For Comments Only

DRAFT INDIAN STANDARD

SPECIFICATION FOR ABRASION RESISTANT IRON CASTINGS

(Third Revision of IS 4771)

ICS No. 77.080.10

Last date for receipt of comments is 31 07 2010

FOREWORD

(Formal clauses will be added later on)

This standard was first published in 1968 and subsequently revised in 1972 and 1985. In view of the experience gained during these years, it was decided by the Committee to revise the standard with following modifications:

a) A new classification/grading of abrasion resistant white cast irons is done in harmonization with their chemical composition and hardness.

b) In order to have interchangeability with other International Standards, International designation is used.

c) Cast iron having a structure which consists of eutectic iron carbides in a predominantly pearlitic matrix have been included.

d) Separate tabulation for chemical composition of abrasion resistant iron castings having constituent-low alloy, Nickel-chromium and high chromium including min. Brinell Hardness Values (HBW).

e) Sub-clause for freedom from defects added.

f) Heat treatments classified for low ally, Ni-Cr and High Cr.

g) Hardening, tempering, soft annealing and annealing temperatures and methods are integrated one by one for high chromium cast irons.

The requirement of Low Alloy Types of Abrasion-resistant Iron Castings as given in IS 7925:1976 has been incorporated in the standard with modification. With the publication of this standard the IS 7925:1976 will be superseded.

In the preparation of this standard, assistance has been derived from International Standard ISO 21988 'Abrasion-resistant 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.

1 SCOPE

1.1 This Indian Standard covers the requirement of abrasion-resistant iron castings.

1.2 These castings are widely used in the mining, earth moving, milling and manufacturing industries.

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 are indicated below:

IS No.	*Title*
1387:1993	General requirements for the supply of metallurgical material (*second revision*)
228	Methods of chemical analysis of pig iron, cast iron, plain carbon and low alloy steels (*revised*) (*issued in parts*)
397 (Part 1):2003	Method for statistical quality control during production – Part 1: Control charts for variables (*second revision*)
397(Part 2): 1975	Method for statistical quality control during production – Part 2: Control charts for attributes (*third revision*)
1500:2005/	Method for Brinell Hardness test for metallic materials
ISO 6506:1999	(*third revision*)

3 GRADES AND DESIGNATION

3.1 There shall be three grades of abrasion resistant cast iron which are as follows:

(a) Unalloyed or low alloy cast irons

Cast iron having a structure which consists of eutectic iron carbides in a predominantly pearlitic matrix

(b) Nickel-Chromium cast irons covering two general types:

i) 2% Cr 4% Ni cast irons:

Simple eutectic carbides M_3C type (M= Fe, Cr)in a matrix which is predominantly martensitic

ii) 9% Cr 5% Ni cast irons:

Complex eutectic carbides (M_7C_3 and M_3C)in a matrix which is predominantly martensitic

(c) High chromium cast irons covering 5 ranges of chromium content

i) Cr > 11% to ≤ 14%
ii) Cr > 14% to ≤ 18%
iii) Cr > 18% to ≤ 23%
iv) Cr > 23% to ≤ 30%

Cast iron containing between 11% and 40% Cr having a structure consisting of complex carbides in a matrix which, in the hardened condition , is predominantly martensitic, but which can also contain some austenite or other transformation products of austenite

3.2 The abrasion resistant cast iron material shall be designated by symbolic pattern HBW/Cr denoting the Brinell Hardness and the chemical composition in accordance with the designations given in Table 1, 2 and 3.

Note -_Three digits after HBW represents the minimum Brinell hardness and two digits after Cr represent the chromium content.

For example, HBW 500 Cr 09 means the material is having min. Brinell Hardness of 500 HBW , Chromium content in the range 8 to 10% and other chemical composition in accordance with this designation as given in table 2

4 SUPPLY OF MATERIAL

General requirements relating to the supply of abrasion-resistant iron castings shall be as laid down in IS : 1387.

5 MANUFACTURE

The castings shall be made by any suitable melting process ensuring that the requirements of this standard are met.

6 CHEMICAL COMPOSITION

The chemical composition of the metal for different grades of abrasion – resistant iron castings shall be as given in the Table 1, 2 and 3.

7 CHEMICAL ANALYSIS

Chemical analysis for the determination of various constituents in casting shall be done in accordance with IS : 228.

