INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	Unit	Symbol
Mass	metre	m
Time	kilogram	kg
Electric current	second	s
Thermodynamic temperature	ampere	A
Luminous intensity	kelvin	K
Amount of substance	candela	cd
	mole	mol

Supplementary Units

Quantity	Unit	Symbol
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	Unit	Symbol	Conversion
Force	newton	N	1 N = 1 kg.1 m/s²
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m²
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Pressure, stress	pascal	Pa	1 Pa = 1 N/m²

INDIAN STANDARDS INSTITUTION

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SPECIFICATION FOR WHITEHEART MALLEABLE IRON CASTINGS

(First Revision)

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INDIAN STANDARDS INSTITUTION

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NEW DELHI 110002

Price Rs 6·00

May 1977

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Indian Standard

SPECIFICATION FOR WHITEHEART MALLEABLE IRON CASTINGS

(First Revision)

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(*Continued on page* 2)

(Continued from page 1)

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Indian Standard

SPECIFICATION FOR WHITEHEART MALLEABLE IRON CASTINGS

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 31 January 1977, after the draft finalized by the Cast Iron and Malleable Cast Iron Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Malleable iron is a cast iron-carbon alloy, which solidifies in the as-cast condition in graphite free structure, that is, the total carbon content is present in its combined form as cementite (Fe_3C). The properties of the material are obtained by heat treatment.

0.2.1 Malleable iron castings may be either whiteheart, blackheart or pearlitic, according to the chemical composition, temperature and time cycle of annealing process, and properties resulting therefrom.

0.2.2 Whiteheart malleable iron castings obtained after annealing in a decarburizing atmosphere have a silvery-grey fracture with a heart darkgrey to black. The microstructure developed in a section depends on the size of the section. In castings of small sections, it is mainly ferritic with certain amount of pearlite. In large sections, microstructure varies from the surface to the core as follows:

Core Zone: Pearlite (+ ferrite) + temper carbon

Intermediate Zone: Pearlite + ferrite + temper carbon

Surface Zone: Ferrite

0.3 The revision of this standard has been considered necessary in view of the improved production facilities available in the country. In this revision hardness value is indicated for guidance only. The bend test has been eliminated as it is no longer considered a requirement of the finished product.

0.4 This standard keeps in view the quality and availability of indigenous raw materials and the manufacturing and trade practices followed in the country in this field. Furthermore, due weightage has also been given to the need for international co-ordination among standards prevailing in different countries of the world in this field.

0.5 An appendix A has been incorporated giving the typical properties of whiteheart malleable iron castings for the guidance of the engineers.

0.6 This standard contains clauses **6.1**, **9.1**, **11.2**, **13.4**, **14.1** and **15.2** which require the purchaser to specify his requirements, if necessary, while placing an order.

0.7 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*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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1. SCOPE

1.1 This standard covers the requirements for whiteheart malleable iron castings.

2. GRADES

2.1 This standard covers two grades of whiteheart malleable iron castings, namely, WM410 and WM340.

2.2 Grades are designated on the basis of minimum tensile strength in N/mm^2. Grade WM410, denotes whiteheart malleable iron casting with 410 N/mm^2 as minimum tensile strength.

3. SUPPLY OF MATERIAL

3.1 General requirements relating to the supply of whiteheart malleable iron castings shall be as laid down in IS : 1387-1967†.

4. MANUFACTURE

4.1 The method of manufacture and the heat treatment shall be left to the discretion of the manufacturer, provided the castings always conform to this standard.

5. CHEMICAL COMPOSITION

5.1 Phosphorus contents of all grades should not exceed 0·15 percent. (This value is for information only.) However, if the phosphorus content is required by the purchaser, it should be specified on the order, and determined in accordance with the procedure laid down in IS : 228-1959‡.

NOTE — The chemical composition of the metal is of less importance than the mechanical properties of the malleable castings. Therefore, the mechanical tests as laid down in this specification should be regarded as the main requirement.

*Rules for rounding off numerical values (*revised*).
†General requirements for supply of metallurgical materials (*first revision*).
‡Methods of chemical analysis of pig iron, cast iron and plain carbon and low alloy steels (*revised*).

6. WORKMANSHIP AND FINISH

6.1 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 and marks as may be specified.

6.2 The purchaser shall specify tolerances on all important dimensions. On other dimensions, tolerances specified in IS : 8349-1977* shall apply.

7. MICROSTRUCTURE

7.1 The material shall be free from primary graphite and shall not contain free cementite in a form detrimental to the physical properties and machinability of the castings.

