भारतीय मानक **IS 11286 : 2024**

Indian Standard

कठोर अनुप्रयोगों के लिए संक्षारण प्रतिरोधक उच्च मिश्र धातु इस्पात निकल और कोबाल्ट से बनी निवेश ढ़लाईयाँ— विशिष्टि

(दूसरा पुनरीक्षण)

Corrosion Resistant High Alloy Steel, Nickel Base and Cobalt Base Investment Castings for Severe Applications — Specification

(Second Revision)

ICS No. 77.140.20

भारतीयमानकब्यूरो

BUREAU OF INDIAN STANDARDS

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Foundry Steel Casting Sectional Committee, MTD 14

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards after the draft finalized by the Foundry and Steel Castings Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1985 and subsequently revised in 1995. This revision has been brought out to bring the standard in the latest style and format of the Indian Standards. In addition, the following modifications have been incorporated:

a) Reference clause has been modified;
b) Amendment No.1 June 1996, has been incorporated; and
c) Marking clause has been modified.

Corrosion resistant steel, nickel base and cobalt base castings meant for severe corrosion applications and made with investment casting process are used in various industries, such as chemical, values, petroleum refining, air compressors, pumps and gas turbines for service at normal atmospheric and elevated temperatures. These castings are resistant to corrosion at atmospheric and elevated temperatures for severe corrosion applications.

For the guidance of the purchaser and the manufacturer, typical applications of various grades of castings specified in this standard have been included in Annex A.

The composition of the Committee responsible for the formulation of this standard is given in Annex D.

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 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. 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

CORROSION RESISTANT HIGH ALLOYSTEEL, NICKEL BASE AND COBALT BASEINVESTMENT CASTINGS FOR SEVERE APPLICATIONS — SPECIFICATION

(Second Revision)

1 SCOPE

This standard covers the requirements for corrosion resistant high alloy steel, nickel base and cobalt base investment castings for severe corrosion applications.

2 REFERENCES

The standards listed in Annex B 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 edition of these standards.

3 TERMINOLOGY

3.1 For the purpose of this standard, the following definitions shall apply.

3.1.1 Cast (melt) the product of any of the following:

a) One furnace heat;
b) One crucible heat; and
c) A number of furnace or crucible heats of similar composition mixed in a ladle ortapped in separate ladles and poured simultaneously for making a casting.

3.1.2 *Batch* — A group of castings of one grade of material, casting from the same melt and heat-treated together under identical conditions.

3.1.3 *Investment Casting* — An investment casting is one that is produced in a mould shell obtained by investing (surrounding) an expandable pattern with a bonded refractory. The expandable pattern may be made of urea, plastic or other material and is removed by heating or any other process prior to filling the mould with the liquid metal.

3.1.4*Master Heat* — Metal supplied in cast or wrought form, the chemical composition of which has been established by chemical analysis, and which is re-melted into smaller batches for pouring into mould cavity.

4 GRADES

This standard covers a total of nine grades of castings.

5 SUPPLY OF MATERIAL

General requirements relating to supply of steel castings shall be as laid down in IS 11709.

6 MANUFACTURE

The steel for the castings shall be made by electric arc or electric induction or such other processes as maybe agreed to between the purchaser and the manufacturer.

7 PARTICULARS TO BE SPECIFIED WHILE ORDERING

The benefit of the purchaser, particulars to be specified while ordering for steel castings to this specification are given in Annex C.

8 CHEMICAL COMPOSITION

8.1 The ladle analysis of steel when carried out either by the method specified in IS 228 and its relevant parts or any other established instrumental/chemical methods shall be as given in Table 1. In case of dispute the procedure given in IS 228 shall be the referee method. However, where the method is not given in IS 228, the referee method shall be as agreed to between the purchaser and the manufacturer.

8.2 The manufacturer shall carry out analysis from a sample of each melt and, if so specified by the purchaser at the time of enquiry and order, shall supply a test certificate of chemical analysis of the sample for each melt.

8.3 Product Analysis

If specified at the time of enquiry and order, the product analysis may be carried out from a test piece or from a casting representing each melt.

Drillings for analysis shall be taken from not less than 6 mm beneath the cast surface, and in such

a manner as not to impair the usefulness of any casting selected. The permissible variation in product analysis from the limits specified in Table 1 shall be as given in IS 6601.

8.4 Residual Elements

8.4.1 Elements not specified in Table 1 shall not ordinarily be added to the steel and all reasonable precautions shall be taken to prevent contamination from scrap etc to keep them as low as practicable.

