INTERNATIONAL STANDARD

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Grey cast irons — Classification

Fontes à graphite lamellaire — Classification

Reference number
ISO 185:2005(E)

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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 185 was prepared by Technical Committee ISO/TC 25, *Cast irons and pig irons*, Subcommittee SC 3, *Grey cast irons*.

This second edition cancels and replaces the first edition (ISO 185:1988), which has been technically revised.

Introduction

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

The properties of grey cast irons depend on the form and distribution of the graphite and the structure of the matrix.

However, for many applications, tensile strength or hardness are not the only interesting or determining properties. Other mechanical or physical properties can be decisive for the use of grey cast iron, for example:

— the thermal capacity and the thermal diffusivity for disc brakes as well as radiators;

— the damping capacity for engine blocks or machine beds;

— the thermocycle fatigue for exhaust manifolds or ingot moulds.

Therefore, Annex A provides additional information of interest to casting designers.

In addition:

— Annex B contains “Additional information on the relationship between hardness and tensile strength”;

— Annex C contains “Additional information on the relationship between tensile strength, hardness and wall thickness of grey iron castings”.

NOTE This International Standard does not cover technical delivery conditions for grey iron castings.

Grey cast irons — Classification

1 Scope

This International Standard 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.

This International Standard specifies the characterizing properties of grey cast iron by either

a) the tensile strength of separately cast samples, or if agreed by the manufacturer and the purchaser, of cast-on samples or samples cut from a casting (see Table 1), or

b) if agreed between the manufacturer and the purchaser, the hardness of the material measured on castings (see Table 2) 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 b) may be specified. When specifying a combination of tensile strength and hardness, it is recommended to consult the information in Annex B.

This International Standard does not apply to grey cast irons used for pipes and pipe fittings and continuous cast products.

This International Standard specifies eight grades of grey cast iron according to the tensile strength (see Table 1) and six grades of grey cast iron according to the Brinell hardness (see Table 2).

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

ISO 6506-1, *Metallic materials — Brinell 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
grey cast iron
cast material, iron and carbon based, carbon being present mainly in the form of flake (lamellar) graphite particles

NOTE 1 Grey cast iron is also known as flake graphite cast iron, and less commonly as lamellar graphite cast iron.

NOTE 2 Graphite form, distribution and size are specified in ISO 945.

3.2
relevant wall thickness
section of the casting, agreed between the manufacturer and the purchaser, to which the determined mechanical properties apply

4 Designation

The material shall be designated as given in either Table 1 or Table 2. The designation system is given in ISO/TR 15931.

5 Order information

The following information shall be supplied by the purchaser:

a) the complete designation of the material;

b) any special requirements which have to be agreed between the manufacturer and the purchaser.

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

6 Manufacture

The method of producing grey cast iron and its chemical composition shall be left to the discretion of the manufacturer, who shall ensure that the requirements of this International Standard are met for the material grade specified in the order.

NOTE 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.

7 Requirements

7.1 Mechanical properties

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

7.2 Tensile properties

7.2.1 Test pieces machined from separately cast samples

The tensile properties of the eight grades of grey cast iron specified by tensile strength, when measured in accordance with 9.1 using test pieces machined from separately cast samples, shall be in accordance with the requirements of Table 1.

The number in position 3 of the designation is the minimum tensile strength of the grade. The maximum tensile strength of the grade is the minimum value plus 100 N/mm^2.

7.2.2 Test pieces machined from cast-on samples

The tensile properties of test pieces machined from cast-on samples, for the eight grades of grey cast iron defined by tensile strength, shall be in accordance with the requirements of Table 1.

7.2.3 Test pieces cut from a casting

If applicable, the tensile properties of test pieces cut from a casting, for the eight grades of grey cast iron defined by tensile strength, shall be agreed between the manufacturer and the purchaser, and these tensile properties shall be in accordance with the requirements in the agreement.

Table 1 — Tensile strength of grey cast irons

Material designation	Relevant wall thickness [a] t mm		Tensile strength R_m [b] mandatory values			Tensile strength R_m [c] anticipated values in casting[d]
			in separately cast sample [f] N/mm²	in cast-on sample N/mm²		N/mm²
	>	⩽	min.	min.		min.
ISO 185/JL/**100**	5[e]	40	**100**	—		—
ISO 185/JL/**150**	2,5[e]	5	**150**	—		180
	5	10		—		155
	10	20		—		130
	20	40		120		110
	40	80		110		95
	80	150		100		80
	150	300		90[d]		—
ISO 185/JL/**200**	2,5[e]	5	**200**	—		230
	5	10		—		205
	10	20		—		180
	20	40		170		155
	40	80		150		130
	80	150		140		115
	150	300		130[d]		—
ISO 185/JL/**225**	5[e]	10	**225**	—		230
	10	20		—		205
	20	40		190		170
	40	80		170		150
	80	150		155		135
	100	300		145[d]		—
ISO 185/JL/**250**	5[e]	10	**250**	—		250
	10	20		—		225
	20	40		210		195
	40	80		190		170
	80	150		170		155
	150	300		160[d]		—
ISO 185/JL/**275**	10[e]	20	**275**	—		250
	20	40		230		220
	40	80		205		190
	80	150		190		175
	150	300		175[d]		—

Table 1 (*continued*)

Material designation	Relevant wall thickness [a] t mm		Tensile strength R_m [b] mandatory values			Tensile strength R_m [c] anticipated values in casting[d]
			in separately cast sample [f] N/mm²	in cast-on sample N/mm²		N/mm²
	>	⩽	min.	min.		min.
ISO 185/JL/**300**	10[e]	20	**300**	—		270
	20	40		250		240
	40	80		220		210
	80	150		210		195
	150	300		190[d]		—
ISO 185/JL/**350**	10[e]	20	**350**	—		315
	20	40		290		280
	40	80		260		250
	80	150		230		225
	150	300		210[d]		—

NOTE 1 1 N/mm² is equivalent to 1 MPa.