8. FREEDOM FROM DEFECTS

8.1 The castings shall be sound, clean and free from porosity, blow holes, hard spots, coldshuts, distortion and other harmful defects. They shall be well-dressed and fettled, and readily machinable.

8.2 In order to ensure internal soundness, up to one percent of all castings submitted for inspection may, at the discretion of the purchaser, be rough machined or subjected to destruction test by sectioning.

9. TEST BARS

9.1 Provision of Test Bars — All test bars shall be cast separately. They shall be suitably marked so that the castings they represent should be identified.

NOTE — It is considered undesirable to cast test bars integrally with the castings. Only in special circumstances and by agreement between the purchaser and the manufacturer, such integral test bars may be provided.

9.1.1 Test bars shall be cast in green or dry sand moulds of the same material as the moulds used for the castings they represent. They shall be cast at the same time and from the same melt as the castings they represent.

9.1.2 Test bars shall in all cases undergo the malleabliring heat treatment together with the castings they represent.

9.1.3 In the event of any further heat treatment being given to the castings to meet the requirements provided under **10**, test bars shall be suitably heat-treated along with the castings they represent.

9.2 Dimensions of Test Bars

9.2.1 Tensile test bars shall be cast to the dimensions specified in Table 1. The dimensions of the shanks may be modified to suit the jaws of the testing machine.

*Deviations for untoleranced dimensions of malleable iron castings.

9.2.2 The cast tensile test bars may be dressed or cleaned and shall be tested in the unmachined condition.

9.2.3 Unless otherwise specified, the test bar sizes given in Table 1 shall correspond to thicker sections of the castings.

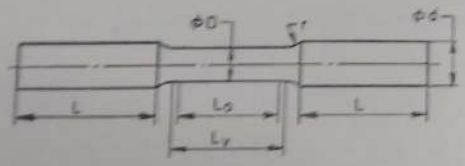
10. MECHANICAL TESTS

10.1 Tensile Test — A tensile test bar cast as far as practicable to the dimensions shown in Table 1 shall, when tested in accordance with IS : 1608-1972* without any machining of the gauge length, give results not less than those specified in Table 2. Since the test bars are in unmachined state, they may not be quite circular, in which case the tensile strength shall be calculated on the mean diameter at the middle of the gauge length by taking two measurements at right angles, one of which shall be the maximum diameter.

TABLE 1 DIMENSIONS OF TENSILE TEST BAR

(*Clauses* 9.2.3, 9.7.3 *and* 10.1)

All dimensions in millimetres.



Nominal Diameter D	Tolerance on Nominal Diameter	Shape Dimensions		Gauge Length ($L_o = 3D$)	Length L_c	Radius at Shoulder r
		Diameter d	Length L			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
9	$^{-0}_{+0.6}$	13	40	27	30	6
12	$^{-0}_{+0.7}$	16	50	36	40	8
15	$^{-0}_{+0.7}$	19	60	45	50	8

*Method for tensile testing of steel products (*first revision*).

TABLE 2 TENSILE PROPERTIES OF WHITEHEART MALLEABLE IRON CASTINGS

(*Clauses* 10.1, 15.2 *and* 16.3)

Grade Designation (as IS : 4843-1968*)	Nominal Thickness Represented, mm	Diameter of Test Bar, mm	Tensile Strength, Min, N/mm² (kgf/mm²)	0·2 Proof Stress, Min, N/mm² (kgf/mm²)	Elongation ($L_o = 5D$), Min, Percent
(1)	(2)	(3)	(4)	(5)	(6)
WM 350	8 and under	9	350 (36)	200 (20)	10
	Over 8 up to and including 15	12	350 (40)	220 (24)	6
	Over 15	15	400 (42)	230 (26)	4
WM 340	8 and under	9	270 (28)	—	5
	Over 8 up to and including 15	12	310 (32)	—	4
	Over 15	15	340 (35)	—	5

*Code for designation of ferrous castings.

10.2 Hardness Test

10.2.1 Castings produced according to different grades of this standard are expected to have Brinell hardness not greater than 220 HB. This value is for information only. However, if the hardness is required by the purchaser it shall be specified on the order and tested in accordance with IS : 1709-1961*.

11. SAMPLING

11.1 For quality control during production, use of control chart techniques is recommended to the manufacturer for which a reference is invited to IS : 397 (Part I)-1972†. The results of such tests conducted at the place of manufacture may be made available along with the material supplied, to enable the purchaser to judge its acceptability.