8.4.2 Analysis and reporting of the analysis in the test certificate for the above residual elements shall be done only when so specified by the purchaser in the enquiry and order. However, the manufacturer shall ensure that the residual elements are within limits, when such limits are specified by the purchaser in the enquiry and order.

9 WORKMANSHIPAND FINISH

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

9.2 The purchaser shall specify the tolerances on all important dimensions. On other dimensions, tolerances specified in IS 11166 shall apply.

10 FREEDOMS FROM DEFECTS

10.1 All castings shall be free from defects that will adversely affect machining or utility of castings.

10.2 When necessary to remove risers or gates by flame or arc or a combination thereof, or by any other process involving intense heat, care shall be taken to make the cut at sufficient distances from the body of the casting so as to prevent any defect being introduced into the casting due to local heating. Any such operation is to be done before final heat treatment.

10.3 In the event of any casting proving defective from foundry causes in the course of preparation, machining or erection, such casting may be rejected notwithstanding any previous certification of satisfactory testing and/or inspection.

11 FETTLING AND DRESSING

All castings shall be properly fettled and dressed, and all surfaces shall be thoroughly cleaned.

12 HEAT TREATMENT

12.1 The castings shall be heat-treated in a properly constructed furnace, having adequate means of temperature control and which shall permit the whole of the castings being uniformly heated to the necessary temperature. All castings shall be suitably heat treated so as to attain the specified mechanical properties.

12.2 Unless otherwise specified in the enquiry and order or agreed to between the purchaser and the manufacturer, all castings shall be supplied in heat treatment condition given in Table 2.

12.3 The test pieces shall be heat treated along with the castings they represent.

12.4 Care shall be taken to minimize the damage from oxidation or decarburization where relevant, during heat treatment. The limit of oxidation and decarburization where relevant may be agreed upon mutually between the purchaser and the manufacturer at the time of enquiry and order.

13 MECHANICAL TESTS

13.1 Test Samples

The thickness or diameter of the as cast test bar should ordinarily be 18 mm ± 3 mm. However, size other than this may be agreed to between the manufacturer and the purchaser.

13.2 The mechanical properties specified are those which are to be obtained from test bars cast either separately from or attached to the castings to which they refer and heat treated as given in **12**. The test values so exhibited, therefore, represent the quality of the metal from which the castings have been poured; they do not necessarily represent the properties of the castings themselves.

13.3 The tensile test shall be carried out in accordance with IS 1608 (Part 1). If specified in the enquiry and order, high temperature tensile test shall be carried out in accordance with IS 1608 (Part 2). The relevant mechanical properties shall be as given in Table 3.

13.4 If so stipulated in that enquiry and order, Brinell hardness test shall be carried out as per IS 1500 (Part 1). The requirements of Brinell hardness values shall be as mutually agreed to.

13.5 If specified in the enquiry and order, impact test, bend test and stress rupture test shall be carried out. The methods of testing and their requirements shall be as mutually agreed to. In case of dispute, the test shall be carried out as per the methods mentioned in the following Indian Standards:

a) Charpy V-notch pendulum impact test as per IS 17416;
b) Izod impact test of metalsas per IS 1598;
c) Bend test as per IS 1599; and
d) Stress rupture test as per IS 3407 (Part 2).

Table 1 Chemical Composition of Corrosion Resistant High Alloy Steel, Nickel Base and Cobalt Base Investment Castings for Severe Applications

(*Clause 8*)

Sl No.	Constituent	Requirements Percentage [1)]								
		Grade 1	Grade 2	Grade 3	Grade 4A	Grade 4B	Grade 5	Grade 6	Grade 7	Grade 8
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	Carbon	0.03	0.07	1.00	0.35	0.35	0.12	0.90 - 1.40	1.10 - 1.70	2.0 - 2.7
ii)	Silicon	2.00	1.50	2.00	2.00	1.25	1.00	1.50	1.50	1.0
iii)	Manganese	1.50	1.50	1.15	1.50	1.50	1.00	1.00	1.00	1.0
iv)	Sulphur	0.040	0.040	0.030	0.030	0.030	0.030	0.040	0.040	0.040
v)	Phosphorus	0.040	0.040	0.030	0.030	0.030	0.040	0.040	0.040	0.040
vi)	Chromium	17.00 - 21.00	19.00 - 22.00	—	—	—	1.00	27.00 - 31.00	27.00 - 31.00	29.0 - 33.0
vii)	Nickel	9.00 - 13.00	27.50 - 30.50	Reminder	Reminder	Reminder	Reminder	3.00	3.00	3.0
viii)	Molybdenum	2.00 - 3.00	2.00 - 3.00	—	—	—	26.00 - 33.00	1.50	—	—
ix)	Copper	—	3.00 - 4.00	1.25	26.00 - 33.00	26.00 - 33.00	—	—	—	—
x)	Tungsten	—	—	—	—	—	—	3.50 - 5.50	7.00 - 9.50	11.0 - 14.0
xi)	Vanadium	—	—	—	—	—	0.20 - 0.60	—	—	—
xii)	Iron	Reminder	Reminder	3.00	3.50	3.50	4.00 - 6.00	3.00	3.00	3.00
xiii)	Cobalt	—	—	—	—	—	—	Reminder	Reminder	Reminder