NOTE 2 For high damping capacity and thermal conductivity, ISO 185/JL/100 is the most suitable material.

NOTE 3 The figures given in bold indicate the minimum tensile strength to which the material designation of the grade is related.

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 = separately cast sample;

/U = cast-on sample.

[a] If a cast-on sample is to be used, the relevant wall thickness of the casting shall be agreed.

[b] If tensile strength is specified as a characterizing property, the type of the sample (see 8.2) should also to be stated in the order. If not stated on the order, the type of sample is left to the discretion of the manufacturer.

[c] This column gives guidance only about the likely variation in tensile strength for different casting wall thicknesses when a casting of simple shape and uniform wall thickness is cast in a given grey cast-iron material. For castings of non-uniform wall thickness, or castings containing cored holes, the table values are only an approximate guide to the likely tensile strength in different sections, and casting design should be based on the measured tensile strength in critical parts of the casting.

[d] These values are guideline values. They are not mandatory.

[e] This value is included as the lower limit of the relevant wall-thickness range.

[f] The values relate to an as-cast test-bar diameter of 30 mm; this corresponds to a relevant wall thickness of 15 mm.

7.3 Hardness properties

The Brinell hardness values of the six grades of grey cast iron specified by hardness, when measured in accordance with 9.2, shall be as given in Table 2. The number in position 3 of the designation is the maximum Brinell hardness value for a relevant wall thickness $t > 40$ mm and $t \leqslant 80$ mm.

If it is not possible to use the Brinell test method in accordance with ISO 6506-1, alternative test methods may be used, which shall have correlated values with Brinell hardness.

If a casting is ordered on the basis of hardness, the relevant wall thickness and the position of the test shall be agreed. Minimum and maximum Brinell hardness values, for the relevant wall thickness specified by the purchaser, shall be mandatory for the castings covered by the order.

NOTE 1 This subclause establishes hardness grades for grey cast iron.

NOTE 2 This classification is applicable principally where machinability or wear resistance are of importance.

NOTE 3 For a relevant wall thickness $t > 80$ mm, grades are not classified by hardness.

Table 2 — Brinell hardness of castings of grey cast iron, mandatory and anticipated values at the agreed test position

Material designation	Relevant wall thickness t mm		Brinell hardness [a, b] HBW	
	>	⩽	min.	max.
ISO 185/JL/HBW**155**	**40**[c]	**80**	—	**155**
	20	40	—	160
	10	20	—	170
	5	10	—	185
	2,5	5	—	210
ISO 185/JL/HBW**175**	**40**[c]	**80**	**100**	**175**
	20	40	110	185
	10	20	125	205
	5	10	140	225
	2,5	5	170	260
ISO 185/JL/HBW**195**	**40**[c]	**80**	**120**	**195**
	20	40	135	210
	10	20	150	230
	5	10	170	260
	4	5	190	275
ISO 185/JL/HBW**215**	**40**[c]	**80**	**145**	**215**
	20	40	160	235
	10	20	180	255
	5	10	200	275
ISO 185/JL/HBW**235**	**40**[c]	**80**	**165**	**235**
	20	40	180	255
	10	20	200	275
ISO 185/JL/HBW**255**	**40**[c]	**80**	**185**	**255**
	20	40	200	275

NOTE 1 Information on the relationship between Brinell hardness and tensile strength is indicated in Annex B, and on the relationship between Brinell hardness and relevant wall thickness is indicated in Annex C.

NOTE 2 The figures given in bold indicate the minimum and maximum Brinell hardness, to which the material designation of the grade is related, and the corresponding reference relevant wall-thickness range limits.

[a] For each grade, Brinell hardness decreases with increasing wall thickness.

[b] By agreement between the manufacturer and the purchaser, a narrower hardness range may be adopted at the agreed position on the casting, provided that this is not less than 40 Brinell hardness units. An example of such a circumstance could be castings for long-series production.

[c] Reference relevant wall thickness for the grade.

7.4 Graphite structure

If the graphite structure is agreed upon, the test shall be carried out in accordance with 9.3.

8 Sampling

8.1 General

Samples shall be supplied in order to characterize the grade of the material.

If heat treatment is used to modify the properties of the material, then the samples shall be heat-treated in the same way as the castings they represent.

8.2 Tensile test

8.2.1 Separately cast samples

The separately cast samples used to establish the material grade shall be cast vertically (see Figure 1). The moulds used to cast separately cast samples shall have comparable thermal behaviour to the moulding material used to cast the castings. The moulds may be made for casting several samples simultaneously.

The length L (see Figure 1) shall be determined according to the length of the test piece A or B (see 9.1) and the clamping device used.

Other dimensions of the mould shall meet the dimensional requirements of Figure 1.

