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भारतीय मानक

सामान्य औद्योगिक उपयोग के लिए मिश्र इस्पात

गढ़ाइयाँ — विशिष्ट

(पहला पुनरीक्षण)

Indian Standard

**ALLOY STEEL FORGINGS FOR GENERAL
INDUSTRIAL USE — SPECIFICATION**

(First Revision)

UDC 669.15 — 194 — 134

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BUREAU OF INDIAN STANDARDS
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Price Group 4

Steel Forgings Sectional Committee, MTD 18

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Steel Forgings Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1967. On the basis of experience gained in the production and use of steel forgings, the following major modifications have been incorporated in this version:

- a) In Table 1, one new grade 20NiCrMo₃ has been included.
- b) A new clause indicating type of condition of delivery has been included.
- c) Requirements for macrostructure, inclusion rating and grain size have been incorporated.
- d) Tool steel part has been deleted from this standard. A separate standard will be published covering the requirements of tool steel.

For the benefit of the purchaser an informative annexure (see Annex A) giving particulars to be specified by the purchaser has been included.

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
ALLOY STEEL FORGINGS FOR GENERAL INDUSTRIAL USE — SPECIFICATION
(First Revision)

1 SCOPE

1.1 This standard covers the requirements relating to the supply of alloy steel forgings for general industrial use in as forged, heat-treated or machined condition.

2 REFERENCES

2.1 The following Indian Standards are necessary adjuncts to this standard :

<i>IS No.</i>	<i>Title</i>
1387 : 1967	General requirements for the supply of metallurgical materials (<i>first revision</i>)
1499 : 1977	Method for Charpy impact test (U-notch) for metals (<i>first revision</i>)
1500 : 1983	Method for Brinell hardness test for metallic materials (<i>second revision</i>)
1586 : 1988	Method for Rockwell hardness test for metallic materials (Scales A - B - C - D - E - F - G - H - K) (<i>second revision</i>)

IS No.

Title

1598 : 1977	Method for <i>ixod</i> impact test of metals (<i>first revision</i>)
1608 : 1972	Method for tensile testing of steel products (<i>first revision</i>)
1762 (Part 1) : 1974	Code for designation of steels, based on letter symbols (<i>first revision</i>)
3469 (Parts 1 to 3) : 1974	Tolerances for closed die steel forgings (<i>first revision</i>)
4163 : 1982	Method for determination of inclusion content in steel by microscopic method (<i>first revision</i>)
4748 : 1988	Methods for estimating average grain size of metals (<i>first revision</i>)

3 SUPPLY OF MATERIAL

3.1 General requirements relating to the supply of alloy steel forgings shall conform to IS 1387 : 1967.

3.2 Forgings of different steels covered by this standard shall be ordered and delivered on any one of the following basis :

Requirements

Type of Condition of Delivery

	Type of Condition of Delivery											
	A	B	C	D	E	F	G	H	J	K	M	N
Chemical composition	X	X	X	X	X	X	X	X	X	X	X	X
Hardness in as supplied condition : Normalized/Annealed/Spheroidized	—	X	X	X	X	X	X	X	X	X	—	—
Microstructure	—	—	X	X	—	X	X	X	X	X	—	X
Macrostructure	—	—	—	—	—	X	X	X	X	X	X	X
Grain Size	—	—	X	X	X	X	X	X	X	X	—	X
Hardenability	—	—	—	X	X	—	—	—	X	X	—	—
Inclusion rating	—	—	X	X	X	X	—	X	X	X	X	X
Mechanical properties in simulated case hardened condition	—	—	—	—	—	—	—	X	—	X	—	—
Mechanical properties in quenched and tempered condition	—	—	—	—	—	—	—	—	—	—	X	X

NOTE — 'X' indicates the property required.
— indicates the property not required.

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4 MANUFACTURE

4.1 Forgings shall be manufactured from steel produced by open-hearth, electric or any other approved process. Steel shall be fully killed. Steel may be processed through ingot or continuous casting route with sufficient reduction as per agreement with the suppliers.

