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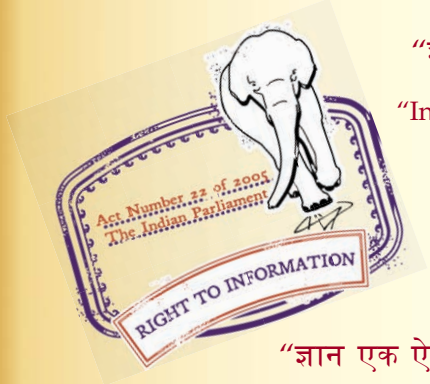
IS 210 (2009): Grey Iron Castings [MTD 6: Pig iron and Cast Iron]



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"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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IS 210 : 2009
(Superseding IS 6331 : 1987)

भारतीय मानक

भूरे लोहे की ढलाईयाँ — विशिष्टि

(पाचवाँ पुनरीक्षण)

Indian Standard

GREY IRON CASTINGS — SPECIFICATION

(Fifth Revision)

ICS 77.080.10

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

July 2009

Price Group 5

Pig Iron and Cast Iron Sectional Committee, MTD 6

FOREWORD

This Indian Standard (Fifth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Pig Iron and Cast Iron Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1950 and subsequently revised in 1962, 1970, 1978 and 1993. The Pig Iron and Cast Iron Sectional Committee decided to revise IS 210 by merging it with IS 6331 : 1987. After publication of this standard, IS 6331 : 1987 will be withdrawn.

The various diameters of test bars according to the section size of the castings have been replaced by a single size of test bar. Guidelines on the effect of section size of the casting on the tensile strength are, however, given in Annex A. A comparison between grades is given in Annex B.

The production of castings in the higher grades of grey cast iron often involves special techniques. It is recommended, therefore, that for either large or intricate castings or a casting involving both these conditions, or where the castings have to withstand exceptional conditions, the grade of grey cast iron selected and any heat treatment involved should be agreed between the manufacturer and the purchaser. The higher grades of grey cast iron (that is, Grades FG 300, FG 350 and FG 400) present special difficulties for section 10 mm and thinner.

For the benefit of the purchaser, typical properties of grey cast iron have been added in Annex C.

Information to be supplied by the purchaser while ordering grey iron castings according to this specification is given in Annex D.

In the formulation of this standard assistance has been derived from ISO 185 : 2005 'Grey cast irons — Classification', issued by the International Organization for Standardization.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GREY IRON CASTINGS — SPECIFICATION

(Fifth Revision)

1 SCOPE

This standard covers the requirements for grey iron castings.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1387 : 1993	General requirements for the supply of metallurgical material (*second revision*)
1500 : 2005/ ISO 6506-1 : 1999	Method for Brinell hardness test for metallic materials (*third revision*)
1608 : 2005/ ISO 6892 : 1998	Metallic materials — Tensile testing at ambient temperature (*third revision*)
4843 : 1968	Code for designation of ferrous castings
5139 : 1969	Recommended procedure for repair of grey iron castings by oxyacetylene and manual metal arc welding
5519 : 1979	Deviations for untoleranced dimensions of grey iron castings (*first revision*)
7754 : 1975	Method for designation of microstructure of graphite in cast iron
13655 : 1993	Guidelines for heat treatment of cast iron

3 SUPPLY OF MATERIAL

General requirements relating to the supply of grey iron castings shall be as laid down in IS 1387.

4 GRADES

There shall be seven grades of grey iron castings namely, grades FG 150, FG 200, FG 220, FG 260, FG 300, FG 350 and FG 400. The designation system for grey cast iron is given in IS 4843.

5 MANUFACTURE

The castings shall be made by any process, as agreed between the supplier and the purchaser, that will produce castings complying with the requirements of this standard and shall be in accordance with the pattern or working drawing as supplied by the purchaser.

6 CHEMICAL COMPOSITION

6.1 The composition of cast iron shall be left to the discretion of the manufacturer, but a maximum limit for phosphorus and/or sulphur may be specified by the purchaser, if he so desires.

6.2 In case of special castings, the detailed chemical composition shall be as agreed to between the purchaser and the manufacturer.

7 WORKMANSHIP AND FINISH

7.1 The castings shall be accurately moulded in accordance with the pattern or working drawings supplied by the purchaser, with the addition of such letters, figures or marks as may be specified.

