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Spheroidal graphite cast irons — Classification

Fontes à graphite sphéroïdal — Classification

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Foreword

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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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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 25, *Cast irons and pig irons*.

This fourth edition cancels and replaces the third edition (ISO 1083:2004), which has been technically revised with the following changes:

— solid-solution strengthened ferritic spheroidal graphite cast irons grades have been added;

— side-by-side cast samples have been added;

— several definitions have been added;

— the relation between mechanical properties and wall thickness has been added;

— figures for separately cast or side-by-side cast samples have been updated;

— the tensile test piece figure has been updated and the Charpy V-notched impact test piece figure has been removed;

— Annex A has been partially reworded;

— Annex C has been entirely reworded;

— Annex D has been developed;

— Annex E has become informative;

— Annex G has been developed;

— Annex H has been added.

Introduction

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

Spheroidal graphite cast irons covered by this document are divided into two groups:

a) ferritic to pearlitic spheroidal graphite cast irons;

b) solid-solution strengthened ferritic spheroidal graphite cast irons.

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

— 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 E 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.

Some material grades can be suitable for pressure applications.

Further technical data on spheroidal graphite cast irons is given in Annexes C and G.

Spheroidal graphite cast irons — Classification

1 Scope

This document defines the grades and the corresponding requirements for spheroidal graphite cast irons.

This document specifies two 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 document also gives an informative classification as a function of hardness.

This document does not apply to the following:

— spheroidal graphite cast irons used for pipes, fittings and accessories which are specified in accordance with ISO 2531 and ISO 7186;

— highly alloyed (austenitic) spheroidal cast irons which are specified in accordance with ISO 2892;

— ausferritic cast irons which are specified in accordance with ISO 17804.

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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 945-1, *Microstructure of cast irons — Part 1: Graphite classification by visual analysis*

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

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

ISO/TR 15931, *Designation system for cast irons and pig irons*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

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 (3.1) 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 (3.1) with a matrix mainly consisting of ferrite, solution strengthened by increasing the amount of silicon compared to *ferritic to pearlitic spheroidal graphite cast iron* (3.2)

3.4
graphite spheroidizing treatment
process 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 process is often followed by a second process called inoculation.

3.5
cast sample
quantity of material cast to represent the cast material, including *separately cast sample* (3.6), *side-by-side cast sample* (3.7) and *cast-on sample* (3.8)

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
sample cut from a casting
sample obtained directly from the casting

3.10
relevant wall thickness
section of the casting, agreed between the manufacturer and the purchaser, to which the determined mechanical properties shall apply

3.11
test unit
number of pieces or the tonnage of castings to be accepted or rejected together, on the basis of the tests carried out on test pieces in accordance with the requirements of the relevant specification, material standard or order

Note 1 to entry: This term is sometimes referred to as “inspection lot” or “test batch”.

[SOURCE: EN 1559-1:2011, 3.12]

4 Designation

The material shall be designated in accordance with ISO/TR 15931. The relevant designations are given in Tables 1 to 3.

NOTE Further information on designation is given in Annex I.

5 Order information

The following information shall be supplied by the purchaser:

a) the complete designation of the material;

b) any special requirements (including the relevant wall thickness, where necessary) that shall be agreed upon between the manufacturer and the purchaser by the time of acceptance of the order;

c) the number of this document, i.e. ISO 1083.

6 Manufacture

The 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 document are met for the material grade specified in the order.

For ferritic to pearlitic cast iron grades, the level of the mechanical properties is determined by the ferrite to pearlite ratio. The ferrite to pearlite ratio is normally adjusted by alloying or, less commonly, by heat treatment.

For solid-solution strengthened cast iron grades, the level of the mechanical properties is determined by the extent of solid solution strengthening of the ferritic matrix. Solid-solution strengthening is normally governed by the silicon content.

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 greater than 200 mm, the manufacturer and the purchaser shall agree on the minimum mechanical properties, the type and size of the cast sample, and microstructure requirements.

NOTE 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 t mm	0,2 % proof strength $R_{p0,2}$ MPa min.	Tensile strength R_m MPa min.	Elongation after fracture A % min.
ISO1083/JS/350-22-LT[a]	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	220 210 200	350 330 320	22 18 15
ISO1083/JS/350-22-RT[b]	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	220 220 210	350 330 320	22 18 15
ISO1083/JS/350-22	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	220 220 210	350 330 320	22 18 15
ISO1083/JS/400-18-LT[a]	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	240 230 220	400 380 360	18 15 12
ISO1083/JS/400-18-RT[b]	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	250 250 240	400 390 370	18 15 12
ISO1083/JS/400-18	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	250 250 240	400 390 370	18 15 12
ISO1083/JS/400-15	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	250 250 240	400 390 370	15 14 11
ISO1083/JS/450-10	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	310 to be agreed upon between the manufacturer and the purchaser	450	10
ISO1083/JS/500-7	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	320 300 290	500 450 420	7 7 5
ISO1083/JS/550-5	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	350 330 320	550 520 500	5 4 3
ISO1083/JS/600-3	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	370 360 340	600 600 550	3 2 1
ISO1083/JS/700-2	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	420 400 380	700 700 650	2 2 1
ISO1083/JS/800-2	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	480 to be agreed upon between the manufacturer and the purchaser	800	2
ISO1083/JS/900-2	$t \leq 30$ $30 < t \leq 60$ $60 < t \leq 200$	600 to be agreed upon between the manufacturer and the purchaser	900	2

NOTE 1 Elongation values are determined from $L_0 = 5\,d$. For other gauge lengths, see 9.1 and Annex B.

NOTE 2 The mechanical properties of test pieces machined from cast samples do not necessary reflect exactly the properties of the casting itself. Values for tensile properties of the casting are given in Annex D for guidance.