4.2 In case of ingot, sufficient discard shall be made to ensure freedom from pipe, marked segregation and other harmful defects.

4.3 The amount of hot working and finishing temperature shall be such as to ensure complete soundness and adequate uniformity of structure and mechanical properties after heat treatment. The forgings shall not be produced from overheated stock.

4.4 Forgings shall be suitably heat-treated or cooled after forging to avoid cracks or flakes and shall be finished as nearly as practicable to the dimension of the drawing supplied or within the tolerances mutually agreed upon between the supplier and the purchaser.

5 FREEDOM FROM DEFECTS

5.1 The forgings shall be free from any harmful internal and surface defects, such as cracks, laps, seams and slag inclusion. The forgings may be tested by physical inspection, ultrasonic flaw detector and macro-etch, magnetic particle testing method, as agreed to between the purchaser and the manufacturer.

5.2 Maximum depth of total decarburization and other surface defects shall not exceed 80 percent of the machining allowance or as specially agreed to with the supplier.

5.3 The forgings shall be free from scale.

5.4 Defects in forgings may be repaired with prior consent of the purchaser.

6 TOLERANCES

6.1 Tolerances for forgings shall be as specified in IS 3469 (Parts 1 to 3): 1974. In special cases, tolerances shall be as agreed to between the supplier and the purchaser.

7 CHEMICAL COMPOSITION

7.1 The ladle analysis of alloy steel forgings shall be as given in Table 1.

7.1.1 Elements not specified in Table 1 shall not be added to steel, except when agreed, other than for the purpose of finishing the heat and shall not exceed the limits which are as follows :

Constituent	Percent
Chromium	0.30
Nickel	0.30
Molybdenum	0.05
Copper	0.25
Vanadium	0.05
Tin	0.05
Boron	0.0003

NOTES

1 Trace elements (Cr+Ni+Mo) when added together should not exceed 0.50 percent.

2 Percent copper $\times 10 \times$ (Percent tin) should not exceed 0.50 percent.

7.2 Check Analysis

The permissible variation in the case of product from the limits specified in Table 1 shall be as given in Table 2.

8 SELECTION OF TEST SAMPLES

8.1 The ladle analysis shall be furnished by the supplier. If check analysis is required, at least one sample per heat shall be taken.

8.2 For small forgings, with ruling section equivalent to a diameter of 30 mm or less, separate test samples shall be provided from the bars or billets from which forgings are made. They shall be similarly and simultaneously heat-treated with the forgings they represent.

8.2.1 For forgings with a ruling section exceeding 30 mm, the test samples for mechanical properties shall be mutually agreed to between the purchaser and the manufacturer.

8.2.1.1 For forgings more than ruling section of 100 mm, separate test bar of equivalent ruling section shall be forged from the same stock, and heat-treated along with forgings and shall be tested. If found passing the test it shall be acceptable for batch of forgings. Alternately, an integral test sample may be provided in the forging itself and tested for acceptance.

8.2.2 For case hardening steel, where the size of the forging is greater than 30 mm diameter separate test bars shall be prepared by forging or by machining or by both to 30 mm; but for smaller sizes the test bars shall be heat-treated in the full section. The test pieces shall be blank-carburized and then refined and hardened as specified in the individual specification, except that by agreement between the supplier and the purchaser carburizing or blank-carburizing may be omitted. One tensile and one impact test shall be taken per heat.

8.3 Unless otherwise agreed to between the purchaser and the manufacturer, one set of samples as specified in 8.2 and 8.2.1, shall be made per heat per heat-treated batch.