7.2 The purchaser shall specify tolerances, machining location and allowances with reference to all important dimensions. On other dimensions tolerances specified in IS 5519 shall apply.

8 HEAT TREATMENT

Castings are generally supplied without having any heat treatment. However, if required by the purchaser, the heat treatment may be carried out in accordance with 2 of IS 13655.

9 MICROSTRUCTURE

Where so required, the microstructure of grey iron castings and the location for taking the sample shall be as agreed to between the purchaser and the manufacturer.

9.1 Unless otherwise specified, the microstructure shall be substantially free of primary cementite and/or massive steadite and shall consist of flake graphite in a matrix of ferrite or pearlite or mixture thereof.

9.1.1 Unless otherwise specified, the graphite structure shall be primarily Distribution A in accordance with IS 7754.

10 FREEDOM FROM DEFECTS

10.1 The castings shall be sound, clean and free from porosity, blow holes, hard spots, cracks, hot tears, coldshuts, distortion, sand and slag inclusions and other harmful defects. They shall be well-dressed and fettled, and shall be readily machinable.

10.2 No welding or repairs shall be carried out without the prior permission of the purchaser. Welding referred to here includes fusion welding in accordance with the common foundry practice. The method of repair by welding (*see* IS 5139) and subsequent stress-relieving shall be as agreed to between the purchaser and the manufacturer.

11 PROVISION OF TEST BARS

11.1 All test bars shall be cast separately in sand moulds and the number of test bars required shall be as specified in 11.2. They shall be cast at the same time and from the same melt as the castings they represent.

11.2 The test bar material shall be identifiable with that of the castings represented.

11.3 When castings are subjected to heat treatment, the test bars shall be heat-treated together with the castings they represent.

11.4 The test bars shall be cast in dried, baked or chemically bonded moulds made mainly of an aggregate of siliceous sand with appropriate binders. The average grain size of the sand shall be approximate to that of the sand in which the castings are poured. Moulds for the test bars shall be approximately at room temperature when poured. More than one test bar may be cast in a single mould, but each bar in the mould shall be surrounded by a thickness of sand which is not less than the diameter of the bar.

12 FREQUENCY OF TESTING

12.1 The number of tests required for each melt or batch of castings shall be as laid down in Table 1, various classes of castings being divided into five representative groups according to mass.

12.2 In the case of large tonnage of castings being produced continuously, the minimum number of test bars to be provided shall be one tensile test representing every two hours of production from melting furnace.

13 SIZE OF TEST BARS

A test bar from which the tensile test piece is machined shall be cast as a uniform cylindrical bar of 30 mm diameter. The tolerance on the diameter shall be $+\frac{2}{0}$ mm. The minimum length of the test bar shall be 230 mm.

14 TENSILE TEST

The tensile test shall be carried out in accordance with IS 1608, using a test piece conforming to the dimensions in Fig. 1 read with Table 2. The test piece shall be accurately machined, with a good surface finish. The transition between the ends and the parallel length shall be smooth, without undercutting or a sudden step down in diameter.

NOTE — Self-aligning grips are recommended to ensure axial loading.

Table 1 Number of Tests
(*Clause* 12.1)

Group	Mass of Individual Castings	Test Requirements
(1)	(2)	(3)
1[1]	Up to 12.5 kg	One test for each of 5 kg of castings or part thereof
2[1]	Over 12.5 kg and up to 50 kg	One test for every 1 tonne of castings or part thereof
3[1]	Over 50 kg and up to 500 kg	One test for every 2 tonnes of castings or part thereof
4[1]	Over 500 kg and up to 1 tonne	One test for every 3 tonnes of castings or part thereof
5	Over 1 tonne	One test for every 4 tonnes of castings or part thereof or one test for every casting weighing 4 tonnes or more

[1] In addition Groups 1, 2, 3 and 4 all castings represented by one test shall be poured from the same ladle or same heat as the bar or bars provide for the test.

