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DEUTSCHE NORM **August 1997**

Founding

Grey cast iron

English version of DIN EN 1561

DIN
EN 1561

ICS 77.080.10

Descriptors: Grey cast iron.

Gießereiwesen – Gußeisen mit Lamellengraphit

Supersedes DIN 1691 and Suppl 1 to DIN 1691, May 1985 editions, and DIN 50109, April 1989 edition.

European Standard EN 1561 : 1997 has the status of a DIN Standard.

A comma is used as the decimal marker.

National foreword

This standard has been prepared by CEN/TC 190.

The responsible German body involved in its preparation was the *Normenausschuß Gießereiwesen* (Foundry Practice Standards Committee), Technical Committee *Grauguß*.

For ease of reference, a National Annex is provided overleaf in which the material grades specified in this standard are correlated with those previously used in Germany.

Amendments

DIN 1691 and Supplement 1 to DIN 1691, May 1985 editions, and DIN 50109, April 1989 edition, have been superseded by the specifications of EN 1561.

Previous editions

DIN DVMA 109: 1933-09; DIN 1691: 1928-04, 1929-08, 1933-07, 1942-08, 1949x-11, 1964-08, 1985-05; Suppl to DIN 1691: 1964-08; Suppl 1 to DIN 1691: 1985-05; DIN 50108: 1947-01, 1950-10, 1967-01; DIN 50109: 1947-01, 1950-10, 1962-02, 1968-03, 1989-04.

Continued overleaf.

EN comprises 19 pages.

Ref. No. DIN EN 1561 : 1997-08
English price group 12 *Sales No. 1112*
02.98

National Annex NA

List of grey cast iron grades used in this standard correlated with those used previously in DIN 1691

Designation as in DIN 1691		Designation as in DIN EN 1561	
Symbol	Material number	Symbol	Material number
GG-10	0.6010	EN-GJL-100	EN-JL1010
GG-15	0.6015	EN-GJL-150	EN-JL1020
GG-20	0.6020	EN-GJL-200	EN-JL1030
GG-25	0.6025	EN-GJL-250	EN-JL1040
GG-30	0.6030	EN-GJL-300	EN-JL1050
GG-35	0.6035	EN-GJL-350	EN-JL1060
GG-150 HB	0.6012	EN-GJL-HB155	EN-JL2010
GG-170 HB	0.6017	EN-GJL-HB175	EN-JL2020
GG-190 HB	0.6022	EN-GJL-HB195	EN-JL2030
GG-220 HB	0.6027	EN-GJL-HB215	EN-JL2040
GG-240 HB	0.6032	EN-GJL-HB235	EN-JL2050
GG-260 HB	0.6037	EN-GJL-HB255	EN-JL2060

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1561

June 1997

ICS 77.140.80

Descriptors: Grey cast iron.

English version

Founding

Grey cast iron

Fonderie – Fonte à graphite lamellaire

Gießereiwesen – Gußeisen mit Lamellengraphit

This European Standard was approved by CEN on 1997-05-02.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

The European Standards exist in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 1561:1997 E

Contents

Foreword

This European Standard 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 December 1997, and conflicting national standards shall be withdrawn at the latest by December 1997.

Within its programme of work, Technical Committee CEN/TC 190 requested CEN/TC 190/WG 2.10 "Grey cast iron" to prepare the following standard:

EN 1561
Founding – Grey cast irons

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Grey cast iron is a casting alloy, iron and carbon based, the latter element being present mainly in the form of lamellar graphite particles.

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

This European Standard deals with the classification of grey cast iron in accordance with the mechanical properties of the material, either tensile strength or hardness.

Further technical data on grey cast irons are given in annexes A to C.

Annex A (informative) contains "Additional information on mechanical and physical properties in addition to tables 1 and 2".

Annex B (informative) contains "Additional information on the relationship between hardness and tensile strength".

Annex C (informative) contains "Additional information on the relationship between tensile strength, hardness and section thickness of grey iron castings".

NOTE: This standard does not cover technical delivery conditions for grey iron castings. Reference should be made to EN 1559-1 and EN 1559-3.

1 Scope

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

This 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 by the time of acceptance of the order, of cast-on samples or samples cut from a casting (see table 1);

or

b) if agreed by the manufacturer and the purchaser by the time of acceptance of the order, the hardness of the material measured on castings (see table 2) or on a cast-on knob.

This European Standard does not apply to grey cast iron used for pipes and fittings according to prEN 877-1.

This European Standard specifies six grey cast irons according to the tensile strength (see table 1) and six grey cast irons according to the Brinell hardness (see table 2).