11.2 Sampling for Chemical Analysis — Samples for chemical analysis shall be drawn either from a finished casting or test bar for tensile test representing each heat or cast, as agreed to between the purchaser and the manufacturer.

11.3 Sampling for Tensile Tests — Three tensile test bars shall be cast for every 1 500 kg (or part of 1 500 kg) of castings of each heat or cast, and heat treated in the same batch. From each set of these test bars, one tensile test bar shall be tested. The remaining two tensile test bars shall be reserved for the purpose of retest, if necessary under **13.1** to **13.4**.

*Method for Brinell hardness test for grey cast iron.

†Method for statistical quality control during production: Part I Control chart for variables.

11.3.1 In case the tonnage of castings being produced is very large, a lesser number of test bars may be considered representative. The minimum number of test bars to be provided under these circumstances shall be one set of three tensile test bars for each two hours' production from a melting furnace, but there shall be at least one such set of test bars for each heat treatment batch.

12. VALIDITY OF TESTS

12.1 A test may be disregarded if poor results are obtained and are not due 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 test machine;

b) defective casting or machining of the test piece;

c) fracture of the tensile test piece beyond the gauge marks; and

d) casting defects in the test piece, evident after fracture.

12.1.1 In the above cases, a new test piece shall be taken from additional test bars provided under **11.3** and **11.3.1**, and the results obtained substituted for those of the defective test piece.

13. RETESTS

13.1 Should any of the tests fail to meet the specified property requirements, two retests per failed test may be carried out.

13.2 The batch is regarded as conforming to the specified requirements when the results of the two retests conform to the value shown in Table 2. However, the batch shall be rejected if one of the retests fails.

13.3 If the separately cast test bars are not available for further test then the test bars may be cut from the finished castings and the results so obtained shall be not less than 80 percent of all the minimum values specified in Table 2.

13.4 When the shape and size of the castings do not permit preparation of such test bars, if agreed to between the purchaser and the manufacturer, one or more finished castings shall be submitted to an agreed microstructure and hardness test.

14. HYDRAULIC, STEAM OR AIR PRESSURE TESTS

14.1 Where hydraulic, steam or air pressure tests are required, the tests shall be as agreed to between the purchaser and the manufacturer.

15. MARKING

15.1 Where practicable, each casting shall be legibly marked with a number or identification mark by which it may be traced to the melt and the batch of heat treatment from which it was made.

15.2 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.

15.2.1 The castings may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

APPENDIX A

(*Clause* 0.5)

TYPICAL PROPERTIES OF WHITEHEART MALLEABLE IRON

A-0. The following information is given for the guidance of engineers and designers. It is not part of this standard and should not be used for acceptance purposes.

A-1. MICROSTRUCTURE

A-1.1 The structure of whiteheart malleable iron may vary according to the thickness of the casting, the distance below the surface and the method of manufacture. Most of its properties vary in a corresponding way as outlined in this appendix. In thin sections and near the surface of thicker sections, there may be a complete absence of graphite and the matrix may contain no combined carbon whereas in thicker sections the matrix may contain combined carbon in various forms.

A-1.2 Material complying with the requirements of this standard may show a dark or a light fracture.

A-2. COMPRESSIVE STRENGTH

A-2.1 The stress/strain properties in compression are similar to those in tension. The proof stress value in compression is, however, slightly higher than in tension because the onset of plastic deformation is delayed under compressive stress.

A-3. SHEAR STRENGTH

A-3.1 This is approximately 0·9 times the tensile strength.

A-4. TORSIONAL STRENGTH

A-4.1 The torsional strength is 0·9 times the tensile strength. The proof stress value in torsion is 0·75 times the value in tension.

A-5. MODULUS OF ELASTICITY

A-5.1 A value of 175·8 kN/mm² is typical.

A-6. MODULUS OF RIGIDITY

A-6.1 A typical value is 70·3 kN/mm².

A-7. POISSON'S RATIO

A-7.1 A value of 0·26 is appropriate.

A-8. FATIGUE LIMIT (WÖHLER)

A-8.1 The unnotched fatigue limit is about 0·45 times the tensile strength. The notched fatigue limit is about 0·6 times the unnotched fatigue limit.

A-9. HARDNESS

A-9.1 With the structure variation between edge and centre of sections, the hardness depends on the distance from the surface and the section thickness. Maximum hardness values up to 229 HB may be obtained in thick sections with values down to 220 HB in thin sections or at the surface of thick sections.