[1)] All the percentages given were maximum, unless a range is specified.

Table 2 Heat treatment Requirements

(*Clause* 12.2)

Sl No.	Grade	Heat Treatments
(1)	(2)	(3)
i)	1	Heat to 1 040 °C minimum. Hold for sufficient time to heat castings to temperature. Quench in water or rapid cool by other means so as to develop acceptable corrosion resistance.
ii)	2	Heat to 1 120 °C minimum. Hold for sufficient time to heat casting to temperature. Quench in water or rapid cool by other means so as to develop acceptable corrosion resistance
iii)	3, 4A, 4B	As cast
iv)	5,6,7	
v)	and 8	

Table 3 Mechanical Properties of Corrosion Resistant High AlloyCasting for Severe Application

Sl No.	Property	Requirement								
		Grade 1	Grade 2	Grade 3	Grade 4A	Grade 4B	Grade 5	Grade 6	Grade 7	Grade 8
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	Tensile strength, *Min*, MPa	480	425	345	450	450	520	575	685	–
ii)	0.2 percent yield strength, *Min*, MPa	205	170	120	175	170	315	660	–	–
iii)	Elongation, percent, *Min*	26	31	9	22	25	6	3	–	–

(*Clause* 13.3)

14 NON-DESTRUCTIVE TESTS

14.1 Non-destructive testing shall be applied if specified in the enquiry and order. Under this heading the tests are grouped, which aim at revealing defects which cannot be revealed by a simple visual examination, such as liquid penetrant, magnetic particle, ultrasonic, X-ray radiographic, or gamma-radiographic inspection; also included under this heading are tests on the surface condition by visual or visual – tactile examination. The purchaser shall specify in the enquiry and order:

a) The type of non-destructive testing which he intends to carry out or to have carried out;

b) The area or areas of the casting to which these tests apply, and the types of discontinuity, where relevant;

c) Whether all, or what proportion, of the castings are to be tested;

d) The severity level defining the acceptability or non-acceptability of defects which may be revealed; and

e) Whether the manufacturer is or is not contractually responsible for carrying out the tests.

14.2 Unless otherwise agreed upon, when non-destructive testing is to be done, the castings shall be examined as follows:

a) Liquid penetrant examination as per IS 3658 magnetic particle flaw detection as per IS 3703; and

b) Radiographic examination as per IS 2595, ultrasonic pulse echo testing by contact and immersion methods as per IS 3664.

14.3 Unless otherwise agreed upon the following shall be the acceptance standards:

a) IS 11732 for liquid penetrant inspection; and

b) IS 12938for radiographic inspection.

NOTES

1 In case of nickel base alloys given in Table 1 the method of ultrasonic examination shall be as agreed to between the purchaser and the manufacturer.

2 In case of austenitic grades, ultrasonic examination is often very difficult and magnetic particle examination would not ordinarily be feasible.

15 ADDITIONAL TEST

If specified in the enquiry and order, intergranular corrosion test and metallographic test may be carried out. The methods of testing and acceptance standards shall be agreed upon between the manufacturer and the purchaser.

16 REPAIR OF CASTINGS

16.1 Unless otherwise specified by the purchaser in the enquiry and order, castings may be rectified by welding. All repairs by welding shall be carried out in accordance with the procedure laid down in IS 5530. If castings have been subjected to non-destructive or hydraulic testing by agreement between the purchaser and the manufacturer, the castings shall be re-examined in the area of repair following any rectifying operation performed on the castings.