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 1559-1
Founding – Technical conditions of delivery – Part 1: General

EN 1559-3
Founding – Technical conditions of delivery – Part 3: Additional requirements for iron castings

EN 10002-1
Metallic materials – Tensile testing – Part 1: Method of test (at ambient temperature)

EN 10003-1
Metallic materials – Brinell hardness test – Part 1: Test method

NOTE: Informative references used in the preparation of this standard, and cited at the appropriate places in the text, are listed in a bibliography, see annex D.

3 Definitions

For the purposes of this standard, the following definitions apply:

3.1 grey cast iron

Iron-carbon cast material in which the free carbon is present as graphite, mainly in lamellar form (flake graphite).

NOTE: Graphite form and distribution are specified in EN ISO 945.

3.2 relative hardness

Quotient of measured hardness to the hardness calculated from the measured tensile strength by means of an empirical relationship (also referred to as RH).

NOTE: RH is influenced mainly by the raw materials, the melting process and the metallurgical working method and usually varies between 0,8 and 1,2.

3.3 relevant wall thickness

Wall thickness for which the mechanical properties apply.

NOTE: The relevant wall thickness is twice the modulus or twice the volume/surface area ratio.

4 Designation

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

5 Order information

The following information shall be supplied by the purchaser:

a) the number of this European Standard (EN 1561);

b) the designation of the material;

c) any special requirements which have to be agreed by the time of acceptance of the order (see EN 1559-1 and EN 1559-3).

6 Manufacture

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

NOTE: For grey cast iron 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 by the time of acceptance of the order.

7 Requirements

7.1 Mechanical properties

In addition to EN 1559-1 and EN 1559-3 the order should specify in an unambiguous manner as to 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.

The characterizing property shall be checked only when this has been agreed by the time of acceptance of the order.

7.2 Tensile properties

7.2.1 Test pieces machined from separately cast samples

The tensile properties of the six grey cast irons defined 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.

7.2.2 Test pieces machined from cast-on samples

The tensile properties of test pieces machined from cast-on samples for the six grey cast irons 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 six grey cast irons defined by tensile strength shall be agreed between the manufacturer and the purchaser by the time of acceptance of the order 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[1] mm		Tensile strength R_m[2] mandatory values		Tensile strength R_m[4] anticipated values in casting[5]
				in separately cast sample[3] N/mm²	in cast-on sample N/mm²	N/mm²
Symbol	Number	over	up to and including		min.	min.
EN-GJL-**100**	EN-JL1010	5[6]	40	**100** to 200[7]	–	–
EN-GJL-**150**	EN-JL1020	2,5[6]	5	**150** to 250[7]	–	180
		5	10		–	155
		10	20		–	130
		20	40		120	110
		40	80		110	95
		80	150		100	80
		150	300		90[5]	–
EN-GJL-**200**	EN-JL1030	2,5[6]	5	**200** to 300[7]	–	230
		5	10		–	205
		10	20		–	180
		20	40		170	155
		40	80		150	130
		80	150		140	115
		150	300		130[5]	–
EN-GJL-**250**	EN-JL1040	5[6]	10	**250** to 350[7]	–	250
		10	20		–	225
		20	40		210	195
		40	80		190	170
		80	150		170	155
		150	300		160[5]	–
EN-GJL-**300**	EN-JL1050	10[6]	20	**300** to 400[7]	–	270
		20	40		250	240
		40	80		220	210
		80	150		210	195
		150	300		190[5]	–
EN-GJL-**350**	EN-JL1060	10[6]	20	**350** to 450[7]	–	315
		20	40		290	280
		40	80		260	250
		80	150		230	225
		150	300		210[5]	–

[1]) If a cast-on sample is to be used the relevant wall thickness of the casting shall be agreed upon by the time of acceptance of the order.
[2]) If by the time of acceptance of the order proving of the tensile strength has been agreed, the type of the sample is also to be stated on the order (see 8.2). If there is lack of agreement the type of sample is left to the discretion of the manufacturer.
[3]) For the purpose of acceptance the tensile strength of a given grade shall be between its nominal value n (position 5 of the material symbol) and $(n+100)$ N/mm².
[4]) This column gives guidance to 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.
[5]) These values are guide-line values. They are not mandatory.
[6]) This value is included as the lower limit of the relevant wall thickness range.
[7]) The values relate to samples with an as-cast casting diameter of 30 mm, this corresponds to a relevant wall thickness of 15 mm.

