 as well as 2 and 4 can be chosen differently.

NOTE 2 Small castings are typically produced under serial conditions, e.g. automatic moulding lines, with a mass up to 500 kg.

NOTE 3 Large castings are typically hand moulded, with a mass higher than 500 kg.

4.2 Extent of examination

The areas of the casting to be examined shall be agreed. This agreement shall state how these areas are to be examined, i.e. point testing or scanning, and in which directions.

NOTE These areas should be preferably indicated on the casting drawing.

For wall thicknesses outside of the range 10 mm to 500 mm, agreement shall be made between the parties concerned on the examination procedure and also on the recording and acceptance levels.

4.3 Maximum permissible size of discontinuities

Unless otherwise agreed between the parties concerned, the maximum permissible sizes of discontinuities shall not exceed those of the severity level given in either Table 1 and/or Table 2.

4.4 Personnel qualification

Ultrasonic examination should be performed by qualified personnel according to EN 473 or equivalent.

4.5 Wall section zones

The wall section shall be divided into zones as shown in Figure 1. For wall thickness equal or less 10 mm the wall thickness shall be considered as rim zone.

NOTE Unless otherwise agreed these wall sections shall relate to the dimensions of the casting in the “as delivered” condition.

When a discontinuity is located simultaneously in both, the rim zone and the core zone, the following applies:

— ≥ 50 % in the rim zone, the specified area of the largest discontinuity for the rim zone shall be doubled;

— < 50 % in the rim zone, the specified area of the largest discontinuity for the core zone shall be halved.

5 Test method

5.1 Principles

The principles given in EN 583-1 and EN 583-2 shall apply.

5.2 Material

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

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

NOTE If a distance gain size diagram (DGS) is available, the suitability of castings for ultrasonic examination with normal probes can be determined for example as follows: with the suppression switched off, the backwall echo is brought to any reference level desired. The amplification according to the DGS diagram is then increased so that the echo signal height from the substitute reflector according to 5.3.5.3 reaches the reference level. If the amplification is further increased by 6 dB the background noise level should not exceed the reference height. If necessary, a reference reflector can be used to determine the testing suitability in areas without the backwall echo.

5.3 Equipment, coupling medium, calibration and sensitivity

5.3.1 Ultrasonic instrument

The ultrasonic instrument shall meet the requirements given in EN 12668-1 and shall have the following characteristics:

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

— gain, adjustable in 2 dB maximum steps over a range of at least 80 dB with a measuring accuracy of 1 dB;

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

— suitability at least for nominal frequencies from 0,5 MHz up to and including 5 MHz in pulse-echo technique with single-crystal and twin-crystal probes.

5.3.2 Probes and transducer frequencies

The probes and transducer frequencies shall be as given in EN 12668-2 and EN 12668-3 with the following exceptions:

— to cover the range of discontinuity types to be detected, the casting can be examined using compression-wave single-crystal or twin-crystal probes.

NOTE 1 Twin-crystal probes should be used for the examination of areas close to the test surface.

— for special geometrical conditions, angle probes can be used up to a sound-beam path length of about 100 mm, preferably with nominal angles between 45° and 70°. The frequency value shall be selected to suit the examination and shall be within the range 0,5 MHz to 5 MHz. Higher frequencies can be used for examining wall thicknesses of less than 20 mm or areas close to the surface.

NOTE 2 For the detection of near-surface discontinuities, the use of twin-crystal and/or angle probes is recommended.

NOTE 3 Since sound travels at different velocities in steel and spheroidal graphite cast iron, the actual angle of refraction deviates from the nominal angle of the probe for steel.

If the sound velocity of spheroidal graphite cast iron is known, the angle of refraction of the probe can be determined from the sound velocity according to Figure 2.

Figure 3 shows how the angle of refraction can be determined to an accuracy sufficient for practical purposes using two probes of the same type. The sound velocity of spheroidal graphite cast iron can also be determined from the angle of refraction α as follows:

$$C_c = 3\,255 \times \frac{\sin \alpha_c}{\sin \alpha_s} \quad (1)$$

where

C_c the sound velocity in the casting in metres per second;

α_c is the angle of refraction in the casting in degrees;

α_s is the angle of refraction in steel in degrees.

NOTE 4 Typical sound velocity for spheroidal graphite cast iron is over 5500 m/s.

NOTE 5 To simplify examination, special probes can be used, e.g. angle probes for longitudinal waves.

5.3.3 Checking the ultrasonic examination equipment

The ultrasonic examination equipment shall be checked regularly by the operator according to EN 12668-3.

5.3.4 Coupling medium

A coupling medium in accordance with EN 583-1 shall be used. The coupling medium shall wet the examination area to ensure satisfactory sound transmission. The same coupling medium shall be used for calibration and all subsequent examination operations.

NOTE The sound transmission can be checked by ensuring one or more stable backwall echoes in areas with parallel surfaces.

5.3.5 Calibration of the ultrasonic equipment

5.3.5.1 General

A spheroidal graphite cast iron reference block shall be used for calibration. The thickness of the reference block shall be comparable to the wall thickness range of the casting to be examined and shall be agreed at the time of enquiry and order. The reference block shall have the same ultrasonic properties as the casting to be examined and shall have the same surface finish. The reference block shall contain flat-bottomed holes according to Table 3 or equivalent side-drilled holes as substitute reflectors.