Table 1 Chemical Composition of Low Alloy Steels

(Clauses 7.1, 7.1.1 and 7.2)

Designation as per IS 1762 (Part 1): 1974	C	Si	Mn	Ni	Cr	Mo	V	Al
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
20C15	0.06-0.24	0.10-0.35	1.30-1.70	—	—	—	—	—
15Cr3	0.12-0.18	0.10-0.35	0.40-0.60	—	0.50-0.80	—	—	—
16Mn5Cr4	0.14-0.19	0.10-0.35	1.00-1.30	—	0.80-1.10	—	—	—
20Mn5Cr5	0.18-0.22	0.10-0.35	1.00-1.40	—	1.00-1.30	—	—	—
21Cr4Mo2	0.26 Max	0.10-0.35	0.50-0.80	—	0.90-1.20	0.15-0.30	—	—
07Cr4Mo6	0.12 Max	0.15-0.60	0.40-0.70	0.30 Max	0.70-1.10	0.45-0.65	—	—
10Cr9Mo10	0.15 Max	0.50 Max	0.40-0.70	0.30 Max	2.00-2.50	0.90-1.10	—	—
13Ni13Cr3	0.10-0.15	0.10-0.35	0.40-0.70	3.00-3.50	0.60-1.00	—	—	—
15Ni16Cr5	0.12-0.18	0.10-0.35	0.40-0.70	3.80-4.30	1.00-1.40	—	—	—
15Ni5Cr4Mo1	0.12-0.18	0.10-0.35	0.60-1.00	1.00-1.50	0.75-1.25	0.08-0.15	—	—
15Ni7Cr4Mo2	0.12-0.18	0.10-0.35	0.60-1.00	1.50-2.00	0.75-1.25	0.10-0.20	—	—
15Ni8Cr6Mo2	0.12-0.20	0.10-0.35	0.40-0.70	1.80-2.20	1.40-1.70	0.15-0.25	—	—
36Si7	0.33-0.40	1.50-2.00	0.80-1.00	—	—	—	—	—
37C15	0.32-0.42	0.10-0.35	1.30-1.70	—	—	—	—	—
35Mn6Mo3	0.30-0.40	0.10-0.35	1.30-1.80	—	—	0.20-0.35	—	—
40Cr4	0.35-0.45	0.10-0.35	0.60-0.90	—	0.90-1.20	—	—	—
40Cr4Mo3	0.35-0.45	0.10-0.35	0.90-0.80	—	0.90-1.20	0.20-0.35	—	—
35Ni5Cr2	0.30-0.40	0.10-0.35	0.60-0.90	1.00-1.50	0.45-0.75	—	—	—
40Ni6Cr4Mo3	0.35-0.45	0.10-0.35	0.40-0.70	1.25-1.75	0.90-1.30	0.20-0.35	—	—
40Ni10Cr3Mo6	0.36-0.44	0.10-0.35	0.40-0.70	2.25-2.75	0.90-0.80	0.40-0.70	—	—
25Cr13Mo6	0.20-0.30	0.10-0.35	0.40-0.70	0.30 Max	2.90-3.40	0.45-0.65	—	—
55Si7	0.50-0.60	1.50-2.00	0.80-1.00	—	—	—	—	—
50Cr4V2	0.45-0.55	0.10-0.35	0.50-0.80	—	0.90-1.20	—	0.15-0.30	—
20Ni7Mo2	0.18-0.23	0.20-0.35	0.70-0.90	0.40-0.70	0.40-0.60	0.15-0.25	—	—
27Mn5Si5	0.33-0.41	1.10-1.40	1.10-1.40	—	—	—	—	—

NOTES

1 Sulphur and phosphorus can be ordered as per following limits:

- i) S & P - 0.030 Max
- ii) S 0.02-0.035 and P 0.035 Max

2 When the steel is Al killed, total Al content shall be between 0.02-0.05 percent.

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9 MECHANICAL PROPERTIES

9.1 The mechanical properties of alloy steel forgings shall be as given in Table 3.

9.1.1 In case the forgings are supplied in annealed or normalized condition, the properties shall be mutually agreed to between the supplier and the purchaser, unless the test samples are separately heat-treated in which case they shall conform to the requirements as given in Table 3.

9.1.2 In case of hardening steel, the properties shall conform to the requirements as specified in Table 3. When the test sample is smaller than 30 mm diameter, the properties shall be subject to mutual agreement between the supplier and the purchaser.

9.2 Tensile Test

Tensile test shall be carried out in accordance with IS 1608 : 1972.