NOTE 1: 1 N/mm² is equivalent to 1 MPa.
NOTE 2: For high damping capacity and thermal conductivity, EN-GJL-**100** (EN-JL1010) is the most suitable material.
NOTE 3: The material designation is in accordance with EN 1560.
NOTE 4: The figures given in bold indicate the minimum tensile strength to which the symbol of the grade is related.

7.3 Hardness properties

The Brinell hardness values of the six grey cast irons defined by hardness when measured in accordance with 9.2 shall be as given in table 2.

If it is not possible to use the Brinell test method in accordance with EN 10003-1 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 upon by the time of the acceptance of the order. The values given for wall thicknesses over 40 mm and up to and including 80 mm in table 2 against the various grades shall be mandatory hardness values for that wall thickness range.

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: The hardness values given for smaller thickness ranges ≤ 40 mm are anticipated values only.

NOTE 4: For a relevant wall thickness above 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 mm		Brinell hardness[1], [2] HB 30	
Symbol	Number	over	up to and including	min.	max.
EN-GJL-**HB155**	EN-JL2010	**40**[3]	**80**	–	**155**
		20	40	–	160
		10	20	–	170
		5	10	–	185
		2,5	5	–	210
EN-GJL-**HB175**	EN-JL2020	**40**[3]	**80**	**100**	**175**
		20	40	110	185
		10	20	125	205
		5	10	140	225
		2,5	5	170	260
EN-GJL-**HB195**	EN-JL2030	**40**[3]	**80**	**120**	**195**
		20	40	135	210
		10	20	150	230
		5	10	170	260
		4	5	190	275
EN-GJL-**HB215**	EN-JL2040	**40**[3]	**80**	**145**	**215**
		20	40	160	235
		10	20	180	255
		5	10	200	275
EN-GJL-**HB235**	EN-JL2050	**40**[3]	**80**	**165**	**235**
		20	40	180	255
		10	20	200	275
EN-GJL-**HB255**	EN-JL2060	**40**[3]	**80**	**185**	**255**
		20	40	200	275

[1]) For each grade, Brinell hardness decreases with increasing wall thickness.
[2]) 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.
[3]) Reference relevant wall thickness for the grade
NOTE 1: Information on the relationship between Brinell hardness and tensile strength is indicated in figure B.1 and the relationship between Brinell hardness and relevant wall thickness in figure C.2 of annexes B and C respectively.
NOTE 2: The material designation is in accordance with EN 1560.
NOTE 3: The figures given in bold indicate the minimum and maximum Brinell hardness, to which the symbol of the grade is related and the corresponding reference relevant wall thickness range limits.

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.

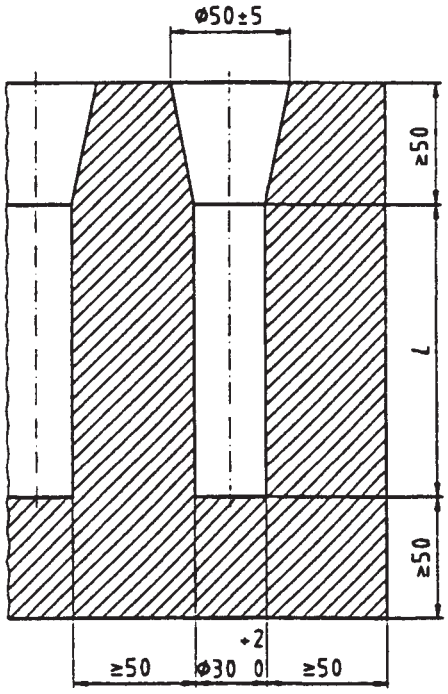
8.2 Tensile test

8.2.1 Separately cast samples

The separately cast samples to establish the material grade shall be cast vertically (see figure 1). The moulds shall be either sand moulds or moulds with comparable thermal diffusivity. The moulds may be made for casting several samples simultaneously.

The length L 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.



All dimensions are given 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 stripped from the mould at a temperature not exceeding 500 °C.

NOTE: However, the samples may by agreement between the manufacturer and the purchaser be taken from their moulds at a temperature in excess of 500 °C, if the castings are also to be removed at this 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.

NOTE 1: 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 less than 80 mm wall thickness and the large size set is used for castings equal to or greater than 80 mm wall thickness.

