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Founding - Ausferritic spheroidal graphite cast iron

Gießereiwesen - Ausferritisches Gusseisen mit Kugelgraphit

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Founding - Ausferritic spheroidal graphite cast iron

Gießereiwesen - Ausferritisches Gusseisen mit Kugelgraphit

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Foreword

This document (prEN 1564:2009) has been prepared by Technical Committee CEN/TC 190 “Foundry technology”, the secretariat of which is held by AFNOR.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1564:1997.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directive(s).

For relationship with EC Directive(s), see informative Annex ZA, which is an integral part of this document.

Introduction

Ausferritic spheroidal graphite cast iron is a cast alloy, iron, carbon and silicon based, the carbon being present mainly in the form of spheroidal graphite particles, of form VI as shown in EN - ISO 945 Part 1.

NOTE Ausferritic spheroidal graphite cast iron is also known as austempered ductile iron (ADI).

Compared with the spheroidal graphite cast iron grades, see EN 1563 [1], this material combines higher strength and toughness properties as a result of the austempering heat treatment.

This European Standard deals with the classification of ausferritic spheroidal graphite cast irons in accordance with the mechanical properties of the material.

The mechanical properties of these ausferritic spheroidal graphite cast irons depend on their structure, e.g. the form of the graphite and the structure of the matrix.

The required structure is developed by selecting the appropriate composition and subsequent processing.

The mechanical properties of the material can be evaluated on machined test pieces prepared from cast samples or samples cut from a casting.

Five grades of ausferritic spheroidal graphite cast iron are defined by the mechanical properties measured on machined test pieces prepared from cast samples. When, for these grades, hardness is a requirement of the purchaser as being important for the application, Annex C provides guidance values for hardness.

Two grades of ausferritic spheroidal graphite cast iron are defined in Annex A in accordance with their hardness. These cast irons are used in applications (e.g. mining, earth moving and manufacturing industries) where high abrasion resistance is required.

Ausferritic spheroidal graphite cast iron can be used for pressure equipment. Annex ZA gives information relating to the conformance of ausferritic spheroidal graphite cast iron to the Pressure Equipment Directive 97/23/EC.

The suitable material grades for pressure applications and the conditions for their use are given in specific product or application standards. For the design of pressure equipment, specific design rules apply.

1 Scope

This European Standard defines the grades and the corresponding requirements for ausferritic spheroidal graphite cast irons.

This European Standard specifies five grades of ausferritic spheroidal graphite cast iron by a classification based on mechanical properties measured on machined test pieces prepared from cast samples.

This European Standard also specifies two grades by a classification as a function of hardness.

This standard does not cover technical delivery conditions for iron castings, see EN 1559-1 [2] and EN 1559-3 [3].

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*.

EN 10045-1, *Metallic materials — Charpy impact test — Part 1: Test method*.

EN 10204, *Metallic products — Types of inspection documents*.

EN ISO 945-1, *Designation of microstructure of cast irons — Part 1 : Graphite classification by visual analysis*.

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1:Test method*.

NOTE Informative references to documents used in the preparation of this European standard, and cited within square brackets at appropriate places in the text, are listed in the Bibliography.

3 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

3.1
ausferritic spheroidal graphite cast iron
Iron based cast material with the carbon being present mainly in the form of spheroidal graphite particles, subjected to an austemper heat treatment in order to produce an ausferritic matrix

3.2
graphite spheroidising treatment
operation that brings the liquid iron into contact with a substance to produce graphite in the predominantly spheroidal (nodular) form during solidification

3.3
austemper heat treatment of spheroidal graphite cast iron
process, consisting of heating the castings above the A_{C1} temperature and holding a sufficient time to increase the carbon content of the austenite, followed by cooling at a rate sufficient to avoid the formation of pearlite and transforming the matrix structure for a time and a temperature (above the martensite start temperature) sufficient to produce the desired properties

This process produces a microstructure that consists predominantly of ferrite and austenite. This microstructure is called ausferrite.

3.4
cast sample
quantity of material cast to represent the cast material, including separately cast sample, side by side cast sample and cast-on sample

3.5
separately cast sample
sample cast in a separate sand mould under representative manufacturing conditions and material grade

3.6
side-by-side cast sample
sample cast in the mould alongside the casting, with a joint running system

3.7
cast-on sample
sample attached directly to the casting

3.8
relevant wall thickness
section of the casting, agreed between the manufacturer and the purchaser, to which the determined mechanical properties apply.