Dimensions in millimetres

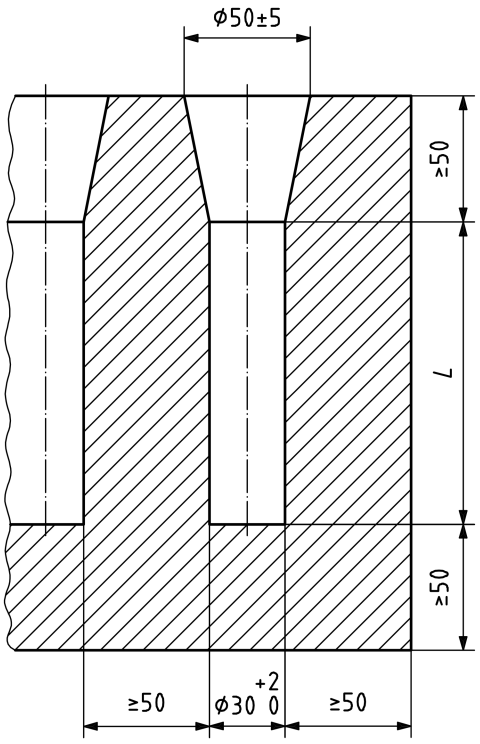


Figure 1 — Separately cast samples

Samples of other dimensions, and using other casting procedures, may be agreed between the manufacturer and the purchaser for the purpose of representing the properties of particular castings (an indication of the likely values of tensile strength is given in Figure C.1).

Samples shall be made from the metal used to produce the castings which they represent, and during the same period as when the castings are made.

The frequency of casting the separately cast samples shall be in accordance with the in-process quality assurance procedures adopted by the manufacturer.

The samples shall be removed from the mould at a temperature $\leqslant$ 500 °C.

NOTE By agreement between the manufacturer and the purchaser, samples may be removed from the mould at a temperature $\geqslant$ 500 °C, if the castings are also to be removed from the moulds at this higher temperature.

8.2.2 Cast-on samples

The test pieces used for the tests specified in Clause 7 shall be machined from a cast-on sample, as indicated in Figures 2 or 3. The test pieces shall be in accordance with 7.2.2. The type of sample shall be chosen in such a way as to provide approximately the same cooling conditions as for the casting to be represented. The type of sample, and the location of the sample on the casting, shall be agreed between the manufacturer and the purchaser. If there is no such agreement, the manufacturer shall decide on the type of sample and it shall be located at a representative position on the casting.

Cast-on samples should be used only when a casting is more than 20 mm thick and the mass is more than 200 kg.

NOTE Two possible sets of sizes are shown in Figures 2 and 3, with the larger test-piece size option being shown in brackets. The small-size set is used for castings of less than 80 mm wall thickness, and the large-size set is used for castings equal to or greater than 80 mm wall thickness.

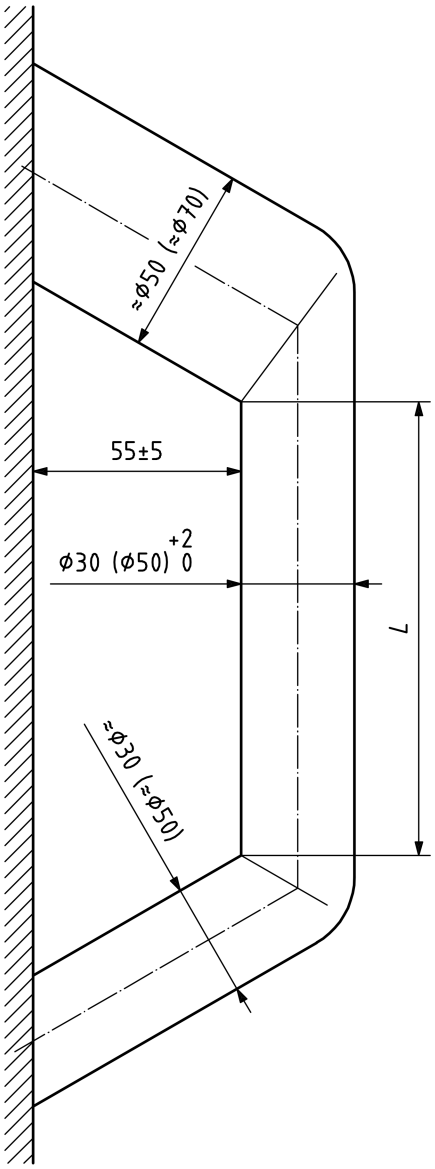
The length L (see Figures 2 and 3) shall be determined according to the length of the test piece and the clamping device.

8.2.3 Test pieces cut from a casting

Table 1 shows anticipated minimum values of tensile strength for test pieces cut from a casting with a uniform section of simple shape.

NOTE Values obtained in castings of variable wall thickness can differ from those given in Table 1.