NOTE 3 The data apply to separately cast samples, cast on samples and side-by-side cast samples; therefore the suffix "S" is not included.

[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.

NOTE The relevance of the use of impact energy as a measure of resistance to brittle fracture in castings, subjected to application loads, is currently being reassessed. Annex C gives information about a 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	Minimum impact energy values J					
		Room temperature (23 ± 5) °C		Low temperature (−20 ± 2) °C		Low temperature (−40 ± 2) °C	
	T mm	Mean value (3 tests)	Individual value	Mean value (3 tests)	Individual value	Mean value (3 tests)	Individual value
ISO1083/JS/350-22-LT[a]	$t \leq 30$	—	—	—	—	12	9
	$30 < t \leq 60$	—	—	—	—	12	9
	$60 < t \leq 200$	—	—	—	—	10	7
ISO1083/JS/350-22-RT[b]	$t \leq 30$	17	14	—	—	—	—
	$30 < t \leq 60$	17	14	—	—	—	—
	$60 < t \leq 200$	15	12	—	—	—	—
ISO1083/JS/400-18-LT[a]	$t \leq 30$	—	—	12	9	—	—
	$30 < t \leq 60$	—	—	12	9	—	—
	$60 < t \leq 200$	—	—	10	7	—	—
ISO1083/JS/400-18-RT[b]	$t \leq 30$	14	11	—	—	—	—
	$30 < t \leq 60$	14	11	—	—	—	—
	$60 < t \leq 200$	12	9	—	—	—	—

NOTE 1 These material grades can be suitable for some pressure vessel applications. (For fracture toughness, see Annex C.)

NOTE 2 The mechanical properties of test pieces machined from cast samples do not necessarily reflect exactly the properties of the casting itself.

NOTE 3 The data apply to separately cast samples, cast on samples and side-by-side cast samples; therefore the suffix "S" is not included.

[a] LT for low temperature.

[b] RT for room temperature.

7.2.2 Test pieces machined from samples cut from a casting

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

— the locations on a casting where the samples 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 D).

NOTE 1 The properties of castings are often not uniform, because casting properties depend on the complexity of the casting and variation in section thickness.

NOTE 2 Mechanical properties for test pieces cut from a casting are affected not only by material properties (covered by this document) but also by the local casting soundness (not covered by this document).

7.2.3 Classification by hardness

The classification by Brinell hardness shall only be specified when agreed between the manufacturer and the purchaser (see Annex E).

7.2.4 Graphite structure

The graphite structure shall be mainly of form VI and form V in accordance with ISO 945-1. A more precise definition of graphite structure may be agreed between the manufacturer and the purchaser.

This structure shall be confirmed either by metallographic examination or by non-destructive methods. In case of dispute, the result of the metallographic examination shall prevail.

NOTE Annex F gives more information on nodularity.

7.2.5 Matrix structure

Information on matrix structure is given in Table G.1 and ISO/TR 945-3.

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 t mm	0,2 % proof strength $R_{p0,2}$ MPa min.	Tensile strength R_m MPa min.	Elongation after fracture A % min.
ISO1083/JS/450-18	$t \leq 30$ $30 \leq t \leq 60$ $t > 60$	350 340 to be agreed upon between the manufacturer and the purchaser	450 430	18 14
ISO1083/JS/500-14	$t \leq 30$ $30 \leq t \leq 60$ $t > 60$	400 390 to be agreed upon between the manufacturer and the purchaser	500 480	14 12
ISO1083/JS/600-10	$t \leq 30$ $30 \leq t \leq 60$ $t > 60$	470 450 to be agreed upon between the manufacturer and the purchaser	600 580	10 8

NOTE 1 The mechanical properties of test pieces machined from cast samples do not necessarily reflect exactly the properties of the casting itself. Values for tensile properties of the casting are given in Annex D for guidance.

NOTE 2 The data apply to separately cast samples, cast on samples and side-by-side cast samples; therefore the suffix "S" is not included.

7.3.2 Test pieces machined from samples cut from a casting

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

— the locations on a casting where the samples 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 D).

NOTE 1 The properties of castings are often not uniform, because casting properties depend on the complexity of the casting and variation in their section thickness.

NOTE 2 Mechanical properties for test pieces cut from a casting are affected not only by material properties (covered by this document) but also by the local casting soundness (not covered by this document).

7.3.3 Classification by hardness

The classification by Brinell hardness shall only be specified when agreed between the manufacturer and the purchaser (see Annex E).

7.3.4 Graphite structure

The graphite structure shall be mainly of form VI and form V in accordance with ISO 945-1. A more precise definition of graphite structure may be agreed between the manufacturer and the purchaser.

This structure shall be confirmed either by metallographic examination or by non-destructive methods. In case of dispute, the result of the metallographic examination shall prevail.

NOTE 1 A.2.3 gives more information on graphite structure.

NOTE 2 Annex F gives more information on nodularity.

7.3.5 Matrix structure

Information on matrix structure is given in A.2.2, Table G.1 and ISO/TR 945-3.

8 Sampling

8.1 General

Samples shall be provided to represent the castings produced.

Samples shall be made from the same material as that used to produce the castings which they represent (see 8.4).

Several types of sample (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 appropriate the type of sample should be agreed between the manufacturer and the purchaser. Unless otherwise agreed the choice of the option is left to the discretion of the manufacturer.

When the mass of the casting exceeds 2 000 kg and its relevant wall thickness exceeds 60 mm, cast-on samples or side-by-side cast samples should be preferably used; representative dimensions and the location of the sample shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order.

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 subject to the same heat treatment, as that of the castings they represent, if any.

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