NOTE Relevant wall thickness may be associated to a range of casting sections and/or to a sample type and size according to Table 3. The association is made considering the cooling conditions during solidification and heat treatment.

4 Designation

The material shall be designated either by symbol or by number as given in Tables 1, 2 or A1.

NOTE The comparison of EN 1564 grade designations with the grades from the current ISO standard for ausferritic spheroidal graphite cast iron, ISO 17804 [4], is given in Annex B.

5 Order information

The following information shall be supplied by the purchaser:

a) number of this European Standard (EN 1564)

b) designation of the material;

NOTE The material grade is derived from the relevant wall thickness and the required mechanical properties.

c) relevant wall thickness

In the absence of information on the relevant wall thickness the manufacturer shall communicate the relevant wall thickness that he proposes to the purchaser.

d) any special requirements

All requirements shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order e.g. technical delivery conditions according to EN 1559-1 and EN 1559-3.

6 Manufacture

The method of producing ausferritic spheroidal graphite cast iron, its chemical composition and heat treatment shall be left to the discretion of the manufacturer, who shall ensure that the casting process and heat treatment process are carried out with the same process parameters as the approved first samples.

7 Requirements

7.1 General

The property values apply to ausferritic spheroidal graphite cast iron cast in sand moulds or moulds of comparable thermal behaviour. Subject to amendments to be agreed upon in the order, they can apply to castings obtained by alternative methods.

The material designation is based on the minimum mechanical properties obtained in cast samples with a thickness or diameter of 25 mm.

Mechanical properties are wall thickness dependant as shown in Table 1.

NOTE Mechanical properties for test pieces cut from a casting are affected not only by material properties (subject of this standard) but also by the local casting soundness (not subject of this standard). Tensile testing requires sound test bars in order to guarantee pure uni-axial stress during the test.

7.2 Test pieces machined from cast samples

7.2.1 General

The mechanical properties of ausferritic spheroidal graphite cast iron shall be as specified in Table 1, and, if applicable, in accordance with the requirements given in 7.2.2.

7.2.2 Impact test

The impact energy values given in Table 2 at room temperature, if applicable, shall only be determined if specified by the purchaser by the time of acceptance of the order.

7.3 Test pieces machined from samples cut from a casting

If applicable, the manufacturer and the purchaser shall agree on:

— the location(s) on a casting where the sample(s) shall be taken;

— the mechanical properties that shall be measured;

— the minimum values, or allowable range of values, for these mechanical properties (for information, see Annex C).

NOTE The properties of castings are not uniform, depending on the complexity of the castings and variation in their section thickness.

Table 1 — Mechanical properties measured on test pieces machined from cast samples

Material designation		Relevant wall thickness t	0,2 % proof strength $R_{p0,2}$	Tensile strength R_m	Elongation A
			MPa	MPa	%
Symbol	Number	mm	min	min	min
EN-GJS-800-10 EN-GJS-800-10-RT	5.3400 5.3401	$t \leq 30$	500	800	10
		$30 < t \leq 60$		750	6
		$60 < t \leq 100$		720	5
EN-GJS-900-8	5.3402	$t \leq 30$	600	900	8
		$30 < t \leq 60$		850	5
		$60 < t \leq 100$		820	4
EN-GJS-1050-6	5.3403	$t \leq 30$	700	1050	6
		$30 < t \leq 60$		1000	4
		$60 < t \leq 100$		970	3
EN-GJS-1200-3	5.3404	$t \leq 30$	850	1200	3
		$30 < t \leq 60$		1170	2
		$60 < t \leq 100$		1140	1
EN-GJS-1400-1	5.3405	$t \leq 30$	1100	1400	1
		$30 < t \leq 60$		To be agreed between the manufacturer and the purchaser	
		$60 < t \leq 100$			

NOTE 1 1 MPa = 1 N/mm^2

NOTE 2 For relevant wall thicknesses more than 100 mm, the manufacturer and the purchaser shall agree on the type and size of the cast sample and the minimum values to be obtained.

NOTE 3 The relevant wall thickness does not affect the minimum 0,2% proof strength provided the heat treatment parameters and alloying are adjusted as a function of the relevant wall thickness

Table 2 — Minimum impact energy values measured on V-notched test pieces machines from cast samples [3]

Material designation		Relevant wall thickness of the casting	Minimum impact energy value at room temperature (23 ± 5 ºC)	
Symbol	Number	t	Mean value of 3 tests	Individual value
		m	J	J
EN-GJS-800-10-RT	5.3401	$t \leq 30$	10	9
		$30 < t \leq 60$	9	8
		$60 < t \leq 100$	8	7

7.4 Hardness

Brinell hardness and its range values for the grades listed in Table 1 shall only be specified when agreed between the manufacturer and the purchaser by the time of acceptance of the order.