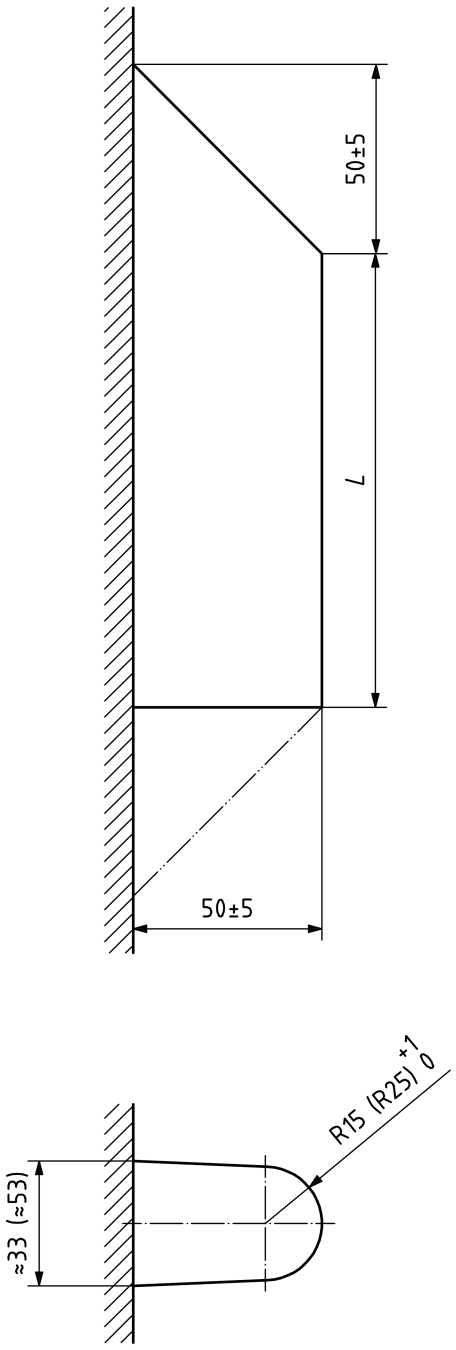
Dimensions in millimetres



NOTE For the significance of figures in brackets, see 8.2.2, note.

Figure 2 — Cast-on sample: Type 1

Dimensions in millimetres



NOTE For the significance of figures in brackets, see 8.2.2, note.

Figure 3 — Cast-on sample: Type 2

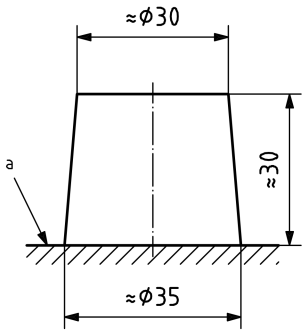
8.3 Hardness test

Hardness tests may be carried out on the separately cast samples described in 8.2.1.

Alternatively, the Brinell hardness test may be carried out, by agreement between the manufacturer and the purchaser, on a test piece (“Brinell knob”) which is cast-on to the casting as shown in Figure 4. The position of the Brinell knob, and its size and shape, shall be agreed between the manufacturer and purchaser.

In order to carry out the Brinell hardness test, the test piece is removed from the casting, ground on the cut surface and then tested on the ground surface.

Dimensions in millimetres



a Surface of casting.

Figure 4 — Example of a Brinell knob

If the casting is heat-treated, the Brinell knob shall not be detached from the casting until the heat-treatment process has been concluded.

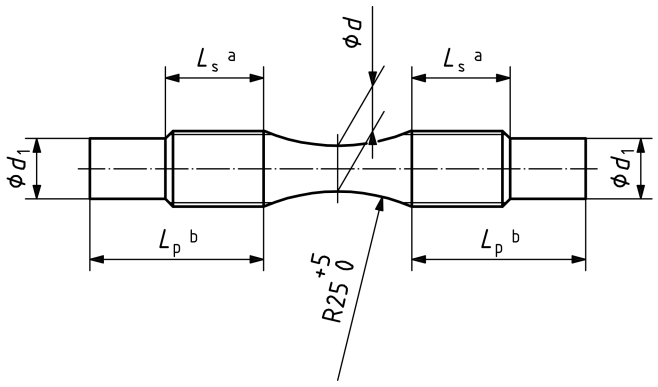
9 Test methods

9.1 Tensile test

The tensile test shall be carried out in accordance with the requirements of ISO 6892, using a test piece in conformance either with Figure 5 or Figure 6.

The dimensions of the test piece shall conform to the dimensions given in Table 3. The gripped parts may be either threaded or plain to suit the clamping device.

Dimensions in millimetres

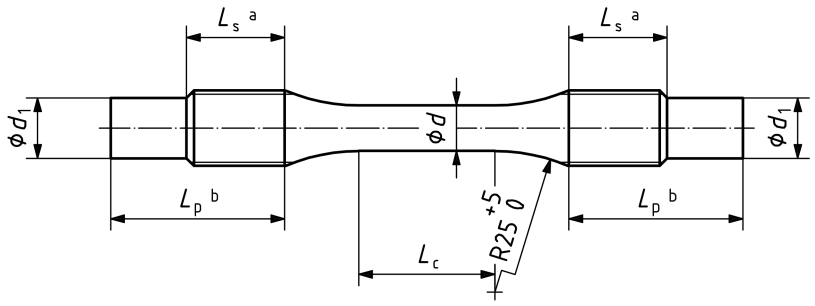


a Length of threaded end.

b Length of plain end.

Figure 5 — Test piece A

Dimensions in millimetres



a Length of threaded end.

b Length of plain end.

Figure 6 — Test piece B

NOTE For the same material, the results achieved using test piece A (see symbols in Table 3) can be slightly higher than those achieved by using test piece B.

Table 3 — Dimensions of test pieces A and B

Values in millimetres

Diameter of the parallel length d a	Thread type for threaded test pieces b	Thread length L_s b	Diameter d_1 for plain ends b	Threaded test piece A, total length	Test piece B, parallel length, L_c
6 ± 0,1	M10	13	8	46	18
8 ± 0,1	M12	16	10	53	24
10 ± 0,1	M16	20	12	63	30
12,5 ± 0,1	M20	24	15	73	36,5
16 ± 0,1	M24	30	20	87	48
20 ± 0,1	**M28**	**36**	**23**	**102**	**60**
25 ± 0,1	M36	44	30	119	75
32 ± 0,1	M45	55	40	143	96

NOTE 1 $L_p > L_s$, to suit the clamping device.

NOTE 2 The row in bold indicates the preferred dimensions for the test pieces.

a The cross-sectional area S_o shall be calculated.

b Recommended dimensions.