A-10. IMPACT PROPERTIES

A-10.1 Because of the variable structure across a section it is not usually possible to obtain a representative impact test specimen. However, irons containing considerable quantities of ferrite, generally in thin sections, have good ductility and toughness. In higher strength irons and thick sections containing more pearlite, impact transition temperature increase and some ductility and toughness is sacrificed to take advantage of the greater strength.

A-11. COEFFICIENT OF THERMAL EXPANSION

A-11.1 Up to 400°C the value will be about $10·0 \times 10^{-6}$/°C to $12·5 \times 10^{-6}$/°C, the higher value being obtained at higher temperatures.

A-12. THERMAL CONDUCTIVITY

A-12.1 This will be within the range from 41·9 to 45·2 W/m°C up to 500°C. The value falls with increasing temperature.

A-13. SPECIFIC GRAVITY

A-13.1 The specific gravity may be expected to be 7·4.

A-14. SPECIFIC HEAT

A-14.1 This is approximately 0·46 J/g°C.

A-15. MAGNETIC AND ELECTRICAL PROPERTIES

A-15.1 The values are typical of the range that may be expected:

Maximum relative magnetic permeability	1 450 to 730
Remanent magnetism	0·75 to 0·74 T
Coercive force	200 to 360 A/m
Hysteresis loss for B = 1 T	1·49 to 0·84 μJ/mm³
Resistivity	24 to 25 μΩcm

The first value approximates to that which would be obtained in a mainly ferritic iron while the second value is typical of a mainly pearlitic iron.

CONVERSION FACTORS

Moduli of elasticity and rigidity:

1 N/mm² = 1 MN/m²
= 0·102 0 kgf/mm²

Thermal conductivity:

1 W/m°C = 2·383 46 × 10^{-3} cal/cm s°C

Specific heat:

1 J/g°C = 0·238 846 cal/g°C

Magnetic and electrical properties:

1 T = 10 000 gauss
1 A/m = 1·256 28 × 10^{-2} oersteds
1 μJ/mm³ = 10 000 erg/cm³

For more detailed conversions *see* IS : 786-1967*

*Specification for conversion factors and conversion tables (*first revision*).

INDIAN STANDARDS
ON
CAST IRON AND MALLEABLE CAST IRON

IS:

210-1970 Grey iron castings (*second revision*)
1230-1968 Cast iron rain-water pipes and fittings (*first revision*)
1536-1975 Centrifugally cast (spun) iron pressure pipes for water, gas and sewage (*second revision*)
1537-1975 Vertically cast iron pressure pipes for water, gas and sewage (*first revision*)
1538 (Parts I to XXIII)-1975 Cast iron fittings for pressure pipes for water, gas and sewage (*second revision*)
1729-1964 Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories
1865-1974 Iron castings with spheroidal or nodular graphite (*second revision*)
1879 (Parts I to X)-1975 Malleable cast iron pipe fittings (*first revision*)
2107-1977 Whiteheart malleable iron castings (*first revision*)
2108-1977 Blackheart malleable iron castings (*first revision*)
2640-1977 Pearlitic malleable iron castings (*first revision*)
2749-1974 Austenitic iron castings (*first revision*)
3005-1964 Grey cast iron ingot moulds, stools and slag ladles
3355-1974 Grey iron castings for elevated temperatures for non-pressure containing parts (*first revision*)
3486-1966 Cast iron spigot and socket drain pipes
3516-1966 Cast iron pipe flanges and flanged fittings, Class 9, for petroleum industry
3896-1966 Comparison of Indian and overseas standards for iron castings
3989-1970 Centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories (*first revision*)
4771-1972 Abrasion-resistant iron castings (*first revision*)
5519-1969 Deviations for untoleranced dimensions of grey iron castings
5531-1969 Cast iron specials for use with asbestos cement pressure pipes
5787-1970 Spheroidal or nodular graphite iron castings for paper mill dryer rolls
5788-1970 Iron castings with spheroidal or nodular graphite for pressure-containing parts for use at elevated temperatures
5789-1970 Austenitic spheroidal iron castings for pressure-containing parts suitable for low-temperature service
6163-1971 Centrifugally cast (spun) iron low pressure pipes for water, gas and sewage
6331-1971 Automotive grey iron castings
6418-1971 Cast iron and malleable cast iron flanges for general engineering purposes
6629-1972 Cast iron rolls
7181-1974 Horizontally cast iron double flanged pipes for water, gas and sewage
7520-1974 Corrosion-resistant high silicon iron-castings