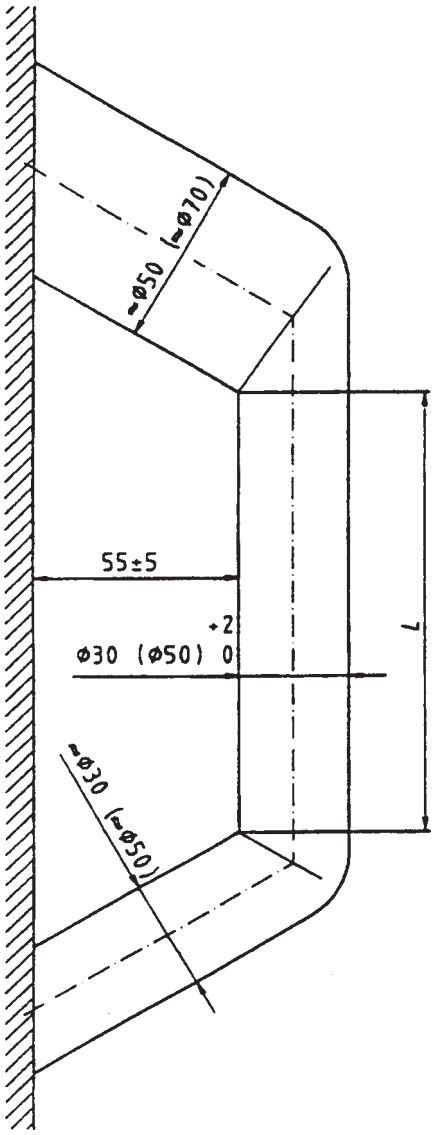
The length L shall be determined according to the length of the test piece and the clamping device.

NOTE 2: Cast-on samples should only be used when a casting is more than 20 mm thick and the mass is more than 200 kg.

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 uniform section of simple shape.

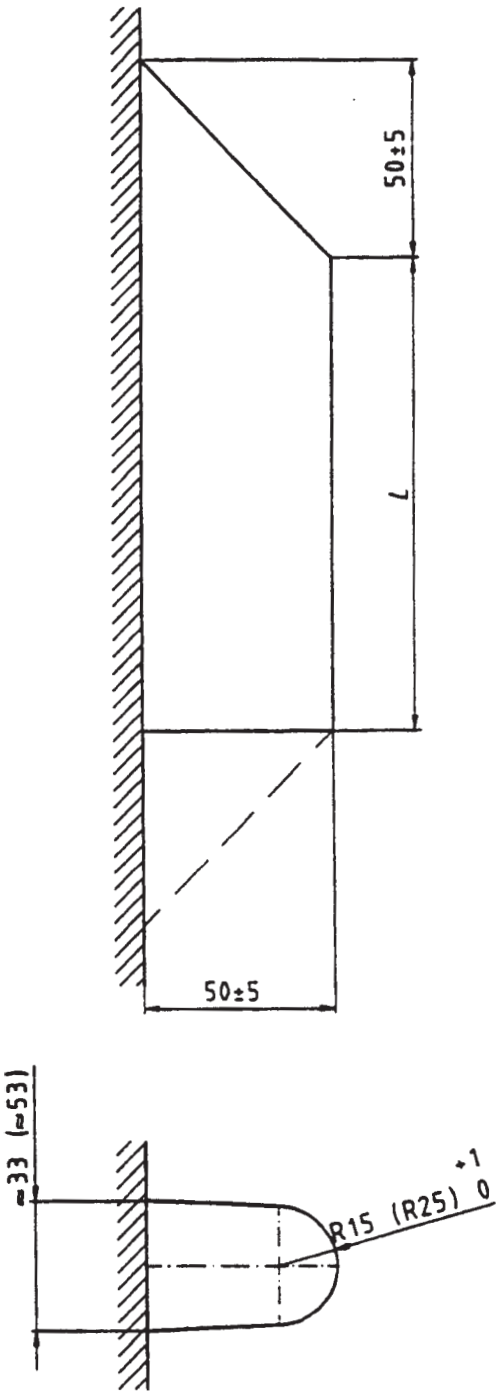
NOTE: Values obtained in castings of variable wall thickness can differ from those given in table 1.



All dimensions are given in millimetres

NOTE: For significance of figures in brackets see 8.2.2.

Figure 2: Cast-on sample: Type 1



All dimensions are given in millimetres

NOTE: For significance of figures in brackets see 8.2.2.

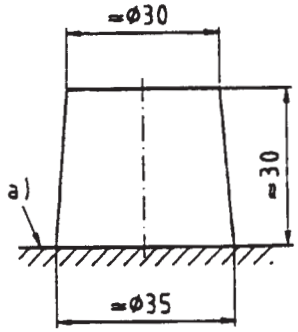
Figure 3: Cast-on sample: Type 2

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 by the time of acceptance of the order.