9.2 Brinell hardness test

The Brinell hardness test, if required, shall be carried out at an agreed position on the casting, in accordance with the requirements of ISO 6506-1.

9.3 Graphite structure

The graphite structure, if required, shall be determined in accordance with ISO 945.

9.4 Alternative test procedures

If agreed between the manufacturer and the purchaser, alternative test procedures, which give equivalent results for tensile strength, Brinell hardness and graphite structure, may be used.

By agreement between the manufacturer and the purchaser, the wedge penetration test may be applied as an alternative to the tensile test.

10 Retests

10.1 Need for retests

Retests shall be carried out if a test is not valid (see 10.2).

It is permitted to carry out retests if a test result does not meet the mechanical property requirements for the specified grade (see 10.3).

10.2 Test validity

A test is not valid if there is:

a) a faulty mounting of the test piece or defective operation of the test machine;

b) a defective test piece because of incorrect pouring or incorrect machining;

c) a casting defect in the test piece, evident after fracture.

In the above cases, a new test piece shall be taken from the same sample or from a duplicate sample cast at the same time. The result of the retest shall be substituted for the result of the invalid test.

10.3 Non-conforming test results

If any test gives results which do not conform to the specified requirements, for reasons other than those given in 10.2, the manufacturer shall have the option to conduct retests. If the manufacturer conducts retests, two retests shall be carried out for each failed test.

If the results of both retests meet the specified requirements, the material shall be deemed to conform to this International Standard.

If the results of one or both retests fail to meet the specified requirements, the material shall be deemed not to conform to this International Standard.

Annex A
(informative)

Additional information on mechanical and physical properties in addition to that given in Tables 1 and 2

Information on mechanical properties is given in Table A.1.

Information on physical properties is given in Table A.2.

Table A.1 — Mechanical properties in separately cast test pieces with 30 mm as-cast casting diameter

Characteristic	Symbol	SI-unit	Material designation [a]						
			ISO 185/JL/**150**	ISO 185/JL/**200**	ISO 185/JL/**225**	ISO 185/JL/**250**	ISO 185/JL/**275**	ISO 185/JL/**300**	ISO 185/JL/**350**
			Basic structure						
			ferritic/ pearlitic	pearlitic					
Tensile strength	R_m	N/mm^2	150 to 250	200 to 300	225 to 325	250 to 350	275 to 375	300 to 400	350 to 450
0,1% proof strength	$R_{p0,1}$	N/mm^2	98 to 165	130 to 195	150 to 210	165 to 228	180 to 245	195 to 260	228 to 285
Elongation after fracture	A	%	0,3 to 0,8	0,3 to 0,8	0,3 to 0,8	0,3 to 0,8	0,3 to 0,8	0,3 to 0,8	0,3 to 0,8
Compression strength	σ_{db}	N/mm^2	600	720	780	840	900	960	1 080
0,1% compression yield point	$\sigma_{d0,1}$	N/mm^2	195	260	290	325	360	390	455
Bending strength	σ_{bB}	N/mm^2	250	290	315	340	365	390	490
Shear strength	σ_{aB}	N/mm^2	170	230	260	290	320	345	400
Torsional strength[b]	τ_{tB}	N/mm^2	170	230	260	290	320	345	400
Modulus of elasticity [c]	E	kN/mm^2	78 to 103	88 to 113	95 to 115	103 to 118	105 to 128	108 to 137	123 to 143
Poisson's ratio	ν	—	0,26	0,26	0,26	0,26	0,26	0,26	0,26
Bending fatigue strength [d]	σ_{bW}	N/mm^2	70	90	105	120	130	140	145
Fatigue limit under reversed tension-compression stresses [e]	σ_{zdW}	N/mm^2	40	50	55	60	68	75	85
Fracture toughness	K_{Ic}	N/mm$^{3/2}$	320	400	440	480	520	560	650

NOTE 1 N/mm^2 is equivalent to 1 MPa.

[a] When there are special requirements relating to machinability or magnetic properties, then ISO 185/JL/**100** is used. The required properties can be obtained by means of a structure-changing heat-treatment process. ISO 185/JL/**100** is not cited here.

[b] Torsional fatigue strength $\tau_{tW} \approx 0{,}42 \times R_m$.

[c] Depends on the quantity and form of the graphite, as well as on the loading.

[d] The following approximately applies: $\sigma_{bW} \approx 0{,}35 - 0{,}50 \times R_m$.

[e] The following approximately applies: $\sigma_{zdW} \approx 0{,}53 \times \sigma_{bW} \approx 0{,}26 \times R_m$.

Table A.2 — Physical properties in separately cast test pieces with 30 mm as-cast casting diameter

