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Founding - Spheroidal graphite cast irons

Gießereiwesen - Gusseisen mit Kugelgraphit

Fonderie - Fontes à graphite sphéroïdal

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Founding - Spheroidal graphite cast irons

Fonderie - Fontes à graphite sphéroïdal

Gießereiwesen - Gusseisen mit Kugelgraphit

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EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 1563:2016) 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 second CEN Enquiry.

This document will supersede EN 1563:2011.

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 EU Directive(s).

For relationship with EU Directive 2014/68/EU, see informative Annex ZA, which is an integral part of this document.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 7 “Spheroidal graphite, silicon molybdenum and austempered ductile iron” to revise EN 1563:2011.

Annex I provides details of significant technical changes between the 1997 edition and the 2011 edition.

Annex J provides details of significant technical changes between this draft European Standard and the 2011 edition (previous edition).

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Introduction

The properties of spheroidal graphite cast irons depend on their structure.

Spheroidal graphite cast irons covered by this draft European Standard are divided in two groups:

- 1) ferritic to pearlitic spheroidal graphite cast irons;
- 2) solid-solution strengthened ferritic spheroidal graphite cast irons.

The two groups present specific properties, for example:

- the ferritic grades of the first group present the highest impact energy;
- the pearlite containing grades are more suitable for wear resistance applications;
- the solid-solution strengthened ferritic grades present for an equivalent tensile strength a higher proof strength and a higher elongation after fracture than that of the ferritic to pearlitic grades;
- a significant property of these solid-solution strengthened ferritic grades is the reduced hardness variation resulting in an improved machinability.

The mechanical properties of the material can be evaluated on machined test pieces prepared from:

- separately cast samples;
- side-by-side cast samples;
- cast-on samples;
- samples cut from a casting.

The material grade is defined by mechanical properties measured on machined test pieces prepared from cast samples.

If hardness is a requirement of the purchaser as being important for the application, then Annex C provides means for its determination.

It is well known that tensile properties and hardness of spheroidal graphite cast irons are interrelated. When considered by the purchaser as being important for the application, both tensile and hardness properties may be specified.

Further technical data on spheroidal graphite cast irons is given in Annexes A, E and H.

In this draft European Standard a new designation system by number, as established in EN 1560 [1], is given.

NOTE This designation system by number is based on the structure and rules of EN 10027-2 [2] and so corresponds with the European numbering system for steel and other materials.

Some spheroidal graphite cast iron grades can be used for pressure equipment.

The permitted material grades of spheroidal graphite cast irons 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.

Annex ZA gives information relating to the conformance of permitted spheroidal graphite cast iron grades to the Pressure Equipment Directive 2014/68/EU.

1 Scope

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

This draft European Standard specifies 2 groups of spheroidal graphite cast iron grades by a classification based on mechanical properties measured on machined test pieces prepared from cast samples. The first group deals mainly with ferritic to pearlitic grades. The second group deals with solid-solution strengthened ferritic grades.

This draft European Standard does not cover technical delivery conditions for iron castings (see EN 1559-1 [3] and EN 1559-3 [4]).

This draft European Standard does not cover all aspects of:

- ausferritic spheroidal graphite cast irons which are specified in EN 1564 [5];
- low alloyed ferritic spheroidal graphite cast irons which are specified in EN 16124 [6];
- continuous cast iron bars which are specified in EN 16482 [7];
- austenitic cast irons which are specified in EN 13835 [8];
- spheroidal graphite cast irons used for pipes, fittings and their joints which are the subject of EN 545 [9], EN 598 [10] and EN 969 [11];
- the grades of spheroidal graphite cast irons as specified in EN 545 which are used for products such as industrial valves, non-industrial manually operated shut-off valves and flanges and their joints, which are the subject of the applicable European product standards.

2 Normative references

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The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 764-5, *Pressure equipment - Part 5: Inspection documentation of metallic materials and compliance with the material specification*

EN 10204, *Metallic products - Types of inspection documents*

EN ISO 148-1, *Metallic materials - Charpy pendulum impact test - Part 1: Test method (ISO 148-1)*

EN ISO 945-1:2008, *Microstructure of cast irons - Part 1: Graphite classification by visual analysis (ISO 945-1:2008)*

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

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1)*

3 Terms and definitions

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

3.1 spheroidal graphite cast iron
cast material, iron, carbon and silicon-based, the carbon being present mainly in the form of spheroidal graphite particles

Note 1 to entry: Spheroidal graphite cast iron is also known as ductile iron, and less commonly as nodular iron.

3.2 ferritic to pearlitic spheroidal graphite cast iron
spheroidal graphite cast iron with a matrix containing ferrite or pearlite or a combination of both

Note 1 to entry: Pearlite can be partially or totally replaced by quenched microstructures in grades having higher strength.

3.3 solid-solution strengthened ferritic spheroidal graphite cast iron
spheroidal graphite cast iron with a matrix mainly consisting of ferrite, solution strengthened by increasing the amount of silicon compared to ferritic to pearlitic spheroidal graphite cast iron

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

Note 1 to entry: This operation is often followed by a second one called inoculation.