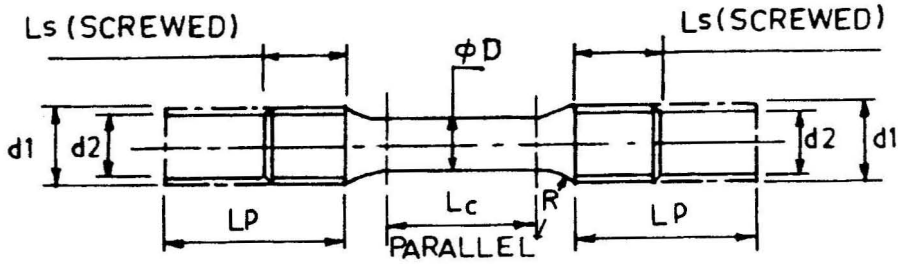


FIG. 1 MACHINED TENSILE TEST PIECE

Table 2 Dimensions of Machined Tensile Test Piece
(*Clause* 14)

All dimensions in millimetres.

Gauge Diameter *D*	Machining Tolerance for the Gauge Diameter	Minimum Parallel Length	Minimum Radius	Plain Ends		Screwed Ends	
				Minimum Diameter	Minimum Length	Minimum Dia at Root	Minimum Length
		L_c	R	d_1	L_p	d_2	L_s
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
20	± 0.5	55	25	23	65	25	30

NOTE — With screwed-ends, any form of thread may be used provided that the diameter at the root of the thread is not less than that specified.

15 TENSILE STRENGTH

When tested in accordance with the requirements of **14** the test piece shall comply with the minimum requirements specified in Table 3. The tensile strength specified is that obtained from test bars cast separately from the castings to which they refer. The test values represent, therefore, only the quality of the metal from which the castings have been poured.

16 HARDNESS TEST

16.1 The Brinell hardness test shall be carried out in accordance with the method given in IS 1500. Brineil hardness values for different grades of grey iron castings shall be as specified in Table 3.

Table 3 Mechanical Test Requirements
(*Clauses* 15 *and* 16.1)

Grade (*see* IS 4843)	Tensile Strength *Min* MPa (N/mm²)	Brinell Hardness HBW
(1)	(2)	(3)
FG 150	150	130 to 180
FG 200	200	160 to 220
FG 220	220	180 to 220
FG 260	260	180 to 230
FG 300	300	180 to 230
FG 350	350	207 to 241
FG 400	400	207 to 270

NOTE — Although mechanical properties are specified for Grade FG 150 the material shall be only tested if required by the purchaser.

16.1.1 The hardness test shall be conducted at specific point on the castings. This specific point shall be such that they are amendable for hardness checking to routine procedure and shall be as agreed to between the purchaser and the manufacturer.

17 TRANSVERSE TEST

If required, the transverse test may be carried out by the manufacturer in accordance with the method given in Annex E. The minimum test requirements shall be agreed upon at the time of enquiry and order.

18 HYDROSTATIC TEST

If specified at the time of enquiry and order the castings may be tested for the hydrostatic test pressure. The requirements for the test pressure shall be mutually agreed to between the purchaser and the manufacturer.

19 RETESTS

19.1 If on being tested any test piece shows obvious signs of a casting defect, the results of the test may be discarded and a further test be made.

19.2 If any sound test piece fails, two further tests shall be made, should either of these test pieces fail.

the castings represented shall not comply with the requirements of this standard.

19.3 In the absence of further separately cast test bars, the manufacturer shall have the option of submitting test bars, sectioned from an agreed position in the castings. The requirements of the test shall be as agreed to between the purchaser and the manufacturer. However, the guidance may be obtained from Annex A.

20 INSPECTION

By agreement with the manufacturer, the purchaser or his representative shall have access at all reasonable times to those parts of the manufacturer's works engaged on his order, he shall be at liberty to inspect the manufacturer at any stage, to witness the required tests and to reject any material that does not comply with this standard. When the castings are to be inspected during manufacture and tested in the presence of the purchaser's representative, this shall be stated in the enquiry and order.

21 MARKING

21.1 Each casting, if feasible, shall be legibly marked with a number of identification marks which it can be traced to the melt, and the batch of heat treatment, if done, from which it was made.

21.2 By agreement between the purchaser and the manufacturer, castings complying with the requirements of this standard shall be, after inspection, legibly marked with an acceptance mark.

21.3 BIS Certification Marking

The castings may also be marked with the Standard Mark.