Table1 Brinell hardness and chemical composition of unalloyed or low alloy abrasion-resistant cast irons

(*Clauses* 3.2, 6 and 10.1)

Material designation SYMBOL	Brinell Hardness HBW min.	Chemical composition in % (mass fraction)			
		C	Si	Mn	Cr
HBW340/Cr02	340	2.4 to 3.9	0.4 to 1.5	0.2 to 1.0	Max. 2.0
HBW400/Cr02	400	2.4 to 3.9	0.4 to 1.5	0.2 to 1.0	Max. 2.0

Table2- Brinell hardness and chemical composition of nickel-chromium abrasion-resistant cast irons

(*Clauses* 3.2, 6 and 10.1)

Material designation SYMBOL	Brinell Hardness HBW min.	Chemical composition in % (mass fraction)						
		C	Si	Mn	P	S	Ni	Cr
HBW480/Cr02	480	2.5 to 3.0	max 0.8	max 0.8	max 0.1	max 0.1	3.0 to 5.5	1.5 to 3.0
HBW500/Cr09	500	2.4 to 2.8	1.5 to 2.2	0.2 - 0.8	0.06	0.06	4.0 to 5.5	8.0 to 10.0
HBW510/Cr02	510	3.0 to 3.6	max 0.8	max 0.8	max 0.1	max 0.1	3.0 to 5.5	1.5 to 3.0
HBW555/Cr09	555	2.5 to 3.5	1.5 to 2.5	0.3-0.8	max 0.08	max 0.8	4.5 to 6.5	8.0 to 10.0
HBW630/Cr09	630	3.2 to 3.6	1.5 to 2.2	3.2-0.8	0.06	0.06	4.0 to 5.5	8.0 to 10.0

NOTE 1- Both toughness and resistance to repeated impact increases as the carbon content decreases.

NOTE 2- Resistance to abrasion increases as the carbon content increases.

NOTE 3-For castings with alloy contents at the low end of the range and supplied in the as-cast condition or in the case of castings with greater wall thickness, it can be difficult to obtain the minimum hardness. The requirements for such castings should be agreed upon between the manufacturer and the purchaser.

Table3- Brinell hardness and chemical composition

of high chromium abrasion-resistant cast irons

(*Clauses* 3.2, 6 and 10.1)

Material designation SYMBOL	**Brinell Hardness HBW min.**	**Chemical composition in % (mass fraction)**								
		C	**Si** max	**Mn**	**P** max	**S** max	**Cr**	**Ni** max	**Mo** max	**Cu** max
HBW555/Cr13	555	1.8-3.6	1.0	0.5-1.5	0.08	0.08	11-14	2.0	3.0	1.2
HBW555/Cr16	555	1.8-3.6	1.0	0.5-1.5	0.08	0.08	14-18	2.0	3.0	1.2
HBW555/Cr21	555	1.8-3.6	1.0	0.5-1.5	0.08	0.08	18-23	2.0	3.0	1.2
HBW555/Cr27	555	1.8-3.6	1.0	0.5-2.0	0.08	0.08	23-30	2.0	3.0	1.2
HBW600/Cr35	600	3.0-5.5	1.0	1.0-3.0	0.06	0.06	30-40	1.0	1.5	1.2

NOTE 1- The carbon range within each material designation should be agreed between the manufacturer and the purchaser to meet the casting service requirements. Both toughness and resistance to repeated impact increases as the carbon content decreases. The lower carbon range (1.8 to 2.4) will provide good toughness and shock resistance. The intermediate carbon range (2.4 to 3.2) will provide a good combination of toughness and shock resistance. The higher carbon range (3.2 to 5.5) will provide higher wear resistance with reduced toughness and shock resistance.

NOTE 2- The structure of high-chromium abrasion-resistant cast-irons depends on the cooling rate and is therefore sensitive to the casting thickness. To obtain specific properties, within the range in Table 3, some adjustments to the percentage of the alloying elements given may be necessary depending upon the casting dimensional variations.

NOTE 3- For castings with alloy contents at the lower end of the range and supplied in the as-cast condition or for castings with greater thickness, it can be difficult to obtain the minimum hardness. The requirements for such castings should be agreed between the manufacturer and the purchaser.

NOTE 4- The corrosion resistance increases as chromium content increases and/or carbon content decreases.

8 WORKMANSHIP AND FINISH

8.1 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.

8.2 The drawings shall specify tolerances on all important dimensions.

8.3 The castings, as delivered to the purchaser shall be free from distortion and injurious defects. By agreement between the purchaser and the manufacturer, any casting defects may be rectified, provided they do not interfere with the ultimate use of the castings. Though welding is not recommended minor repair welding is possible but shall not be carried out except with the approval of the purchaser.

9 MICROSTRUCTURE

9.1 Castings or suitable test samples may be subjected to metallographic examination if agreed to between the purchaser and the manufacture. Location of test samples and area used for examination shall be decided by mutual agreement of the purchaser and the manufacturer.

9.2 The microstructures of all abrasion-resistant irons depend on cooling rate and are therefore sensitive to section size.

10 HARDNESS

10.1 The material shall conform to the requirements stipulated in Table 1, 2 and 3

10.2 The hardness test shall be carried out in accordance with IS:1500 using tungsten carbide ball.

11 HEAT TREATMENT

11.1 Castings shall be supplied either in the as-cast or heat treated condition at the discretion of the manufacturer to meet the hardness requirement specified in Table 1, 2 and 3.