9.3 Hardness Test

9.3.1 Brinell Hardness Test

Brinell hardness test, where specified, shall be carried out in accordance with IS 1500 : 1983.

9.3.2 Rockwell Hardness Test

Rockwell hardness test, where specified, shall be carried out in accordance with IS 1586 : 1988.

9.4 Impact Test

9.4.1 Izod Impact Test

Izod impact test, where specified shall be carried out on test pieces machined from the test sample selected as in 8 in accordance with IS 1598 : 1977.

9.4.2 Charpy Impact Test

Subject to mutual agreement between the purchaser and the manufacturer, charpy impact test may be carried out in place of izod impact test in accordance with IS 1499 : 1977.

10 MACROSTRUCTURE

10.1 The macrostructure shall meet the following requirements :

- a) Macrostructure shall be free from harmful porosity, slag inclusions, rolled in scale, coarse dendrites, harmful segregation and cracks.
- b) The flow lines shall follow the contour of the forging. Flow lines shall not cut the contour.

11 INCLUSION RATING

11.1 When tested in accordance with IS 4163 : 1982, the non-metallic inclusions shall not exceed 3 thin and 2 thick in grades A B C D, unless otherwise agreed to.

12 GRAIN SIZE

12.1 Austenitic grain size shall be between 5-8 when tested in accordance with IS 4748 : 1988.

Table 2 Variation for Check Analysis

Constituent	Maximum of Specified Range	Variation for Maximum Size, mm	
		Up to 250	Over 250
	Percent	Percent (±)	Up to 500 Percent (±)
Carbon	Up to 0.45	0.02	0.04
	Over 0.45 to 0.90	0.03	0.05
Silicon	Up to 0.40	0.03	0.04
	Over 0.40 to 2.0	0.05	0.06
Manganese	Up to 1.20	0.04	0.06
	Over 1.20 to 2.0	0.05	0.07
Nickel	Up to 1.0	0.03	0.03
	Over 1.0 to 2.2	0.05	0.05
	Over 2.2 to 5.0	0.07	0.07
Chromium	Up to 0.80	0.03	0.04
	Over 0.80 to 2.2	0.05	0.06
	Over 2.2 to 5.5	0.11	0.13
Molybdenum	Up to 0.40	0.03	0.04
	Over 0.40 to 1.2	0.04	0.05
Vanadium	Up to 0.15	0.02	0.02
	Over 0.15 to 0.30	0.03	0.03
Sulphur	—	0.005	0.010
Phosphorus	—	0.005	0.010

NOTE: — Variations shall not be applicable both over and under the specified limits in several determinations in a heat.

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13 ADDITIONAL TESTS

13.1 Subject to mutual agreement between the supplier and the purchaser, the following optional tests as applicable may also be carried out. Method for tests may be followed as given in respective/available Indian Standards.

- a) Metallographic test,
- b) Non-destructive test for internal soundness, and
- c) Fracture test.

14 RETESTS

14.1 Should any of the original test pieces fail to pass the mechanical tests specified in 9, two further test samples shall be selected for retest for each test sample

that failed. One of the test samples shall be taken from forging from which the original test sample was taken unless forging has been withdrawn by the manufacturer.

14.2 The mechanical properties obtained from the test pieces prepared from the two further test samples shall comply with the specified requirements.

15 MARKING

15.1 Unless agreed otherwise between the supplier and the purchaser, each forging shall be clearly marked with the following information :

- a) Indication of the source of manufacture,
- b) Steel designation, and
- c) Identification mark by which it can be traced to the heat number of steel from which the forging was made.

ANNEX A

(Foreword)

INFORMATION TO BE FURNISHED BY THE PURCHASER

A-1 BASIS FOR ORDER

A-1.1 While placing an order the purchaser should specify clearly the following :

- a) Grade designation,

- b) Condition of supply,
- c) Test required,
- d) Method of manufacture,
- e) Any special requirements, and
- f) Test report, if required.