21.3.1 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made threrunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Foreword*, and *Clause* 19.3)

APPROXIMATE VARIATION OF STRENGTH

A-1 The Indian Standard grades of grey cast iron are based on the minimum tensile strength obtained when metal is cast into test bars of 30 mm diameter. The strength developed by a given metal shall vary with the cooling rate in the mould higher strengths being obtained if the same metal is cast into smaller bars than 30 mm diameter and lower strengths if the metal is cast into bars larger than 30 mm diameter. Similarly, the cooling rate of a flat plate is slower than that of a bar whose diameter is equal to the thickness of the plate so that the strength developed in the plate will be lower than that developed in the bar.

A-1.1 The cooling rate of a casting in a mould (hence the strength developed in any particular section thickness by the metal employed for its manufacture) is influenced also by the presence of cores, changes in section thickness, the pressure of bosses projection and intersection, such as the junctions of ribs and bosses. Thus, in castings of other than simple shape and uniform thickness the cooling rate of any part can be expected to differ from that of a flat plate of similar section thickness.

A-2 Figure 2 gives a guide to the likely variation in tensile strength in different sections when a given grade of grey iron is cast into a casting of simple shape and uniform thickness or containing cored holed where the cooling rate in the mould of a given section shall differ from that in a casting of sample shape and uniform thickness, the diagram provides only an approximate guide to the likely tensile strength in different sections and design should be based on the measured tensile strength in critical parts of the casting.

A-2.1 Table 4 gives guidance to the likely variation in tensile strength for different casting section thicknesses when a given grade of grey cast iron is cast into a casting of simple shape and uniform thickness. For casting of non-uniform section or castings containing cored holes, the table provides 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.