Characteristic	Symbol	SI-unit	Material designation [a]						
			ISO 185/JL/**150**	ISO 185/JL/**200**	ISO 185/JL/**225**	ISO 185/JL/**250**	ISO 185/JL/**275**	ISO 185/JL/**300**	ISO 185/JL/**350**
Density	ρ	kg/dm^3	7,10	7,15	7,15	7,20	7,20	7,25	7,30
Specific heat capacity between 20 °C and 200 °C	c	J/(kg·K)	460						
Specific heat capacity between 20 °C and 600 °C	c	J/(kg·K)	535						
Linear expansion coefficient between − 100 °C and + 20 °C	α	µm/(m·K)	10,0						
Linear expansion coefficient between 20 °C and 200 °C	α	µm/(m·K)	11,7						
Linear expansion coefficient between 20 °C and 400 °C	α	µm/(m·K)	13,0						
Thermal conductivity at 100 °C	λ	W/(m·K)	52,5	50,0	49,0	48,5	48,0	47,5	45,5
Thermal conductivity at 200 °C	λ	W/(m·K)	51,0	49,0	48,0	47,5	47,0	46,0	44,5
Thermal conductivity at 300 °C	λ	W/(m·K)	50,0	48,0	47,0	46,5	46,0	45,0	43,5
Thermal conductivity at 400 °C	λ	W/(m·K)	49,0	47,0	46,0	45,0	44,5	44,0	42,0
Thermal conductivity at 500 °C	λ	W/(m·K)	48,5	46,0	45,0	44,5	43,5	43,0	41,5
Resistivity	ρ	Ω·mm^2/m	0,80	0,77	0,75	0,73	0,72	0,70	0,67
Coercivity	H_c	A/m	560 to 720						
Maximum permeability at room temperature	μ	µH/m	220 to 330						
Hysteresis losses at B = 1 T		J/m^3	2 500 to 3 000						

[a] When there are special requirements relating to machinability or magnetic properties, then ISO 185/JL/**100** may be used. The required properties can be obtained by means of a structure-changing heat-treatment process. ISO 185/JL/**100** is not cited here.

Annex B
(informative)

Additional information on the relationship between hardness and tensile strength of grey cast irons

Hardness and tensile strength, as well as modulus of elasticity and the modulus of rigidity of grey cast iron of a given grade, are approximately related to each other. In most cases, an increase in the value of one property results in an increase in the values of other properties. Grey cast irons naturally divide into a family or series of grades having different relative hardness (RH) or tensile-strength-to-hardness (T/H) ratios. This Annex briefly discusses RH and T/H for grey cast irons.

B.1 Relative hardness

The following empirical relationship between Brinell hardness (HBW) and tensile strength R_m exists:

$$\text{HBW} = \text{RH} \times (A + B \times R_m)$$

Commonly accepted values for the constants are:

$A = 100$

$B = 0{,}44$

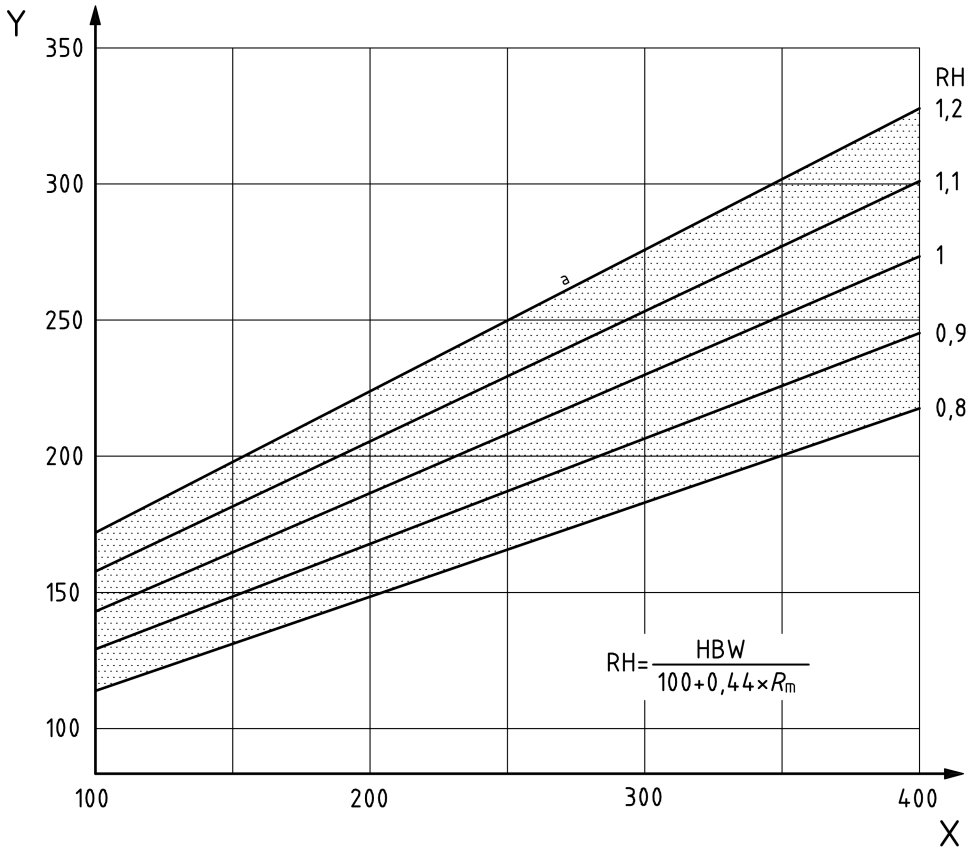
where RH is the relative hardness.

RH has been found to vary between 0,8 and 1,2 (see Figure B.1).

The factor RH is influenced mainly by the raw materials, the melting process, and the metallurgical working method. Within one foundry, these influences can be maintained nearly constant. Therefore, the manufacturer can indicate both hardness and the corresponding tensile strength.