16.2 To form the basis of an agreement between the purchaser and the supplier in this respect where relevant, the following classification shall apply concerning the extent of repair:

a) Weld repair involving a depth not exceeding 20 percent of wall thickness or 25 mm, whichever is lower, shall be termed as a minor repair; and

b) Any weld repair exceeding the above shall be termed as a major repair. Further any single repair having an area exceeding 250 mm square for every millimetre of wall thickness shall also be deemed to be major repair, regardless of the considerations mentioned in a) above.

17 METHOD OF SAMPLING

The method of sampling steel castings for the purpose of chemical analysis and mechanical tests including re-test shall be in accordance with IS 6907.

18 MARKING

18.1 Each casting shall be legibly marked with the following:

a) The number or identification mark by which it is possible to trace the melt and the heat treatment batch from which it was made;

b) The manufacturer's name or trademark; and

c) Other identification marks in accordance with any agreement between the purchaser and the manufacturer.

NOTE — It is recommended that a minimum of markings be use.

18.2 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.

18.3 BIS Certification Marking

The castings may also be marked with the Standard Mark. The use of Standard Mark is governed by the provisions of Bureau of *Indian Standards Act*, 2016 and the Rules and Regulations made there under. 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*)

TYPICAL APPLICATION OF VARIOUS GRADES OF CASTING

A-1 For the guidance of the manufacturers and the users, typical applications of various grades of castings covered by this standard are given below:

Grade	
1	Pumps, valves, fittings etc in reducing acid paper mill equipment, process industries and sea water services. It is also used where resistance to intergranular corrosion is required.
2	Pumps impellers used in naval boiler feed pumps. It is also used where resistance to 2 hot sulphuric acid is required.
3	Used for handling caustic process where low iron and copper content in the equipment is important
4A	Used where resistance to salt water corrosion, erosion and abrasion is required.
Grade	Used for impellers pumping salt cooling water and in chemical pumps.
4B	Same as 4A but preferred where welding in assembly is involved.
5	Used in parts where good toughness, Strength, ductility and corrosion resistance are required.
6	Used in parts such as nozzle, rubbing seals, rollers, guides, supports, etc requiring wear and or erosion resistance with high corrosion and oxidation resistance for use at temperature up to 870 °C.
7 and 8	Used in parts for high temperature gas turbine engines and turbo super charger units. It has good elevated temperature strength with high corrosion resistance and oxidation resistance up 1 150 °C.

ANNEX B

(*Clause 2*)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 228	Methods for chemical analysis of steels (relevant parts)
IS1500 (Part 1) : 2019/ISO 6506-1 : 2014	Metallic materials — Brinell hardness test: Part 1 Test method (*fifth revision*)
IS 1598 : (1977)	Method for izod impact test of metals (*first revision*)
IS 1599 : 2023/ ISO 7438 : 2020	Metallic materials — Bend test (*fifth revision*)
IS 1608	Metallic materials — Tensile testing:
(Part 1) : 2022/ ISO 6892-1 : 2019	Method of test at room temperature (*fifth revision*)
(Part 2) : 2020/ ISO 6892-2 : 2018	Method of test at elevated temperature (*fourth revision*)
IS 1741 : 2019	Latex foam rubber products — Specification (*first revision*)
IS 2595 : 2008	Industrial radiographic testing —Code of practice (*second revision*)
IS 3407 (Part 2) : 1983	Method for creep testing of steel at elevated temperatures: Part 2 Tensile creep stress rupture testing (*first revision*)
IS 3664 : 1981	Code of practice for ultrasonic pulse echo testing by contact and immersion methods (*first revision*)
IS 3703 : 2023	Recommended practice for magnetic particle flaw detection (*third revision*)
IS 5530 : 2005	Recommendations for production, rectification and repair of steel castings by metal arc welding process (*secondrevision*)
IS 6601 : 1987	Permissible deviations in chemical composition for product analysis of steel castings (*first revision*)
IS 6907 : 1992	Steel castings — Methods of sampling (*first revision*)
IS 9565 : 2023	Acceptance standards for ultrasonic inspection of steel castings — Specification (*thirdrevision*)
IS 10724 : 1990	Acceptance standards for magnetic particle inspection of steel castings — Specification (*second revision*)
IS 11166 : 1993	Permissible deviation on dimensions, surface roughness and mass of steel castings made with investment casting process (*first revision*)
IS 11709 : 2007	Technical delivery conditions for investment castings of steel (*second revision*)
IS 11732 : 1995	Acceptance standards for liquid penetrant inspection of steel casting (*first revision*)
IS 12938 : 1990	Acceptance standards for radiographic inspection of steel castings

ANNEX C

(*Clause 7*)

INFORMATION TO BE SUPPLIED BY THE PURCHASER

C-1 BASIC FOR ORDER

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

a) Material specification;
b) Drawing or reference number of the pattern (if supplied by the purchaser), along with a copy of the drawing;
c) Optional/Additional tests required, if any;
d) Whether the castings are to be inspected and tested in the presence of the purchaser's representative;
e) Condition of delivery;
f) Any special requirement; and
g) Test report, if required.