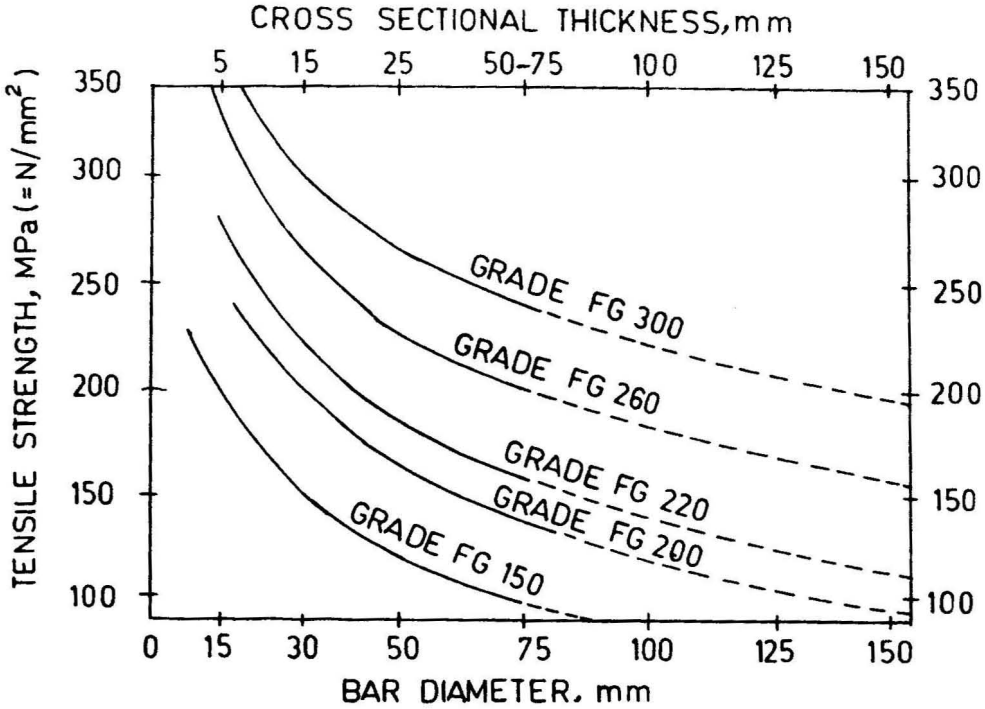


FIG. 2 VARIATION OF TENSILE STRENGTH WITH CROSS-SECTIONAL THICKNESS OF GREY IRON CASTINGS

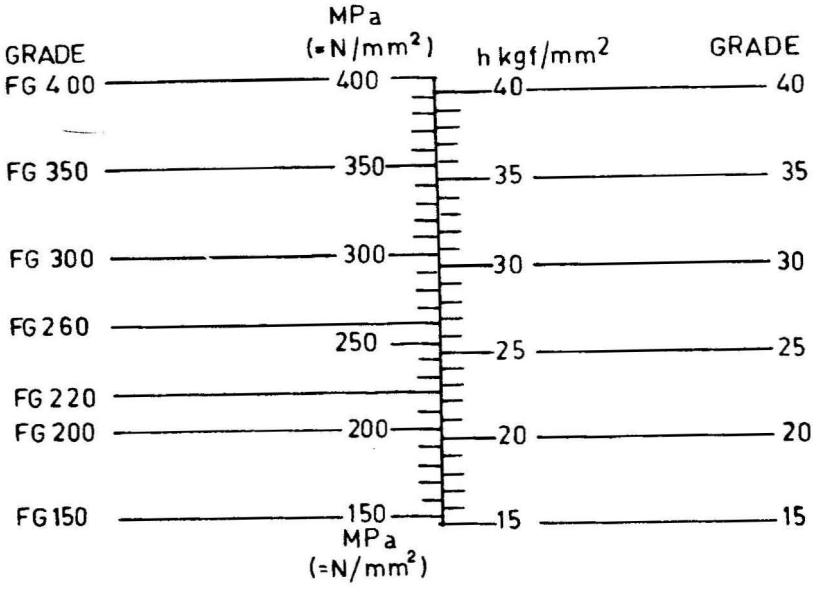
Table 4 Anticipated Tensile Properties for the Castings
(For Information Only)
(*Clause* A-2.1)

Grade	Casting Section Thickness mm		Anticipated Tensile Strength MPa (N/mm²)
	Over	Up to and Including	
(1)	(2)	(3)	(4)
FG 150	2.5	10	155
	10	20	130
	20	30	115
	30	50	105
FG 200	2.5	10	205
	10	20	180
	20	30	160
	30	50	145
FG 260	4.0	10	260
	10	20	235
	20	30	215
	30	50	195
FG 300	10	20	270
	20	30	245
	30	50	225
FG 350	10	20	315
	20	30	290
	30	50	270

ANNEX B

(Foreword)

COMPARISON BETWEEN GRADES



CONVERSION FACTOR 1 N/mm^2 = 1 MPa = 0·1020 kgf/mm^2

FIG. 3 COMPARISON BETWEEN GRADES IN THIS EDITION AND THE PREVIOUS EDITION BASED ON MINIMUM TENSILE STRENGTH

ANNEX C

(Foreword)

TYPICAL PROPERTIES OF GREY CAST IRON

The following information is given for the guidance of engineers and designers. It does not form part of the standard and should not be used for acceptance purposes:

Properties	*Unit*	*Grades*						
		FG 150	FG 200	FG 220	FG 260	FG 300	FG 350	FG 400
Tensile strength	MPa (N/mm^2)	150	200	220	260	300	350	400
0.01 percent proof stress	MPa (N/mm^2)	42	56	62	73	84	98	112
0.1 percent proof stress	MPa (N/mm^2)	98	130	143	169	195	228	260
Total strain at failure	Percent	0.60-0.75[1)]	0.48-0.67[1)]	0.39-0.63[1)]	0.57	0.50	0.50	0.50
Elastic strain at failure	Percent	0.15	0.17	0.18	0.20	0.22	0.25	0.28
Total minus elastic strain at failure	Percent	0.45-0.60[1)]	0.31-0.50[1)]	0.21-0.45[1)]	0.37	0.28	0.25	0.28
Notched tensile strength 320 (*see* Note 2) (Circumferential 45° V-notch, root	MPa (N/mm^2)			120	160	176	208	240 280