B.2 Tensile-strength-to-hardness ratio

Tensile-strength-to-hardness (T/H) ratios are regulated by the eutectic graphite content, up to the eutectic composition shown in Figure B.2, with carbon equivalent (CE) as the graphite parameter. Using tensile strength in N/mm^2, or MPa and Brinell hardness in HBW, the T/H ratios of grey cast irons range from approximately 0,8 to 1,4. A decline in T/H ratio continues as CE increases above the eutectic, but at a much smaller and less predictable rate. Constant T/H lines in Figure B.2 are essentially lines of constant graphite effect on mechanical properties. Properties sensitive to both graphite and matrix, such as bulk tensile strength and bulk hardness, vary in constant proportionality to each other and to their matrix counterparts (matrix tensile strength and matrix hardness) along constant T/H lines. Elastic modulus and damping capacity vary mainly only with graphite and are, therefore, highly uniform along the constant T/H lines. Since these lines are also lines of constant eutectic graphite and carbon equivalent, the most important castability parameters, they are logical grade lines for foundry control, as well as for mechanical property control.



Key

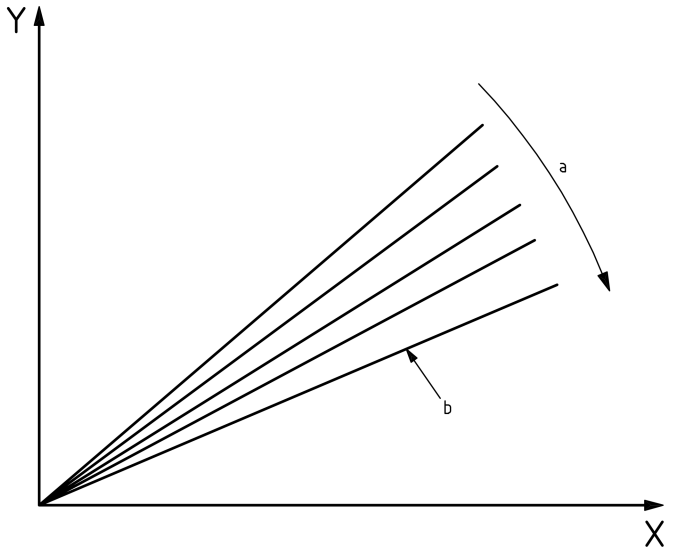
X tensile strength R_m, N/mm^2

Y Brinell hardness HBW

[a] Relative hardness, RH.

NOTE 1 N/mm^2 is equivalent to 1 MPa.

Figure B.1 — Relative hardness (RH) **relationship between Brinell hardness and tensile strength of grey cast irons**



Key

X Brinell hardness HBW

Y tensile strength

a Increasing CE, decreasing T/H.

b Eutectic.

Figure B.2 — Tensile-strength-to-hardness relationship (T/H ratio) **between Brinell hardness and tensile strength of grey cast irons**

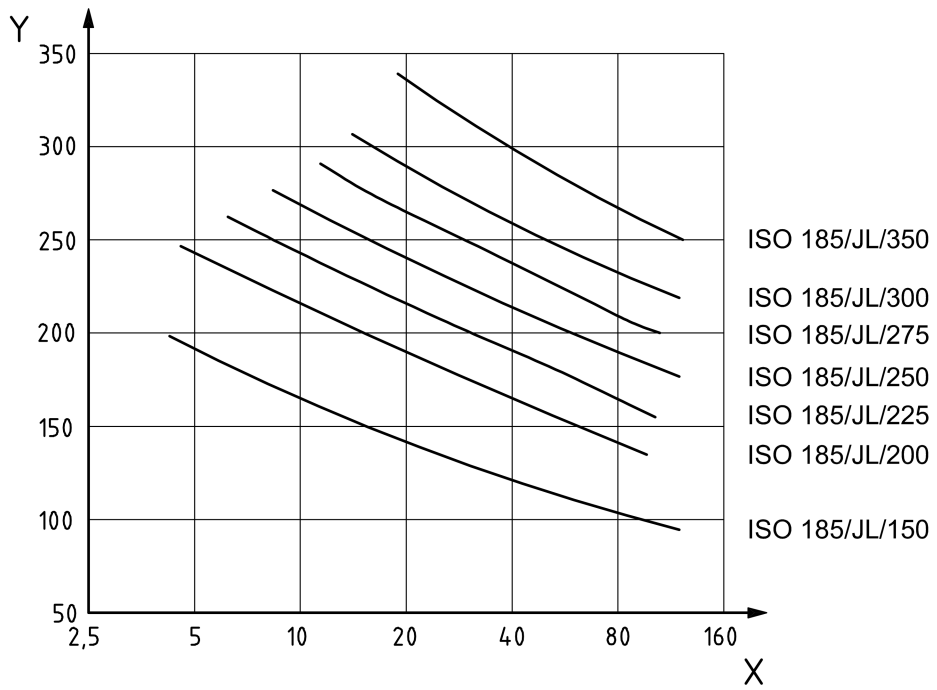
Annex C
(informative)

Additional information on the relationship between tensile strength, hardness and wall thickness of grey iron castings

Figure C.1 provides additional general information on the expected relationship between minimum tensile strength and relevant wall thickness. Figure C.2 provides information on average Brinell hardness and relevant wall thickness of castings.

Not all castings can be produced in any material hardness grade given in Table 2 for any relevant wall thickness, and this is reflected in Figure C.2. To meet the requirements of any hardness range, more than one material grade can be used, depending on the relevant wall thickness involved.

This illustrates the importance of reaching an agreement between the manufacturer and the purchaser on the specification of the hardness required in castings, and also the location where a hardness test should be carried out.