ANNEX D

(*Foreword*)

COMMITTEE COMPOSITION

Foundry and Steel Castings Sectional Committee, MTD 14

Organization	*Representative(s)*
BHEL (CFFP), Haridwar	SHRI V. K. RAIZADA **(*Chairperson*)**
Bharat Heavy Electricals Ltd, HPEP, Hyderabad	SHRI ABHINAV AGRAWAL
BHEL, Haridwar	SHRI A. N. SUDHAKAR SHRI RANJITHLAKRA(*Alternate*)
Bhilai Engineering Corporation Limited, Bhilai	SHRI AKHIL DUBEY SHRI SHIV DUTT MISHRA (*Alternate*)
CSIR - Central Mechanical Engineering Research Institute, Durgapur	DR SUDIP SAMANTHA
CSIR - National Institute for Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram	DR TPDRAJAN DR M. RAVI (*Alternate*)
Directorate General of Quality Assurance, Ichhapur	SHRI ASHOK KUMAR SHRI S. ROY CHOWDHURY (*Alternate*)
Disa India Ltd, Bangalore	SHRI SUNIL KUMAR GHOSH SHRI SURESH KUMAR A. (*Alternate*)
Forace Polymers Private Limited, Haridwar	SHRI D. K. GHOSH
Hindustan Aeronautics, Foundry and Forge Division, Bengaluru	SHRI K. SATYENDRA KUMAR
Indian Institute of Technology, Kharagpur	PROF SARAT PANIGRAHI PROF RAHUL MITRA(*Alternate*)
Indian Ordnance Factory Board, Kolkata	SHRI G. JHA SHRI A. K. LALA (*Alternate*)
Indian Register of Shipping, New Delhi	DR K. K. DHAWAN SHRI S. VELMURUGAN(*Alternate*)
Leader Valves Ltd, Jalandhar	SHRIMATI PURNIMA BERI SHRI SARABJIT SINGH (*Alternate*)
Ministry of Defence (DGQA), Ichapur	SHRI ASHOK KUMAR SHRI RUPESHBANAIT(*Alternate*)
Ministry of Science & Technology, New Delhi	MS TAMANNA ARORA SHRI K. S. P. RAO (*Alternate*)
National Institute of Foundry & Forging Technology, Ranchi	DR KAMLESH KUMAR SINGH DR AMITESH KUMAR (*Alternate*)

Organization	*Representative(s)*
National Metallurgical Laboratory, Jamshedpur	DR D. N. PASWAN MS MINAL SHAH (*Alternate*)
NIT Manipur, Langol, Imphal	PROF (DR) GOUTAM SUTRADHAR DR ANIL KUMAR BIRRU (*Alternate* I) DR SABINDRAKACHHAP (*Alternate* II)
Steel Cast Ltd, Bhavnagar	SHRI V. K. MODI SHRI B. C. ROUTRAY (*Alternate*)
Tata Motors, Jamshedpur	SHRI S. KUMAR DR D. S. PADAN (*Alternate*)
The Institute of Indian Foundry Men, New Delhi	SHRI DINESH GUPTA SHRI SANJEEV KUMAR (*Alternate*)
The Wesman Engineering Co Pvt Ltd, Kolkata	SHRI RANJAN GUHA SHRI ASHUTOSH MONDAL (*Alternate* I) SHRI PARTHA CHATTERJEE (*Alternate* II)
Versatile Equipments Pvt Ltd, Kolhapur	SHRI PUSHKRAJ JANWADKAR SHRI KIRAN PANDI (*Alternate*)
BIS Directorate General	SHRI SANJIV MAINI, SCIENTIST 'F'/SENIOR DIRECTOR AND HEAD (METALLURGICAL ENGINEERING) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SHRI KUNAL KUMAR
SCIENTIST 'D'/JOINT DIRECTOR
(METALLURGICAL ENGINEERING), BIS