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.



a) surface of casting

All dimensions are given in millimetres

Figure 4: Example of a Brinell knob

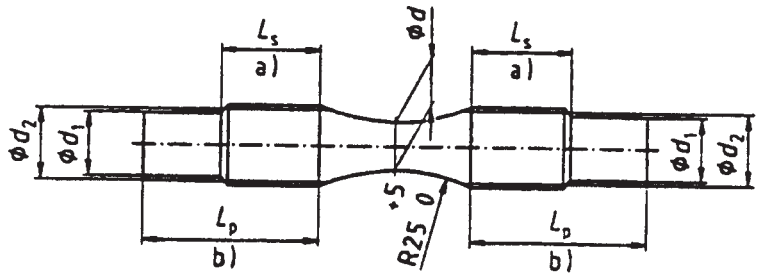
If the casting is heat-treated, the Brinell knob shall not be detached from the casting until the heat-treatment process has been concluded.

9 Test methods

9.1 Tensile test

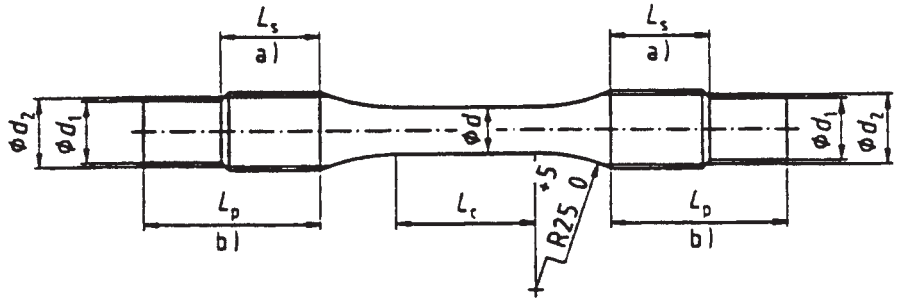
The tensile test shall be carried out in accordance with the requirements of EN 10002-1, using a test piece in conformance either with figure 5 or figure 6.

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.



a) threaded
b) plain

Figure 5: Test piece A



a) threaded
b) plain

Figure 6: Test piece B

NOTE: For the same material, the results achieved using test piece A (symbols 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 d [1)]	Thread type for threaded test pieces[2)]	Thread length L_s[2)]	Diameter d_1 for plain ends[2)]	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	**M30**	**36**	**23**	**102**	**60**
25 ±0,1	M36	44	30	119	75
32 ±0,1	M45	55	40	143	96

[1)] The cross-sectional area S_0 shall be calculated.

[2)] Recommended dimensions

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

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

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 EN 10003-1.

10 Retests

The test shall be disregarded if unacceptable results are obtained which are due not to the quality of the cast iron itself, but to any of the following reasons:

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

b) defective sample or machining of the test piece;

c) casting defects in the test piece, revealed after fracture.

In the above cases, a new test piece shall be taken from the same test unit and the results obtained substituted for those of the defective test piece.

Should the tensile test fail to meet the specified minimum tensile strength requirements, other than for the reasons given above, two retests shall be carried out.

If both retests pass, the material shall be deemed to conform to this European Standard.

If one or both retests fail to meet the specified minimum tensile strength requirement, the material shall be deemed not to conform to this European 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.

If agreed by the manufacturer and the purchaser by the time of acceptance of the order alternative test procedures may be used, for example wedge penetration test for assessment of tensile strength.

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

Characteristic	Symbol	SI-unit	Material designation[1]					Bibliographical references (see annex D)
			EN-GJL-150 (EN-JL1020)	EN-GJL-200 (EN-JL1030)	EN-GJL-250 (EN-JL1040)	EN-GJL-300 (EN-JL1050)	EN-GJL-350 (EN-JL1060)	
			Basic structure					
			ferritic/ pearlitic	pearlitic				–
Tensile strength	R_m	N/mm²	150 to 250	200 to 300	250 to 350	300 to 400	350 to 450	
0,1% proof stress	$R_{p0,1}$	N/mm²	98 to 165	130 to 195	165 to 228	195 to 260	228 to 285	[1]
Elongation	A	%	0,8 to 0,3	0,8 to 0,3	0,8 to 0,3	0,8 to 0,3	0,8 to 0,3	[2]
Compression strength	σ_{db}	N/mm²	600	720	840	960	1080	[1]
0,1% compression yield point	$\sigma_{d0,1}$	N/mm²	195	260	325	390	455	[1]
Bending strength	σ_{bB}	N/mm²	250	290	340	390	490	[1]
Shear strength	σ_{aB}	N/mm²	170	230	290	345	400	[1]
Torsional strength[2]	τ_{tB}	N/mm²	170	230	290	345	400	[1]
Modulus of elasticity[3]	E	kN/mm²	78 to 103	88 to 113	103 to 118	108 to 137	123 to 143	[1]
Poisson's ratio	ν	–	0,26	0,26	0,26	0,26	0,26	[2]
Bending fatigue strength[4]	σ_{bW}	N/mm²	70	90	120	140	145	[3]
Fatigue limit under reversed tension-compression stresses[5]	σ_{zdW}	N/mm²	40	50	60	75	85	[3]
Fracture toughness	K_{Ic}	N/mm$^{3/2}$	320	400	480	560	650	[4]

