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Livarstvo - Siva litina (z lamelastim grafitom)

Founding - Grey cast irons

Gießereiwesen - Gusseisen mit Lamellengraphit

Fonderie - Fontes à graphite lamellaire

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EN 1561:2023 (E)**European foreword**

This document (EN 1561:2023) has been prepared by Technical Committee CEN/TC 190 “Foundry technology”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2024, and conflicting national standards shall be withdrawn at the latest by June 2024.

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

This document supersedes EN 1561:2011.

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

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

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Introduction

This document deals with the classification of grey cast irons, subdivided into two groups, specified by their tensile strength or hardness, respectively.

The properties of grey cast iron depend on the form and distribution of the graphite and the structure of the matrix, resulting from different cooling velocities in different wall thickness of the casting.

Section sensitivity of the properties is more pronounced for grey cast irons EN-GJL, compared to other cast iron materials. When designating a grey cast iron material grade, section sensitivity of the properties needs consideration.

Table 1 specifies material grades according to their mechanical properties, which is relevant for most EN-GJL material orders.

Table 1 designates the cast material. The foundry verifies the properties of the castings within its in-process quality assurance. The customer designates the material grade in view of requirements from component design. The choice of cast samples is based on the relevant wall thickness to ensure comparability with the casting.

Table 1 specifies minimum property values (ultimate tensile strength) for each material grade, based on **cast samples**. For the casting itself, typical property values are given in Table E.1.

Table 2 specifies material grades according to their maximum hardness, e.g. for wear resistance.

Cast iron materials are molten from steel scraps of different compositions (circular economy), pig iron, alloying elements, carburizers, etc., neither using ready alloys nor applying secondary metallurgical methods. Depending on the production route used, the chemical composition can vary (Clause 6). The mechanical properties prevail.

Material designation

The customer designates the material grade based on design requirements (load). In a casting with complex shape and sections with very different wall thicknesses, property values can vary over the casting, due to section sensitivity. A single cast sample cannot be representative for all sections of the entire casting.

If only one cast sample is possible (e.g. due to cost reasons, space in the mould, or when cutting a sample from the casting is not possible), the cast sample will represent the most interesting section of the casting, having the relevant wall thickness.

Since EN 1561:2011, the material designation is based on cast samples with comparable solidification as the casting (Table 3 specifies different sample sizes, representing different relevant wall thickness).

The 30 mm diameter separately cast sample (Type II) can still be used for designating the material grade, e.g. for simple casting shapes. It cannot properly represent property values in sections with greater wall thickness of the casting.

In case of an inappropriate designation of a material grade, the desired properties may not be reached locally, in the most interesting, relevant section of the cast component.

EXAMPLE A thick-walled casting is designated as EN-GJL-250 using the 30 mm diameter separately cast sample (Type II), but the relevant section of the component has 100 mm wall thickness. The minimum tensile strength of 250 MPa will not be reached in the thick-walled section.

This can be avoided by co-operation of customer and foundry early in the design stage. The foundry can adapt its process in order to fulfil the local properties of the part, defined by the customer.

NOTE The short name is designated according to EN 1560. The designation system by number is based on the structure and rules of EN 10027-2 [4] and so corresponds with the European numbering system for steel and other materials.

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Property values

The cast sample represents the properties in the relevant wall thickness section of the casting, given by component design. Compared to EN 1561:2011, the minimum tensile properties to be obtained in cast samples were slightly adapted to consider section sensitivity. They represent today's reproducible production processes for all types of grey cast iron production (long-series with machine moulding, short-series with hand moulding, with smaller to greater wall thicknesses).

Anticipated values in the casting (Table E.1) have been adapted, using the finer wall thickness grading (e.g. 6 ranges for EN-GJL-250, with 3 ranges < 40 mm). Property values were subsequently decreased with increasing wall thickness.

The tensile test piece given in Figure 5 is used to achieve reproducible results. For serial production of grey iron castings using statistical methods, the position of the scatter-band and its lower boundary depends on wall thickness.

When using larger cast samples, microstructural effects become less pronounced. Lower property values often do not result from poor process control but from slower solidification and statistical effects.

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.

Hardness of the material can also be evaluated on the casting.

For many applications, tensile strength and hardness are not the only properties of interest to casting designers. Other mechanical or physical properties can be decisive for the use of grey iron. For example:

- the thermal capacity and the thermal conductivity for brake disks;
- the damping capacity for engine blocks or machine beds;
- the thermocycle fatigue for exhaust manifolds or ingot moulds.

Therefore, Annex A (informative) provides additional information on mechanical and physical properties.

Annex G, Table G.1 provides details of significant technical changes between this document and the previous edition.

1 Scope

This document specifies the properties of unalloyed and low-alloyed grey cast irons used for castings, which have been manufactured in sand moulds or in moulds with comparable thermal behaviour.

NOTE This document can also be applicable to grey cast irons cast in permanent moulds, provided the related cast samples are poured under the same conditions as the castings.