Properties	*Unit*	*Grades*						
		FG 150	FG 200	FG 220	FG 260	FG 300	FG 350	FG 400
radius 0.25 mm or notch depth 2.5 mm, notch dia 20 mm or notch depth 3.3 mm, notch diameter 7.6 mm)								
Circumferential notch, radius 9.5 mm (notch depth 2.5 mm, notch diameter 20 mm)	MPa (N/mm^2)	150	200	220	260	300	350	400
Compressive strength	MPa (N/mm^2)	600	720	768	864	960	1 080	1 200
0.01 percent proof stress	MPa (N/mm^2)	84	112	128	146	168	196	224
0.1 percent proof stress	MPa (N/mm^2)	195	260	286	338	390	455	520
Shear strength	MPa (N/mm^2)	173	230	253	299	345	403	460
Torsional strength	MPa (N/mm^2)	173	230	253	299	345	403	460
Shear strain at failure	Percent	>4	>4	>4	>4	Up to 4	Up to 4	Up to 4
Modulus of elasticity:								
Tension	GPa	100	114	120	128	135	140	145
Compression	GPa	100	114	120	128	135	140	145
Modulus of rigidity	GPa	40	46	48	51	54	56	58
Poisson's ratio	—	← 0.26 →						
Fatigue limit (Wohler):								
Unnotched (8.4 mm) dia	MPa (N/mm^2)	68	90	99	117	135	149	152
V-notched (Circumferential 45° V-notch with 0.25 mm root radius, Diameter at notch 8.4 mm depth of notch 3.4 mm)	MPa (N/mm^2)	68	87	94	108	122	129	127
Coefficient of thermal expression:								
–100°C to 20°C	$X10^{-6}/K$	← 10.0 (*see* Note 3) →						
20°C to 200°C	$X10^{-6}/K$	← 11.0 (*see* Note 3) →						
20°C to 400°C	$X10^{-6}/K$	← 12.5 (*see* Note 3) →						
Thermal conductivity:								
100°C	W/(mk)	52.5	50.8	50.1	48.8	47.4	45.7	44.0
200°C	W/(mk)	51.5	49.8	49.1	47.8	46.4	44.7	43.0
300°C	W/(mk)	50.5	48.8	48.1	46.8	45.4	43.7	42.0
400°C	W/(mk)	49.5	47.8	47.1	45.8	44.4	42.7	41.0
500°C	W/(mk)	48.5	46.8	46.1	44.8	43.4	41.7	40.0

Properties	*Unit*	*Grades*						
		FG 150	FG 200	FG 220	FG 260	FG 300	FG 350	FG
Specific heat capacity:								
20°C to 200°C	J/kgK	265	375	420	460	460	460	460
20°C to 300°C	J/kgK	355	435	455	495	495	495	495
20°C to 400°C	J/kgK	400	465	465	505	505	505	505
20°C to 500°C	J/kgK	425	480	475	515	515	515	515
20°C to 600°C	J/kgK	445	500	495	535	535	535	535
20°C to 700°C	J/kgK	490	555	560	605	605	605	605
Relative density:	(kg/dm^3)	7.05	7.10	7.15	7.20	7.25	7.30	7.30
Magnetic and electrical properties								
Maximum magnetic permeability	μH/m	← 301 to 380 →						
Remnant magnetism	T	← 0.4 to 0.5 →						
Coercive force	A/m	← 560 to 720 →						
Hysteresis loss	J/m^2	← 2 500 to 3 000 →						
at 50 Hz	W/kg	← 17.6 to 20.9 →						
Electrical resistivity	μΩ/m	0.800	0.770	0.760	0.730	0.700	0.670	0.640

NOTES

1 The typical properties given in this Annex are the properties in 30 mm diameter separately cast test bar or in a casting section correctly represented by this size of test bar where the tensile strength does not correspond to that given, other properties may differ slightly from those given.

2 Notched tensile strengths increase slightly as notch severity ratio, notch radius, notch diameter, increase above 0.47.

3 The values quoted for coefficient of thermal expansion of grade FG 400 are for material in pearlitic iron, where accicular iron is used for this grade appropriate values are:

20°C to 200°C 15.0×10^{-6}/K
20°C to 400°C 16.5×10^{-6}/K

[1] Values depend on the composition of iron.

ANNEX D
(Foreword)

INFORMATION TO BE SUPPLIED BY THE PURCHASER

D-1 BASIS FOR ORDER

While placing an order for the purchase of grey iron casting covered by this standard, the purchaser should specify the following:

a) Material specification;

b) Any required limits on the sulphur and phosphorus content;

c) Drawing or reference number of the pattern (if supplied by the purchaser) along with a copy of the drawing;

d) Test required;

e) Whether the castings are to be inspected and tested in the presence of the purchaser's representative;

f) Condition of delivery;

g) Any special requirement of the purchaser, for example, hardness tests and locations of non-destructive testing, quality assurance, etc; and

h) Test reports, if required.