11.2 Unalloyed or low alloy cast irons - They are normally supplied in the as-cast condition and do not require heat treatment. If required by purchaser to improve machinability, it should be indicated in the order

11.3 Nickel-chromium cast irons

11.3.1 2% Cr 4% Ni cast irons - Normally supplied in the as-cast condition. For certain applications castings can benefit from a heat treatment at 250^0 C to 300^0C

for 8h to 16h followed by air or furnace cooling. This treatment relieves residual casting stresses.

For improved resistance to repeated impact and to help the complete breakdown of as-cast austenite, the heat-treatment cycle shall be as follows:

-425^0 C to 475^{0}C for 4h to 6h followed by air or furnace cooling; and then

-250^0 C to 300^{0}C for 8h to 16h followed by air or furnace cooling

11.3.2 9% Cr 5% Ni cast irons - Depending on casting complexity heat-treatment in one of the two ways can be done-

a) For simple shapes, a single heat treatment is adequate, involving heat treatment at 800^{0}C to 850^{0}C for 6h to 12h followed by air or furnace cooling
b) Where maximum resistance to repeated impact is required, castings can benefit from a heat treatment at 800^{0}C to 850^{0}C for 8h to 16h followed by air or furnace cooling and then tempering at 250^{0}C to 300^{0}C for 8h to 12h with air or furnace cooling

NOTE - Air Cooling from 850^{0}C to 800^{0}C may be undesirable for heavy sections of complex design as cracking may occur

11.4 High chromium cast irons

11.4.1 General - High chromium cast iron castings can be supplied in either the as-cast or heat –treated condition. A high risk of cracking exists during heat treatment of large castings, even with a slow heat-up rate. Typical heat treatments are hardening, tempering, soft annealing and annealing.

11.4.2 Hardening - Hardening involves slowly heating up to a temperature within the range of 900^{0}C to 1050^{0}C; holding for a pre-determined period of time and then rapidly cooling

11.4.3 Tempering - Tempering may be required in order to transform any retained austenite to martensite to reduce residual stresses or to reduce the hardness of the material.

A typical tempering cycle involves:
- Slowly heating up to a temperature within the range of 200^{0}C to 550^{0}C
-holding for a period of time appropriate to the thickness
-followed by air or furnace cooling

11.4.4 Soft annealing - If casting hardness below HBW 378 is required (e.g. to facilitate machining), soft annealing can be carried out.

A typical soft annealing method is:
- Slowly heating up to a temperature within the range of 920^0C to 975^0C
-holding for at least 1h
-then slowly cooling down in the furnace to about 810^0C
-then further cooling down to 600^0C at a rate not exceeding 55 K/h
-followed by air or furnace cooling

11.4.5 Annealing - If castings require annealing then a typical annealing involves slowly heating up to a temperature of 700^0C to 750^0C for a minimum of 4h, and then slowly cooling in the furnace to 600^0C, following by air or furnace cooling.

12 SAMPLING

12.1 For quality control during production, use of control chart technique is recommended to the manufacturer for which reference is invited to IS : 397 (Part 1) or IS : 397 (Part-2). The results of such tests done at the place of manufacture along with the material supplied may be made available, to enable the purchaser to judge its acceptability.

12.2 Sampling for chemical Analysis- Chemical analysis shall be carried out either on finished casting or test bar representing each melt. In the case of continuous melting, samples shall be provided at the rate of one sample per hour of production.

12.3 Sampling for Hardness Test- If specified by the purchaser, test shall be carried out either on finished casting or test bar representing each heat-treatment batch; at least one test shall be carried out from each melt in case the castings from two or more melts are heat-treated in one batch. In the case of continuous melting, sufficient number of samples shall be provided to ensure at least one test per hour of production.

13 RETEST

13.1 Chemical Analysis – If a sample selected under **12.2** fails to meet the requirements given in Table 1,2 and 3, the purchaser shall select two further samples from the same lot. If both the samples satisfy the specific requirements,the castings represented shall be accepted. If either of the samples fails, the castings represented shall be deemed as not complying with the standard.

13.2 Hardness Test - If a sample selected under **12.3** fails to meet the requirements given in Table 1,2 and 3, the purchaser shall select two further samples from the same lot. If both the samples satisfy the specific requirements, the castings represented shall be accepted. If either of the samples fails, the castings

represented shall be deemed as not complying with the standard. If the castings are supplied in the heat-treated condition, the manufacturer shall have the right to re heat-treat the product, if he so desires, in any suitable manner before two fresh samples are taken for testing. Should the two test satisfy the requirements of this standard, the lot shall be accepted. Should either of the samples fail, the castings represented shall be taken as not complying with this standard.

14 MARKING

14.1 Where practicable, each casting shall be legibly marked with an identification mark by which it can be traced to the melt and the batch of heat-treatment, where applicable, from which it was made.

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

14.3 BIS Certification Marking

The castings may also be marked with the Standard Mark.

14.3.1 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 thereunder. The details of conditions under which the licence for the use of Standard Mar may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.