This document specifies the characterizing properties of grey cast irons by either:

- a) the tensile strength of cast samples,
- b) if agreed by the manufacturer and the purchaser, the tensile strength of samples cut from a casting,
- c) the hardness determined on the castings or on a cast-on knob.

If agreed by the manufacturer and the purchaser, the combination of both tensile strength from option a) and hardness from option c) can be specified.

This document specifies five grades of grey cast iron by a classification based on tensile strength determined on machined test pieces prepared from cast samples (see Table 1) and six grades of grey cast iron by a classification based on Brinell hardness (see Table 2).

This document does not cover technical delivery conditions for iron castings; see EN 1559-1 and EN 1559-3.

This document does not apply to grey cast irons used for pipes and fittings which are covered by to EN 877 [1].

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.

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

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

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)*

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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:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

grey cast iron

cast material, mainly iron and carbon based, carbon being present mainly in the form of flake (lamellar) graphite particles

Note 1 to entry: Grey cast iron is also known as flake graphite cast iron, and less commonly as lamellar graphite cast iron.

Note 2 to entry: Graphite form, distribution and size are specified in EN ISO 945-1.

3.2

cast sample

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

3.3

separately cast sample

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

3.4

side-by-side cast sample

sample cast in the mould alongside the casting, with a connected but separate running system

3.5

cast-on sample

sample attached directly to the running system or to the casting

3.6

Sample cut from a casting

sample cut from an individual casting, by agreement between the manufacturer and the purchaser

3.7

relevant wall thickness

wall thickness representative of the casting, specified 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 either Table 1 or Table 2.

NOTE 1 The designation system is given in EN 1560 [3].

The number in position 3 of the designation (symbol) in Table 1 is the minimum tensile strength of the grades as determined on test pieces machined from 30 mm diameter cast samples (15 mm relevant wall thickness), separately cast or cast side-by-side. The wall thickness range 10 mm to 20 mm is used for designation.

EXAMPLE 1 Material grade EN-GJL-250. To determine the ultimate tensile strength, a standard 30 mm diameter separately cast sample is poured according to Figure 1, Type II. The cooling velocity of a Type II cast sample is the same as a 15 mm thick plate of infinite length. Type II is the most commonly used sample size, used also for designation. The material grade is designated EN-GJL-250 when the tensile strength exceeds 250 MPa.

Alternatively, the designation may be based on cast-on samples. In this case, the minimum tensile strength is lower due to cooling conditions. By comparing the values in the far-right column of Table 1 with the values from the separately cast sample, the correct material designation can be obtained.

The number in position 3 of the designation (symbol) in Table 2 is the maximum Brinell hardness value of the grade for relevant wall thickness ≥ 40 mm. A designation based on thin walls does not reflect hardness increase due to accelerated cooling.

EXAMPLE 2 Material grade EN-GJL-HB-175. The maximum hardness in the wall thickness range 40 mm to 80 mm is used for designation, as it represents the bulk material (metallic matrix). For thinner walls, hardness can be higher due to accelerated cooling, resulting in a different microstructure.

In the case of samples cut from the casting the letter C is added at the end of the designation by symbol. Guidance values anticipated in the casting are given in Table E.1. Those property values are not intended for material designation.

NOTE 2 Comparison of EN 1561 grade designations to the grades from ISO 185:2020 [6] is given in Annex B.

5 Order information

The order shall specify, in an unambiguous manner, whether the tensile strength measured on cast samples, or the Brinell hardness determined on the casting, is the characterizing property. If it does not do so, then the manufacturer shall characterize the material according to tensile strength.

The following information shall be supplied by the purchaser:

- a) the number of this document (EN 1561);
- 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.

When specifying a combination of tensile strength and hardness, it is recommended to consult the information in Annex C.

EN 1561:2023 (E)**6 Manufacture**

The metallurgical method of producing grey cast irons and their chemical composition shall be left to the discretion of the manufacturer who shall ensure that the requirements of this European Standard are met for the material grade specified in the order.

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

For grey 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 at the time of acceptance of the order.

7 Requirements**7.1 Mechanical properties**

The order shall specify in an unambiguous manner whether the characterizing property is:

- a) tensile strength determined on test pieces machined from separately cast or side-by-side cast samples;
- b) tensile strength determined on test pieces machined from cast-on samples;
- c) tensile strength determined on test pieces machined from samples cut from a casting;
- d) Brinell hardness determined on the casting;
- e) a combination of both tensile strength and Brinell hardness.

If the order does not specify Brinell hardness, then the manufacturer shall characterize the material according to tensile strength.

7.2 Tensile properties**7.2.1 General**

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

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

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

7.2.2 Test pieces machined from cast samples

The tensile properties of the five grades of grey cast irons specified by tensile strength shall be in accordance with the requirements of Table 1. The maximum tensile strength of the grade is the minimum value plus 100 MPa. This shall ensure that the material is correctly designated.

NOTE Tensile strength is determined according to 9.1, using test pieces machined from cast samples (type of sample chosen according to Table 3, corresponding to the relevant wall thickness of the casting)

For process quality assurance purposes, 30 mm diameter cast samples are commonly used.