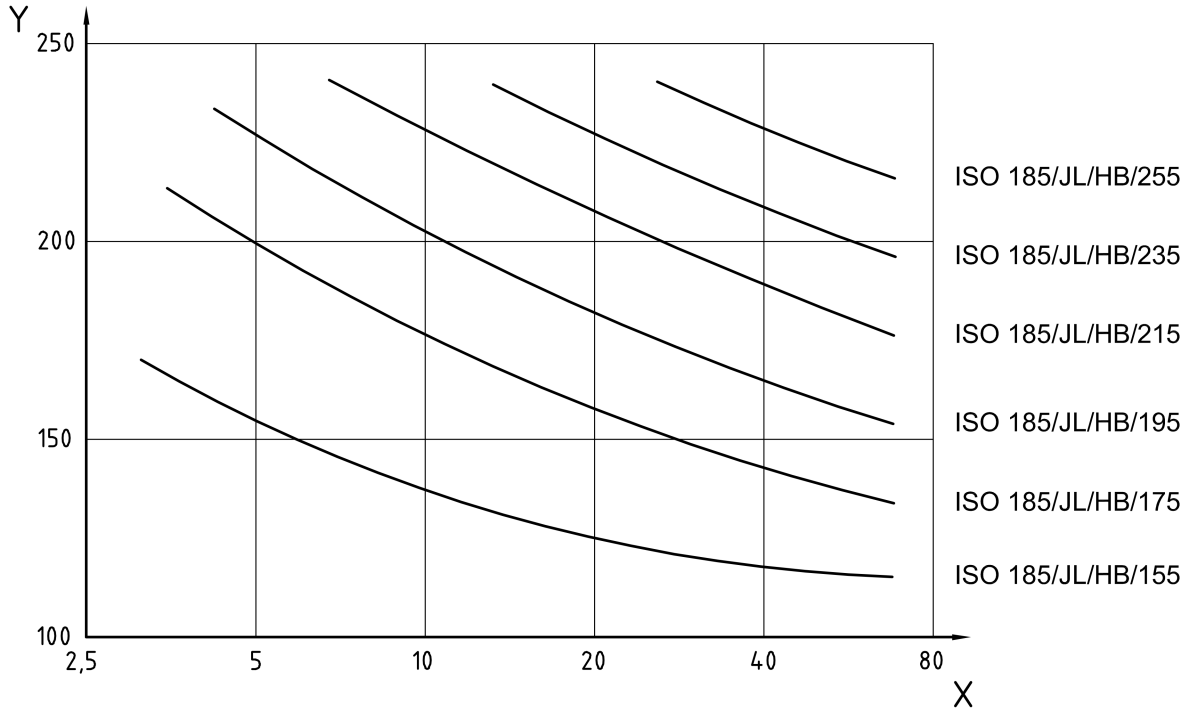
Key

X relevant wall thickness (t), mm

Y tensile strength R_m, N/mm^2

NOTE 1 N/mm^2 is equivalent to 1 MPa.

Figure C.1 — Examples of relationship between minimum values of the tensile strength and the relevant wall thickness of simple shaped castings



Key

X relevant wall thickness (t), mm

Y Brinell hardness HBW

Figure C.2 — Typical relationship between average values of the Brinell hardness and the relevant wall thickness of simple shaped castings

Annex D
(informative)

Cross-references of ISO 185 grade designations to other standard grades of grey cast iron

Table D.1 provides a selection of approximate cross-references of ISO 185 grade designations to standard grades of cast iron according to the previous (1988) edition of ISO 185 and to standard grades from current EN, ASTM, JIS, and SAE specifications for grey cast iron.

Because SAE specifies grey cast-iron grades by a combination of minimum test-bar tensile-strength-to-hardness ratio and minimum casting hardness, SAE J431 grades, in addition to those shown, may also be produced to meet a grade specified only by tensile strength. Because SAE hardness grades specify minimum casting hardness, a direct correlation between SAE J431 and ISO 185 hardness grades is not possible; Table D.1 shows SAE grades which have minimum hardness values approximately the same as ISO grades. Because ISO 185:1988 hardness grades did not differentiate between expected values for different relevant wall thickness, it is possible that more than one of the previous ISO hardness grades may satisfy the requirements of the current grades.

Table D.1 — Approximate cross-references of ISO 185 grade designations to other standard grades of grey cast iron

ISO 185:2004	ISO 185:1988	EN 1561	ASTM A48	JIS G5501	SAE J431
ISO 185/JL/150	150	EN-GJL-150	150	FC150	G9H12
ISO 185/JL/200	200	EN-GJL-200	200	FC200	G10H18
ISO 185/JL/225	—	—	225	—	G10H21 G11H18
ISO 185/JL/250	250	EN-GJL-250	250	FC250	G11H20
ISO 185/JL/275	—	—	275	—	G12H21 G13H19
ISO 185/JL/300	300	EN-GJL-300	300	FC300	G13H22
ISO 185/JL/350	350	EN-GJL-350	350	FC350	G13H24
ISO 185/JL/HBW155	H145	EN-GJL-HB155	—	—	H10
ISO 185/JL/HBW175	H175	EN-GJL-HB175	—	—	H11
ISO 185/JL/HBW195	H175 H195	EN-GJL-HB195	—	—	H13 H14
ISO 185/JL/HBW215	H175 H195 H215	EN-GJL-HB215	—	—	H16
ISO 185/JL/HBW235	H195 H215 H235	EN-GJL-HB235	—	—	H18
ISO 185/JL/HBW255	H215 H235 H255	EN-GJL-HB255	—	—	H20

Bibliography

[1] EN 1561, *Founding — Grey cast irons*

[2] ASTM A48, *Standard Specification for Gray Iron Castings*

[3] JIS G 5501, *Grey iron castings*

[4] SAE J431, *Automotive Gray Iron Castings*

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