ANNEX E
(*Clause* 17)

TRANSVERSE TEST FOR GREY CAST IRON

E-1 OBJECT OF THE TEST

The object of this test is to determine the transverse bending strength of grey cast iron by applying constantly increasing single load at the centre of a test bar arranged as a beam between two supports until fracture occurs.

E-2 TEST BARS

E-2.1 The cast test bar shall have the dimensions given in Table 5.

E-2.2 Test bar is normally tested unmachined. The surface of the test bar shall be free from unevenness and seams which may be removed by careful grinding. The diameter shall be measured at the centre of the test bar in two directions perpendicular to one-another. The difference between two measurements shall not exceed 5 percent of the normal diameter. The mean value of the two diameters shall be the diameter d_o (*see* **E-4**) of the test bar. For its permissible variations from the nominal diameter and the accuracy of measurement of the diameter, the values indicated in Tables 5 and 6 shall apply.

E-3 PROCEDURE

E-3.1 Place the two ends of the test bar on horizontal supports. The support and the point of application of the load shall be rounded to a radius of 5 to 20 mm. Apply a single load vertically at the centre of the bar (*see* Fig. 4).

E-3.2 Increase the load uniformly without shock until the bar fracture. The load should be applied in such a way that the increase of stress does not exceed 3 MPa/s. Find out the load at the fracture of the test bar with the accuracy indicated in Table 6.

E-3.3 Determine the deflection of the test bar from the motion of the thrust relative to the fixed supports or to the supporting table of the machine. In order to eliminate any errors in measuring the deflection, the measurement should be stated after applying a small preload as given in Table 6.

E-4 TEST RESULT

The test report shall include:

a) load at fracture in N;

b) bending strength f_b, to an accuracy of 0.5 MPa calculated from the formula:

$$f_b = \frac{8PL_s}{\pi d_o^3}$$

where

P = maximum load at fracture in N,

L_s = distance between centres of supports in mm, and

d_o = mean diameter in mm, and

c) deflection at fracture in mm.

Table 5 Dimensions of Transverse Test Bars
(*Clauses* E-2.1 *and* E-2.2)

All dimensions in millimetres.

Diameter of the Cast Test Bar	Permissible Variation from Nominal Diameter		Length (L) *Min*
	Unmachined	Machined	
(1)	(2)	(3)	(4)
30	±1.2	±0.2	500

Table 6 Testing Conditions and Accuracy of Readings
(*Clauses* E-2.2, E-3.2 *and* E-3.3)

Nominal Diameter d	Distance Between Centre of Supports L_s	Accuracy of Readings			Pre-load Approx
		Diameter of Bar d	Load P, *Max*	Deflection at Fracture	
mm	mm	mm	N	mm	N
(1)	(2)	(3)	(4)	(5)	(6)
30	450	0.1	100	0.2	200 to 400

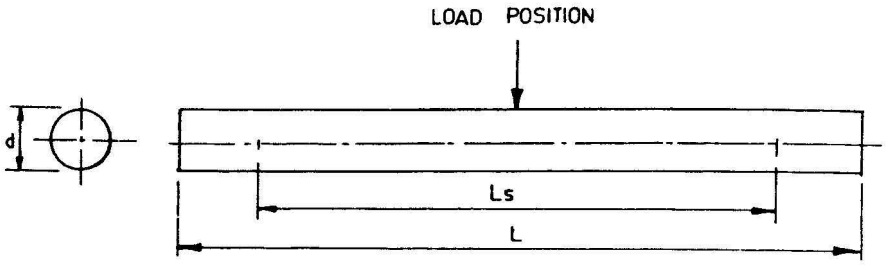


FIG. 4 TRANSVERSE TEST BAR OF GREY CAST IRON

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Bureau of Indian Standards

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices: *Telephones*

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002 — 2323 7617, 2323 3841

Eastern : 1/14, C.I.T. Scheme VII M, V.I.P. Road, Kankurgachi, KOLKATA 700054 — 2337 8499, 2337 8561, 2337 8626, 2337 9120

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Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113 — 2254 1216, 2254 1442, 2254 2519, 2254 2315

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