Information regarding hardness is given in Annex D and Annex E.

7.5 Graphite structure

The graphite structure shall be mainly of form V and VI in accordance with EN ISO 945 Part 1. A more precise definition may be agreed upon by the time of acceptance of the order.

Note Annex F gives more information on graphite structure.

7.6 Matrix structure

The matrix structure of the various grades of ausferritic spheroidal graphite cast iron consists predominantly of ferrite and austenite – otherwise known as ausferrite. Other matrix constituents, (e.g. martensite, bainite, carbides) shall be minimised and may be present at a level that will not affect the required mechanical properties of the grades given in Table 1 and 2, but can be beneficial in the abrasion resistant grades as given in Annex A.

The cooling rate within some sections may not be sufficient to avoid the formation of pearlite or other high temperature transformation products. In such cases, the maximum acceptable quantities of these micro constituents, the locations within the casting, and the mechanical properties in these locations may be agreed upon between the manufacturer and the purchaser.

8 Sampling

8.1 General

Samples shall be made from the same material as that used to produce the casting(s) which they represent.

Several types of samples (separately cast samples, cast-on samples, side-by-side cast samples, samples cut from a casting) can be used, depending on the mass and wall thickness of the casting.

When the mass of the casting exceeds 2000 kg and its relevant wall thickness exceeds 100 mm, cast-on samples or side-by-side samples should preferably be used; the dimensions and the location of the sample shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order.

NOTE If the spheroidizing treatment is carried out in the mould (in-mould process), the separately cast sample should be avoided.

All samples shall be adequately marked to guarantee full traceability to the castings which they represent.

The samples shall be given the same heat treatment as the castings which they represent.

Tensile and impact test pieces shall be finally machined from the samples after the heat treatment.

8.2 Cast samples

8.2.1 Size of cast samples

The size of the sample shall be in correspondence with the relevant wall thickness of the casting as shown in Table 3.

If other sizes are used, this shall be agreed between the manufacturer and purchaser.

Table 3 — Types and size of cast sample and size of tensile test pieces in relation to relevant wall thickness of the casting

Relevant wall thickness *t* mm	Type of sample				Preferred diameter of tensile test piece [a] *D* mm
	Option 1 U-shaped (See Figure 1)	Option 2 Y-shaped (See Figure 2)	Option 3 Round bar (See Figure 3)	Cast-on (See Figure 4)	
$t \leq 12{,}5$	—	I	b, c	A	7 (Option 3: 14 mm)
$12{,}5 < t \leq 30$	—	II	a, b, c,	B	14
$30 < t \leq 60$	[b]	III	—	C	14
$60 < t \leq 100$	—	IV	—	D	14

[a] Other diameters, in accordance with Figure 5, may be agreed between the manufacturer and the purchaser.

[b] The cooling rate of this cast sample corresponds to that of a 40 mm thick wall

8.2.2 Frequency and number of tests

Samples representative of the material shall be produced at a frequency in accordance with the in-process quality assurance procedures adopted by the manufacturer.

In the absence of an in-process quality assurance procedure or any other agreement between the manufacturer and the purchaser, a minimum of one cast sample for the tensile test shall be produced to confirm the material grade, at a frequency to be agreed between the manufacturer and the purchaser.

When impact tests are required, samples shall be produced at a frequency to be agreed between the manufacturer and the purchaser.

8.2.3 Separately cast samples

The samples shall be cast separately in sand moulds and under representative manufacturing conditions and material grade.

The moulds used to cast the separately cast samples shall have comparable thermal behaviour to the moulding material used to cast the castings.

The samples shall meet the requirements of either Figures 1, 2 or 3.

The samples shall be removed from the mould at a temperature similar to that of the castings.

8.2.4 Side-by-side cast samples

Side-by-side cast samples are representative of the castings concurrently cast and also of all other castings of a similar relevant wall thickness from the same test unit, or produced at the same time interval in accordance with the in process quality assurance procedure used by the manufacturer.

For a series of castings poured from the same ladle, one side-by-side cast sample shall be produced, at a minimum, in the last mould poured.

The samples shall meet the requirements of either Figures 1, 2, 3,