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

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

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

3.8 cast-on sample
sample attached directly to the casting

3.9 relevant wall thickness
wall thickness representative of the casting, defined for the determination of the size of the cast samples to which the mechanical properties apply

4 Designation

The material shall be designated either by symbol or by number as given in Tables 1, 2 or 3.

In the case of samples cut from the casting the letter “C” is added at the end of the designation by symbol.

NOTE The comparison of prEN 1563 grade designations with the grades from the ISO standard for spheroidal graphite cast irons, ISO 1083 [12], is given in Annex G.

5 Order information

The following information shall be supplied by the purchaser:

- a) the number of this draft European Standard;
- b) the designation of the material;
- c) the relevant wall thickness;
- 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 metallurgical method of producing spheroidal graphite cast irons and their chemical composition shall be left to the discretion of the manufacturer who shall ensure that the requirements of this draft European Standard are met for the material grade specified in the order.

— Ferritic to pearlitic spheroidal graphite cast irons: [ea2-4672-480b-aed2-563becced4ff/sist-en-1563-2018](https://standards.iteh.ai/en/1563-2018)

For these grades, the level of the mechanical properties is determined by the ferrite to pearlite ratio. This ratio is normally adjusted by alloying with pearlite stabilizing elements or, less commonly, by heat treatment.

— Solid-solution strengthened ferritic spheroidal graphite cast irons:

For these grades, the level of the mechanical properties is determined by the extent of solid solution strengthening of the ferritic matrix. This extent is normally governed by the silicon content.

NOTE For spheroidal graphite cast irons to be used in special applications, the chemical composition and heat treatment may be the subject of an agreement between the manufacturer and the purchaser.

All agreements between the manufacturer and the purchaser shall be made by the time of the acceptance of the order.

7 Requirements

7.1 General

The property values apply to spheroidal graphite cast irons 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. The designation is irrespective of the type of cast sample.

Mechanical properties are wall thickness dependant as shown in Tables 1, 2 and 3. For relevant wall thicknesses more than 200 mm, the manufacturer and the purchaser shall agree on the minimum values to be obtained and the type and size of the cast sample.

Tensile testing requires sound test pieces in order to guarantee pure uni-axial stress during the test.

7.2 Ferritic to pearlitic spheroidal graphite cast irons

7.2.1 Test pieces machined from cast samples

7.2.1.1 Tensile properties

The mechanical properties of ferritic to pearlitic spheroidal graphite cast iron test pieces shall be as specified in Table 1.

Table 1 — Mechanical properties measured on test pieces machined from cast samples for ferritic to pearlitic grades

Material designation		Relevant wall thickness	0,2 % proof strength	Tensile strength	Elongation after fracture
Symbol	Number	t mm	$R_{p0,2}$ MPa min.	R_m MPa min.	A % min.
EN-GJS-350-22-LT ^a	5.3100	$t \leq 30$	220	350	22
		$30 < t \leq 60$	210	330	18
		$60 < t \leq 200$	200	320	15
EN-GJS-350-22-RT ^b	5.3101	$t \leq 30$	220	350	22
		$30 < t \leq 60$	220	330	18
		$60 < t \leq 200$	210	320	15
EN-GJS-350-22	5.3102	$t \leq 30$	220	350	22
		$30 < t \leq 60$	220	330	18
		$60 < t \leq 200$	210	320	15
EN-GJS-400-18-LT ^a	5.3103	$t \leq 30$	240	400	18
		$30 < t \leq 60$	230	380	15
		$60 < t \leq 200$	220	360	12
EN-GJS-400-18-RT ^b	5.3104	$t \leq 30$	250	400	18
		$30 < t \leq 60$	250	390	15
		$60 < t \leq 200$	240	370	12

Material designation		Relevant wall thickness	0,2 % proof strength	Tensile strength	Elongation after fracture
Symbol	Number	t	$R_{p0,2}$	R_m	A
		mm	MPa	MPa	%
			min.	min.	min.
EN-GJS-400-18	5.3105	$t \leq 30$	250	400	18
		$30 < t \leq 60$	250	390	15
		$60 < t \leq 200$	240	370	12
EN-GJS-400-15	5.3106	$t \leq 30$	250	400	15
		$30 < t \leq 60$	250	390	14
		$60 < t \leq 200$	240	370	11
EN-GJS-450-10	5.3107	$t \leq 30$	310	450	10
		$30 < t \leq 60$	to be agreed upon between the manufacturer and the purchaser		
		$60 < t \leq 200$	to be agreed upon between the manufacturer and the purchaser		
EN-GJS-500-7	5.3200	$t \leq 30$	320	500	7
		$30 < t \leq 60$	300	450	7
		$60 < t \leq 200$	290	420	5
EN-GJS-600-3	5.3201	$t \leq 30$	370	600	3
		$30 < t \leq 60$	360	600	2
		$60 < t \leq 200$	340	550	1
EN-GJS-700-2	5.3300	$t \leq 30$	420	700	2
		$30 < t \leq 60$	400	700	2
		$60 < t \leq 200$	380	650	1
EN-GJS-800-2	5.3301	$t \leq 30$	480	800	2
		$30 < t \leq 60$	to be agreed upon between the manufacturer and the purchaser		
		$60 < t \leq 200$	to be agreed upon between the manufacturer and the purchaser		
EN-GJS-900-2	5.3302	$t \leq 30$	600	900	2
		$30 < t \leq 60$	to be agreed upon between the manufacturer and the purchaser		
		$60 < t \leq 200$	to be agreed upon between the manufacturer and the purchaser		

