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Founding — Ausferritic spheroidal graphite cast irons — Classification

Fonderie — Fonte ausferritique à graphite sphéroïdal — Classification

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17804 was prepared by Technical Committee ISO/TC 25, *Cast irons and pig irons*, Subcommittee SC 2, *Spheroidal graphite cast irons*.

Introduction

Ausferritic spheroidal graphite cast iron is a cast alloy, iron and carbon based, carbon being present mainly in the form of spheroidal graphite particles.

Compared with the spheroidal graphite cast-iron grades (see ISO 1083:2004), this material combines higher strength and toughness properties as a result of the austempering heat treatment.

This International 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:

— separately cast samples with an appropriate gating system, able to provide metallurgical conditions similar to those of the castings they represent;

— samples cast onto either the casting or the running system, hereafter referred to as cast-on samples;

— samples cut from a casting (only by agreement between the manufacturer and the purchaser, the agreement specifying, in particular, the conditions of sampling and the values to be obtained).

Two grades of ausferritic spheroidal graphite cast iron are specified 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.

Five grades of ausferritic spheroidal graphite cast iron are specified by the mechanical properties. When, for these grades, hardness is a requirement for the application, Annex D provides means for determining appropriate hardness ranges.

Founding — Ausferritic spheroidal graphite cast irons — Classification

1 Scope

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

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

— separately cast samples or cast-on samples;

— samples cut from a casting.

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

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.

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

ISO 148-2, *Metallic materials — Charpy pendulum impact test — Part 2: Verification of test machines*

ISO 148-3, *Metallic materials — Charpy pendulum impact test — Part 3: Preparation and characterization of Charpy V reference test pieces for verification of test machines*

ISO 945, *Cast iron — Designation of microstructure of graphite*

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

ISO 6507-1, *Metallic materials — Vickers hardness test — Part 1: Test method*

ISO 6892, *Metallic materials — Tensile testing at ambient 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.

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

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

3.2
graphite spheroidising treatment
process which brings the liquid iron into contact with a substance to produce graphite in spheroidal form during solidification

3.3
austemper heat treatment of spheroidal graphite cast iron
process, consisting of heating the castings above the A_{C1} temperature (at which austenite starts to form during heating), 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

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

3.4
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 with a range of casting sections and/or with a sample type and size according to Table 3. The association is made by considering the cooling conditions during solidification and heat treatment.

4 Designation

The material shall be designated in accordance with ISO/TR 15931.

Annex J gives a selection of approximate cross-references of grade designations in this International Standard to standard grades from EN, ASTM, JIS and SAE standards.

5 Order information

The following information shall be supplied by the purchaser:

a) the complete designation of the material;

b) any special requirements.

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

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 for these materials apply to castings 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 separately cast or cast-on samples, cast in a sand mould or a mould of comparable thermal behaviour, corresponding to a relevant wall thickness 12,5 mm $< t \leqslant$ 30 mm, as given in Table 1.

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

7.2 Test pieces machined from separately cast and cast-on 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-resistance 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 E).

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

NOTE 2 Tables 1 and 2 may be used for guidance on the likely mechanical properties of the castings. These properties may be equal to or lower than those given in these tables.

Table 1 — Mechanical properties measured on test pieces machined from separately cast samples or cast-on samples [1]

Material designation	Relevant wall thickness of the casting t mm	Tensile strength R_m N/mm^2 min.	0,2 % proof strength $R_{p0,2}$ N/mm^2 min.	Elongation A % min.
ISO 17804/JS/800-10 ISO 17804/JS/800-10RT	$t \leqslant 30$	800	500	10
	$30 < t \leqslant 60$	750		6
	$60 < t \leqslant 100$	720		5
ISO 17804/JS/900-8	$t \leqslant 30$	900	600	8
	$30 < t \leqslant 60$	850		5
	$60 < t \leqslant 100$	820		4
ISO 17804/JS/1050-6	$t \leqslant 30$	1 050	700	6
	$30 < t \leqslant 60$	1 000		4
	$60 < t \leqslant 100$	970		3
ISO 17804/JS/1200-3	$t \leqslant 30$	1 200	850	3
	$30 < t \leqslant 60$	1 170		2
	$60 < t \leqslant 100$	1 140		1
ISO 17804/JS/1400-1	$t \leqslant 30$	1 400	1 100	1
	$30 < t \leqslant 60$	1 170	To be agreed between the manufacturer and the purchaser	
	$60 < t \leqslant 100$	1 140		

NOTE 1 The properties of castings are not uniform because of the complexity and variation in section thickness.

NOTE 2 With the appropriate heat treatment, the specified minimum 0,2 % proof strength values according to this table can be maintained. However, with increasing casting wall thickness, the tensile strength and elongation values will decrease.

NOTE 3 1 N/mm^2 = 1 MPa.

NOTE 4 If the type of sample is to be specified, a "/" is added to the designation, followed by a letter indicating the type of sample:

— S for a separately cast sample;

— U for a cast-on sample.

Table 2 — Minimum impact-resistance values measured on V-notched test pieces machined from separately cast samples or cast-on samples [1]

Material designation	Relevant wall thickness of the casting t mm	Minimum impact-resistance value at room temperature (23 ± 5 °C) Mean value of 3 tests J	 Individual value J
ISO 17804/JS/800-10RT	$t \leqslant 30$	10	9
	$30 < t \leqslant 60$	9	8
	$60 < t \leqslant 100$	8	7

NOTE If the type of sample is to be specified, a "/" is added to the designation, followed by a letter indicating the type of sample:

— S for a separately cast sample;

— U for a cast-on sample.

7.4 Hardness

Guidance values for the Brinell hardness range of the material grades are given in Annex C.

7.5 Graphite structure

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

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

Additional information regarding nodularity is given in Annex H.

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, carbides) may be present at a level that will not affect the required mechanical properties.

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.

An indirect method to determine if the required microstructure after the heat treatment has been obtained is the impact testing of unnotched Charpy test samples.

The minimum impact energy values to be obtained and details of the unnotched Charpy impact test are given in Annex F.

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.

The same melt and heat treatment processes shall be applied.

Several types of samples (separately cast samples, cast-on samples, samples cut from a casting) can be used, depending on the mass and wall thickness of the casting. (See Table 3.)

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

8.2 Separately cast samples

8.2.1 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 tensile test sample 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.

8.2.2 Samples and test pieces

The samples shall be cast separately in sand moulds at the same time as the castings and under representative manufacturing conditions.

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 Figures 1, 2 or 3.

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

If the spheroidisation treatment is carried out in the mould (in-mould process), the samples may be:

— cast in the same mould with the castings, with a joint running system;

— cast separately, using a similar treatment method in the sample mould as the method used to produce the casting.

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

The tensile test piece is shown in Figure 5. If applicable, the impact test piece shown in Figure 6 shall be machined from a sample shown in Figures 1 and 2 (hatched part) or from the sample shown in Figure 3.

Unless otherwise agreed, the choice is left to the discretion of the manufacturer.

8.3 Cast-on samples

8.3.1 Frequency and number of tests

Cast-on samples are representative of the castings to which they are attached and also of all other castings, of a similar relevant wall thickness, from the same pouring and heat treatment batch.

Cast-on samples shall be produced 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 tensile test shall be carried out to confirm the material, 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.

8.3.2 Samples and test pieces

The samples from which the test pieces for tensile and/or impact tests are taken are cast onto the casting, or cast side-by-side with the casting with a joint running system.

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

The samples shall meet the requirements of either Figures 1, 2, 3 or 4.