NOTE The following formula is used for converting the flat-bottomed hole diameter into the side-drilled hole diameter:

$$D_Q = \frac{4{,}935 \times D_{FBH}^4}{\lambda^2 \times s} \quad (2)$$

where

D_Q is the side-drilled hole diameter in millimetre

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

λ is the wave length in millimetre;

s is the path length in millimetre.

The formula is applicable for $D_Q \geq 2\ \lambda$ and $s \geq 5 \times$ nearfield length and is only defined for single element probes.

Other substitute reflector sizes or reflector types may be agreed at the time of enquiry and order. All sound of the reference block shall be flat and parallel. If standard steel calibration blocks are used, differences in sound velocity, sound attenuation and surface quality between the casting and the calibration blocks shall be taken into consideration.

The equipment can also be set using a DGS diagram [1] (see bibliography) calculated for spheroidal graphite cast iron. In this case, the reference block is not necessary and calibration can be done on the casting itself.

5.3.5.2 Range setting

Range setting shall be carried out. It can be done either on the reference block or calibration block and checked on the casting itself or carried out directly on the casting, if its thickness is known and if it has parallel surfaces.

5.3.5.3 Sensitivity setting

The sensitivity shall be set by reflecting sound from a suitable reflector, e.g. the opposite surface of a casting, a flat-bottomed or side-drilled hole of the reference block or the circular segments of the calibration blocks K1 according to EN 12223 or K2 according to EN 27963. Account shall be taken of the sound attenuation, surface quality and velocity of sound through the casting. The transfer correction shall be determined. When determining the transfer correction, not only the quality of the coupling areas but also the surface quality of the opposite surface shall be taken into consideration. The signal level in the thickness range to be assessed is given by the diameter in millimetres of any suitable reflector (see 5.3.5.1)

NOTE A reference curve can be taken on the substitute reflectors of the reference block and transferred to the instrument screen. In order to prevent incorrect evaluation of the signals for different path lengths, the reference curve should be corrected to take into account different sound attenuations between the reference block and the casting.

5.3.6 Detection sensitivity

The detection sensitivity of the equipment shall ensure at least the setting of the sensitivity in accordance with the requirements of 5.5.3.

5.4 Preparation of casting surfaces for examination

For the preparation of casting surfaces for examination see EN 583-1.

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

NOTE It is recommended that surface condition requirements according to EN 1370 are agreed at the time of enquiry and order (e.g. as-cast, shot-blasted, fettled or machined surfaces).

5.5 Examination procedure

5.5.1 General

The selection of the incidence direction and of the most suitable probes depends largely on the casting shape and the nature and position of the casting discontinuities. Therefore, the applicable examination procedure shall be specified by the manufacture of the casting and the operator as applicable. The method most widely used is vertical incidence with compression wave probes having frequencies within the range 0,5 MHz up to and including 5 MHz. Single-crystal or twin-crystal probes can be used. Oblique incidence (angle probes) can be used for special geometrical conditions, where compression wave probes are not satisfactory. If the intended application of the casting needs special requirements regarding the examination procedure, the purchaser shall inform the manufacturer accordingly.

NOTE Higher frequencies are normally used to examine castings with small wall thicknesses and high-quality requirements.

Complete coverage of all areas specified for scanning shall be conducted by carrying out systematically over-lapping scans.

If scanning is agreed (see 4.2), the scanning rate shall not exceed 150 mm/s.

5.5.2 Sensitivity setting

5.5.2.1 Minimum sensitivity (detection sensitivity)

The sensitivity of the system shall be set in such a way that the echo heights of the flat-bottomed holes given in Table 3 or of the equivalent side-drilled holes shall be at least 40 % of the screen height at the end of the thickness range to be examined. If it is not possible to set this minimum sensitivity, the smallest flat-bottomed hole which can be detected shall be recorded in the examination report. In this case, the purchaser and the manufacturer shall agree on further action.

5.5.2.2 Search sensitivity

When searching for discontinuities, the amplification shall be set in such a way that the noise level is visible on the screen (search sensitivity).

If there are local variations in surface quality, the sensitivity can fluctuate widely. In such cases, the search sensitivity shall not fall below the minimum sensitivity.

NOTE For discontinuity searching with simultaneous observation of the backwall echo (see Table 4), the use of devices with adjustable backwall echo reduction is advantageous.

5.5.3 Consideration of various types of indications

The following types of indications, which are proven not to be due to the casting shape or the coupling, shall be taken into consideration and evaluated in the examination of castings:

— reduction of the backwall echo;

— intermediate echoes.

NOTE All types of indications can occur alone or together. Backwall echo reduction is expressed as a decrease in back echo in decibels; the height of an echo indication is given as a flat-bottomed hole or side-drilled hole diameter (see EN 583-2).

5.5.4 Evaluation and recording of indications

Unless otherwise agreed, all backwall echo reductions or echo heights reaching or exceeding the limits given in Table 4 shall be evaluated and shall be recorded if their values exceed 75 % of the limits given in Tables 1 and 2. Whenever such indications are found, their location shall be indicated and included in the examination report (see 5.6). The location of the indications to be recorded can be described using grids, sketches or photographs.

In case of simultaneous indications according to Tables 1 and 2, the procedure shall be agreed between the contracting parties.

5.5.5 Investigation of indications to be recorded

The locations where indications to be recorded have been found (see 5.5.4) shall be investigated more closely with respect to their type, shape, size and position. This can be achieved by altering the transducer frequency or by altering the examination procedure or by using other examination methods such as radiography.