NOTE The mechanical properties of test pieces machined from cast samples can be different from the properties of the casting itself. Values for tensile properties of the casting are given in Annex B for guidance.

a LT for low temperature.
b RT for room temperature.

7.2.1.2 Impact energy

The impact energy values given in Table 2 for room temperature (RT) and low temperature (LT) applications, if applicable, shall only be determined if specified by the purchaser by the time of acceptance of the order.

The mean value of the three Charpy impact tests and the individual values shall meet the specified requirements in Table 2.

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NOTE The use of impact energy is currently being reassessed regarding its limited relevance as a measure of resistance to brittle fracture in castings subject to application loads. Annex H gives information about fracture mechanical approach to spheroidal graphite cast irons.

Table 2 — Minimum impact energy values measured on V-notched test pieces machined from cast samples for ferritic grades of the ferritic to pearlitic group

Material designation		Relevant wall thickness t mm	Minimum impact energy values					
			Room temperature (23 ± 5) °C		Low temperature (- 20 ± 2) °C		Low temperature (- 40 ± 2) °C	
			Mean value (3 tests)	Individual value	Mean value (3 tests)	Individual value	Mean value (3 tests)	Individual value
EN-GJS-350-22-LT	5.3100	$t \leq 30$	—	—	—	—	12	9
		$30 < t \leq 60$	—	—	—	—	12	9
		$60 < t \leq 200$	—	—	—	—	10	7
EN-GJS-350-22-RT	5.3101	$t \leq 30$	17	14	—	—	—	—
		$30 < t \leq 60$	17	14	—	—	—	—
		$60 < t \leq 200$	15	12	—	—	—	—
EN-GJS-400-18-LT	5.3103	$t \leq 30$	—	—	12	9	—	—
		$30 < t \leq 60$	—	—	12	9	—	—
		$60 < t \leq 200$	—	—	10	7	—	—
EN-GJS-400-18-RT	5.3104	$t \leq 30$	14	11	—	—	—	—
		$30 < t \leq 60$	14	11	—	—	—	—
		$60 < t \leq 200$	12	9	—	—	—	—

NOTE The mechanical properties of test pieces machined from cast samples can be different from the properties of the casting itself.

7.2.2 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 B).

NOTE 1 The properties of castings can vary, depending on the complexity of the castings and variation in their section thickness.

NOTE 2 Mechanical properties for test pieces cut from a casting are affected not only by material properties (subject of this draft European Standard) but also by the local casting soundness (not subject of this standard).

7.2.3 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 C.

7.2.4 Graphite structure

The graphite structure shall be mainly of “form V and VI” in accordance with EN ISO 945-1. However, the microstructure is subordinate to mechanical properties. A more precise definition may be agreed upon by the time of acceptance of the order.

More information on nodularity is given in Annex D.

7.2.5 Matrix structure

Information regarding the matrix structure is given in Table E.1.

7.3 Solid solution strengthened ferritic spheroidal graphite cast irons

7.3.1 Test pieces machined from cast samples

The mechanical properties of solid solution strengthened ferritic spheroidal graphite cast iron test pieces shall be as specified in Table 3.

Table 3 — Mechanical properties measured on test pieces machined from cast samples for solid solution strengthened ferritic grades

Material designation		Relevant wall thickness	0,2 % proof strength	Tensile strength	Elongation after fracture
Symbol	Number	t mm	$R_{p0,2}$ MPa min.	R_m MPa min.	A % min.
EN-GJS-450-18	5.3108	$t \leq 30$	350	450	18
		$30 \leq t \leq 60$	340	430	14
		$t > 60$	to be agreed upon between the manufacturer and the purchaser		
EN-GJS-500-14	5.3109	$t \leq 30$	400	500	14
		$30 \leq t \leq 60$	390	480	12
		$t > 60$	to be agreed upon between the manufacturer and the purchaser		
EN-GJS-600-10	5.3110	$t \leq 30$	470	600	10
		$30 \leq t \leq 60$	450	580	8
		$t > 60$	to be agreed upon between the manufacturer and the purchaser		

NOTE The mechanical properties of test pieces machined from cast samples can be different from the properties of the casting itself. Values for tensile properties of the casting are given in Annex B for guidance.