[1] When there are special requirements relating to machinability or magnetic properties, then EN-GJL-**100** (EN-JL1010) is used. The required properties can be obtained by means of a structure-changing heat-treatment process. EN-GJL-**100** (EN-JL1010) is not cited here.
[2] Torsional fatigue strength $\tau_{tW} \approx 0{,}42 \times R_m$ [3]
[3] Depends on the quantity and form of the graphite as well as on the loading.
[4] The following approximately applies: $\sigma_{bW} \approx 0{,}35 - 0{,}50 \times R_m$ [3].
[5] The following approximately applies: $\sigma_{zdW} \approx 0{,}53 \times \sigma_{bW} \approx 0{,}26 \times R_m$ [3].
NOTE: 1 N/mm² is equivalent to 1 MPa.

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

Characteristic	Symbol	SI-unit	Material designation[1]					Bibliographical references (see annex D)
			EN-GJL-**150** (EN-JL1020)	EN-GJL-**200** (EN-JL1030)	EN-GJL-**250** (EN-JL1040)	EN-GJL-**300** (EN-JL1050)	EN-GJL-**350** (EN-JL1060)	
Density	ϱ	g/cm^3	7,10	7,15	7,20	7,25	7,30	–
Specific heat capacity	c	J/(kg · K)						
between 20 °C and 200 °C					460			[5]
between 20 °C and 600 °C					535			
Linear expansion coefficient	α	μm/(m · K)						
between −100 °C and +20 °C					10,0			[5]
between 20 °C and 200 °C					11,7			
between 20 °C and 400 °C					13,0			
Thermal conductivity	λ	W/(m · K)						
at 100 °C			52,5	50,0	48,5	47,5	45,5	[5]
at 200 °C			51,0	49,0	47,5	46,0	44,5	
at 300 °C			50,0	48,0	46,5	45,0	43,5	
at 400 °C			49,0	47,0	45,0	44,0	42,0	
at 500 °C			48,5	46,0	44,5	43,0	41,5	
Resistivity	ϱ	$\Omega \cdot mm^2/m$	0,80	0,77	0,73	0,70	0,67	[5]
Coercivity	H_c	A/m	560 to 720					[5] [6]
Maximum permeability	μ	μH/m	220 to 330					[5] [6]
Hysteresis losses at B = 1 T		J/m^3	2 500 to 3 000					[5] [6]

[1]) When there are special requirements relating to machinability or magnetic properties, then EN-GJL-**100** (EN-JL1010) is used. The required properties can be obtained by means of a structure-changing heat-treatment process. EN-GJL-**100** (EN-JL1010) is not cited here.

Annex B (informative)

Additional information on the relationship between hardness and tensile strength

Hardness and tensile strength as well as Young's modulus 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 [7] to [9] (see annex D). The following empirical relationship between hardness and tensile strength exists:

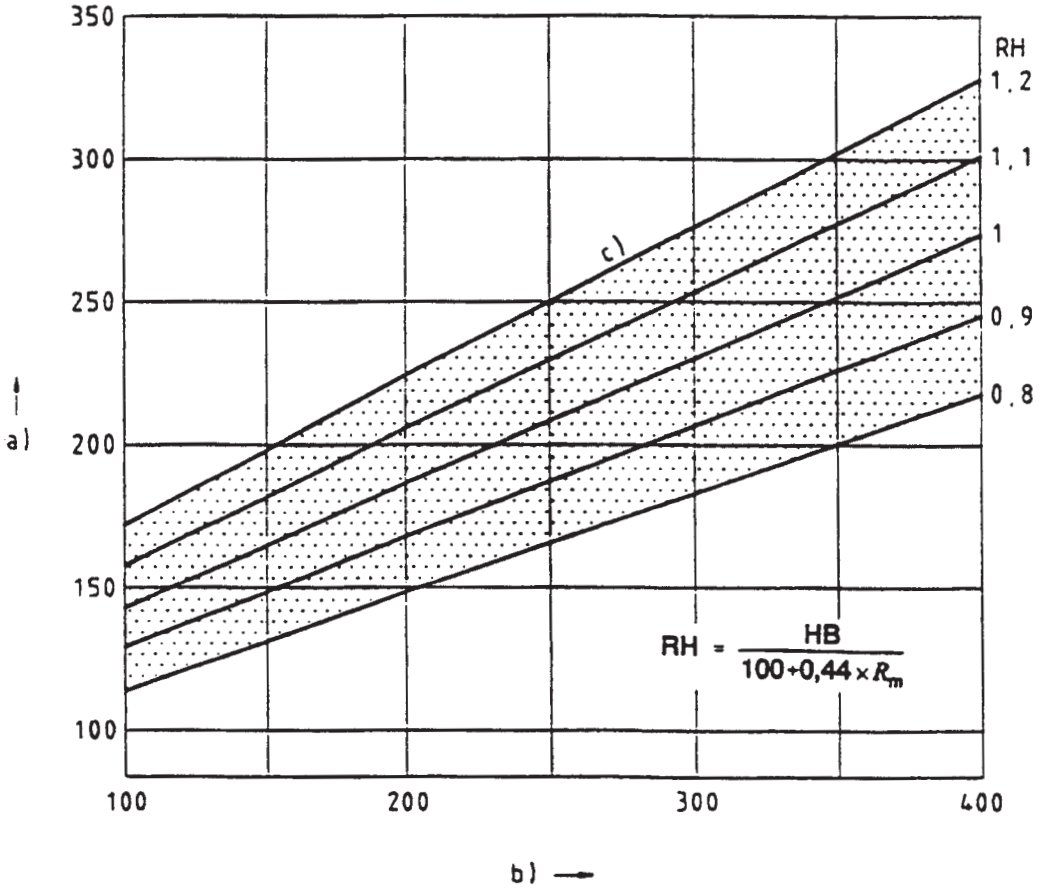
$$HB = RH \times (A + B \times R_m)$$

Commonly accepted values for the constants are:

$$A = 100,\ B = 0{,}44$$ [10], [11]

The factor RH is called relative hardness. This parameter has been found to vary between 0,8 and 1,2. Because of the variation in relative hardness it is difficult to give definitive limits in a standard for both tensile strength and hardness (see figure B.1). More details concerning RH are discussed in literature [10] to [17] (see annex D).

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. The manufacturer can therefore indicate both hardness and the corresponding tensile strength.



a) Brinell hardness, HB
b) Tensile strength R_m, N/mm^2
c) Relative hardness, RH

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

Figure B.1: Relationship between Brinell hardness and tensile strength of grey cast iron

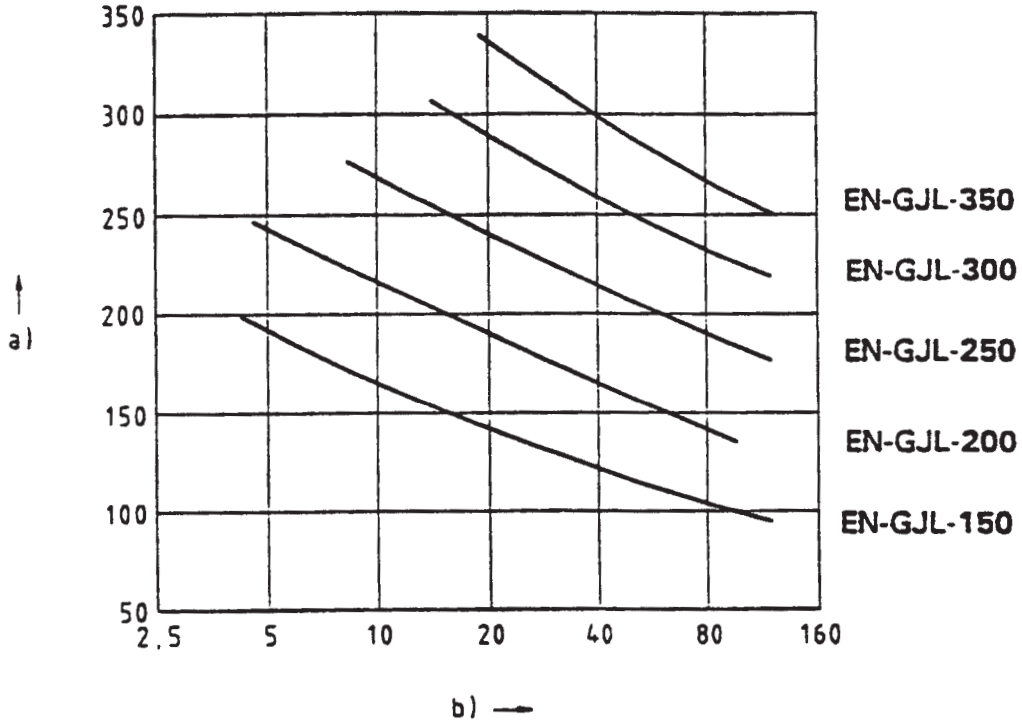
Annex C (informative)