Table 3 Mechanical Properties of Forgings

(Clauses 9.1, 9.1.1 and 9.1.2)

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Designation	Maximum Hardness in Soft Annealed Condition HB	Mechanical Properties in Heat-Treated Condition						
		Condition	Tensile Strength MPa	Yield Strength Min MPa	% Elongation Min Gauge Length 5.65 $\sqrt{S_e}$	Isot Impact Value Min Joules	Hardness HB	Limiting Rolling Section mm
1	2	3	4	5	6	7	8	9
20Cr15	200	H&T	600-750	400	18	50	178-221	63
			700-850	460	16	50	208-252	30
30Cr15	220	-do-	600-750	440	18	50	178-221	150
			700-850	540	18	48	208-252	100
			800-950	600	16	48	235-280	63
			900-1050	700	15	50	268-311	30
15Cr3	170	R, Q & S.R. (Core Properties)	600 Min	-	13	48	-	30
16Mn5Cr4	207	-do-	800 Min	-	10	35	-	30
20Mn5Cr5	217	-do-	1 000 Min	-	8	38	-	30
13Ni13Cr3	229	-do-	850 Min	-	12	48	-	60
15Ni16Cr5	241	-do-	1 350 Min	-	9	35	-	30
15Ni5Cr4Mo1	217	-do-	1 000 Min	-	9	41	-	30
15Ni7Cr4Mo2	217	-do-	1 100 Min	-	9	35	-	30
16Ni8Cr6Mo2	229	-do-	1 350 Min	-	9	35	-	30
20NiCrMo2	213	-do-	900 Min	-	11	41	-	30
36Si7	217	H&T	800-950	-	-	-	235-280	100
37Mn5Si5	217	-do-	780-930	590	14	-	-	-
55Si7	245	-do-	1 300-1 500	-	-	-	380-440	100
35Mn6Mo3	220	-do-	700-850	540	18	55	208-252	150
			800-950	600	16	55	235-280	100
			900-1 050	700	15	50	268-311	63
			1 000-1 150	800	13	45	295-341	30
40Cr4	220	-do-	700-850	540	18	55	208-252	100
			800-950	600	16	55	235-280	63
			900-1 050	700	15	50	266-311	30

Table 3 (Concluded)

1	2	3	4	5	6	7	8	9
07Cr4Mo6 [*]	170	N&T	380-550	225	19	60	--	40
10Cr9Mo10 [*]	187	-do-	410-590	245	18	55	--	50
			520-680	310	18	50	--	--
21Cr4Mo2	210	H&T	650-800	420	16	60	190-235	150
			700-850	460	15	55	208-252	100
			800-950	580	14	50	235-280	40
40Cr4Mo3	220	-do-	700-850	540	18	55	208-252	150
			800-950	600	16	55	235-280	100
			900-1 050	700	15	50	266-311	63
			1 000-1 150	800	13	45	295-341	30
25Cr13Mo6	230	-do-	900-1 050	700	15	55	266-311	150
			1 000-1 150	800	13	48	295-341	150
			1 100-1 250	880	12	41	325-370	100
			1 550 Min	1 300	8	15	450 Min	63
35Ni5Cr2	220	-do-	700-850	540	18	55	208-252	150
			800-950	600	16	55	235-280	100
			900-1 050	700	15	50	266-311	63
40Ni6Cr4Mo3	230	-do-	900-1 050	700	55	55	266-311	150
			1 000-1 150	800	13	48	295-341	100
			1 100-1 250	880	11	41	325-370	63
			1 200-1 350	1 000	10	30	355-399	30
40Ni10Cr3Mo6	250	-do-	1 000-1 150	800	12	48	295-341	150
			1 100-1 250	880	11	41	325-370	150
			1 200-1 350	1 000	10	35	355-399	150
			1 550 Min	130	8	15	450 Min	100
50Cr4V2	240	-do-	900-1 100	700	12	45	266-325	100
			1 000-1 200	900	10	45	295-355	40

H&T = Hardened and Tempered

N&T = Normalised & Tempered

R, Q & SR = Refined, Quenched & Stress Relieved.

*All properties for guidance only. Other values may be mutually agreed between the customer and the supplier.

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