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.

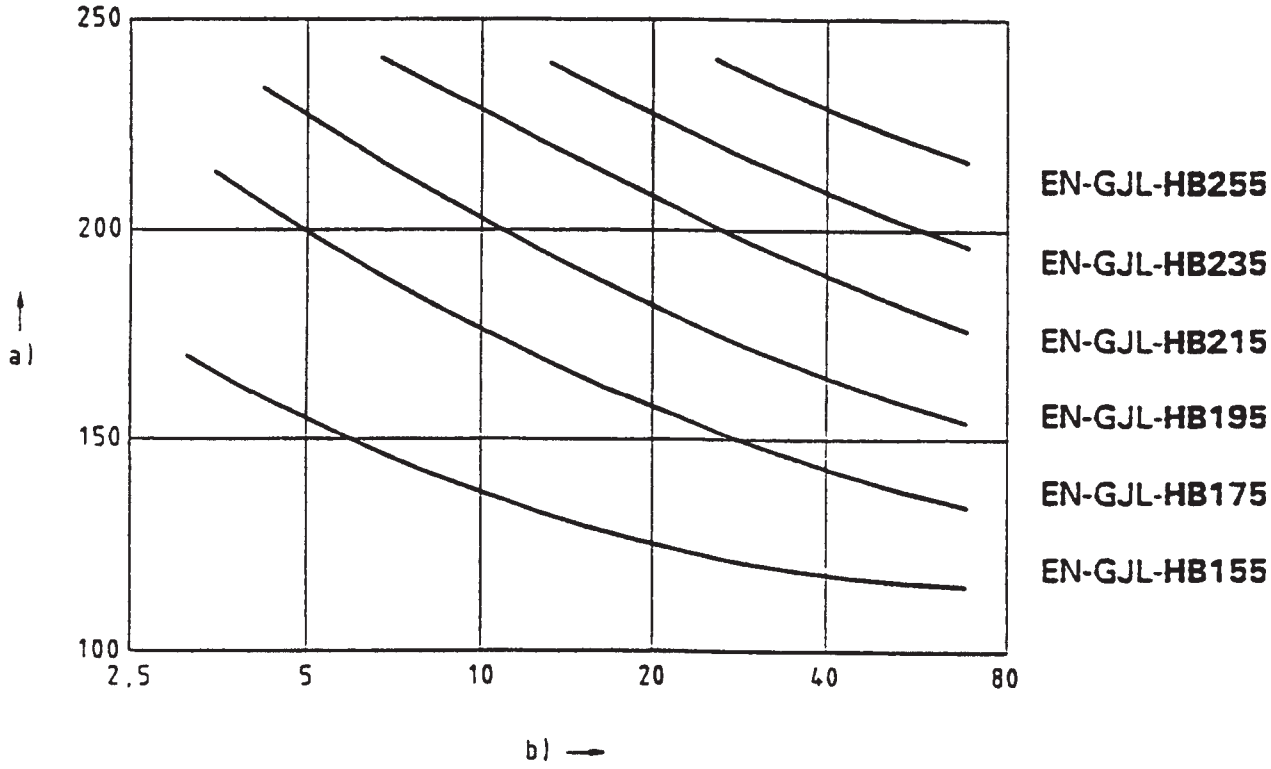
This illustrates the importance of reaching an agreement between the manufacturer and the purchaser on the specification of the hardness required in castings and also the location where a hardness test should be carried out.



a) Tensile strength R_m, N/mm^2
b) Relevant wall thickness, mm

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



a) Brinell hardness HB 30
b) Relevant wall thickness, mm

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

Annex D (informative)

Bibliography

In the preparation of this European Standard, use was made of a number of documents for reference purposes. These informative references are cited at the appropriate places in the text and the publications are listed hereafter.

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