



PLANT PURCHASING SPECIFICATION HYDERABAD

HY10994

Rev. No.05

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PRECIPITATION HARDENING STAINLESS STEEL BARS (SOFTENED) GR: 2S 144

1.0 GENERAL:

This specification governs the requirements of softened precipitation hardening stainless steel bars of grade 2 S 144.

2.0 APPLICATION:

For the manufacture of Impeller forgings meant for centrifugal compressors.

3.0 CONDITION OF DELIVERY:

Hot rolled/forged and softened condition. All forged bars shall be supplied in rough turned condition.

4.0 COMPLIANCE WITH NATIONAL/INTERNATIONAL STANDARDS:

This specification is based on the specification BS 2 S 144.

5.0 DIMENSIONS AND TOLERANCES :

5.1 Dimensions: The dimensions shall be as specified in the order. Unless otherwise specified in the order, the hot rolled bars shall be supplied in random lengths of 3 to 6 meters with a maximum of 10% shorts down to 1 meter. All forged bars shall be supplied in random lengths of 1.5 to 3.0 meters in rough turned condition.

5.2 Tolerances: The tolerances on cross sectional dimension shall be as follows:

5.2.1 Hot Rolled bars: The bars shall not vary from specified diameter or distance across flats by more than $\pm 2\frac{1}{2}\%$.

5.2.2 Forged Bars: The diameter of the forged bars shall not be more than +2.0mm of the ordered size.

6.0 MANUFACTURE :

6.1 The steel used shall be fully killed and shall be manufactured by basic electric process. The steel shall subsequently Vacuum degassed (under an atmospheric pr. of 2 torr. max) followed by refining through ESR process.

6.2 In place of vacuum degassing & ESR process, VAR process may be followed.

6.3 Any other process of steel melting and refining shall be mutually agreed upon.

Revisions: Modified Cl.6.0,8.0 and added
Cl 12.2 & 15.0

Issued :
STANDARDS ENGINEERING DEPARTMENT

Rev. No. 05

Amd. No.

Reaffirmed:

Prepared:

Approved:

Date of 1st issue:

Dt. July 2013

Dt.

Year:

MANAGER
MATLS. ENGG.

AGM (ENGG.)

AUG. 1982

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6.4 The actual Hydrogen gas content shall be analyzed in molten metal after vacuum degassing /VAR process and shall be reported. Hydrogen content shall be less than 2.0 ppm.

6.5 Rolled or forged bars shall be manufactured after giving sufficient reduction to each ingot ensuring that the cast structure is completely broken into fine grain structure. The reduction ratio shall not be less than 4:1 from ingots.

6.6 The material as per this specification shall be supplied by the manufacturers who are having complete in-house steel melting, refining, hot rolling/forging/blooming/etc., heat treatment and testing facilities.

7.0 HEAT TREATMENT :

7.1 Material shall be supplied in softened condition only. However, test samples/ flats shall be subjected to the following heat treatment.

- Solutionizing** at 1000 -1050°C, Soaking for sufficient period not less than 30 min, followed by air cooling.
- Conditioning** at 750 - 850°C, Soaking for sufficient period not less than 2 hrs, followed by air cooling.
- Final ageing** at 450 - 460°C, Soaking for sufficient period not less than 2 hrs, followed by air cooling.

The actual heat treatment cycle followed shall be reported in the test certificates.

7.2 Softened Condition: Heating to 610 - 630°C followed by soaking according to thickness/ diameter (1 min per mm or 2 hrs, whichever is higher) followed by air cooling.

8.0 SURFACE FINISH:

- The surface finish of the bars shall be 6.3 microns (r.m.s.). The edges of bars shall be cut square by sawing or shearing and no crop ends shall be permissible.
- All bars shall be sound and free-from cracks, flakes, cavities and other harmful defects.

9.0 CHEMICAL COMPOSITION:

The steel shall conform to the following Chemical Composition:

Element		C	Si	Mn	Cr	Ni	Cu	S	P	Mo	Nb	H ₂ ppm
Ladle Analysis	Min	-	-	-	13.20	5.00	1.20	-	-	1.20	0.10	-
	Max.	0.07	0.60	1.00	14.70	5.80	2.00	0.025	0.035	2.00	0.40	2.0
Permissible variation in product Analysis		+0.002	+0.05	+0.03	±0.15	±0.10	±0.10	+0.005	+0.005	±0.05	±0.05	-



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10.0 TEST SAMPLES:

10.1 One test sample for chemical analysis shall be taken from a bar representing each melt.

10.2 Test samples selected from each size of the bars in a lot belonging to same melt shall be heat treated according to clause -7.0, before mechanical testing. (Supplier has got the option of upsetting the test coupon to further 1.5 reduction ratios before heat treatment for the bars of sizes above 200 mm diameter).

11.0 MECHANICAL PROPERTIES:

11.1 Test samples shall be taken from heat treated test coupon in tangential direction for each melt of bars more than 150 mm dia. / size. For bars of dia. /size up to 150mm (inclusive), the properties can be tested in longitudinal direction on heat treated samples.

11.2 The following properties shall be achieved. The values obtained shall be reported in test certificate.

Tensile Strength N/mm ²	0.2% Proof Stress, N/mm ² (min.)	% Elongation L=5.65 √So min.	Impact Strength, Min (2mm - V notch) J, at room temperature
1130 - 1330	1030	12	40 (J)

Note:1) Tensile test shall be performed as per IS :1608 or any reputed National Standard.

2) The minimum Impact strength value specified above is the average of three samples at the same location. Only one value can be lower than the specified minimum value, but in no case lower than 2/3rd of the specified minimum value. All the three values shall be reported.

11.3 **Hardness Test:** 10% of the bars or 10 bars minimum (whichever is higher) shall be tested for hardness. Hardness in annealed condition shall be less than 331 BHN. Hardness for the heat treated flats shall be as
The hardness values for the tested bars shall be reported in test certificate.

12.0 NON-DESTRUCTIVE TEST:

12.1 **Ultrasonic test:** The bars shall be subjected to ultrasonic testing as per BHEL Standard AA 0850118 and acceptance norm shall be category 1 of AA0850118.

12.2 **Magnetic particle test:** All the forgings shall be subjected to magnetic particle inspection as per ASTM: E709. Cracks are not acceptable.

13.0 NON METALLIC INCLUSIONS:

The inclusion contents of the steel shall not be greater than class-2 (thin series) and 0.5 thick series as per ASTM: E45, Plate I for inclusion type A, B, C & D.

14.0 RETESTS:

If any of the selected test samples (after heat treatment) fails to meet the specified requirements due to some mechanical reasons, another specimen may be taken.

In the event of failure due to heat treatment, not more than two reheat treatments may be carried out. However, re-tempering is not considered as reheat treatment.

15.0 ADDITIONAL REQUIREMENTS FOR FIRST TIME SUPPLIES:

A comprehensive Manufacturing Process Plan (MPP) and Quality Plan including additional requirements (if any) duly approved by BHEL are mandatory before placement of order on a vendor who has not supplied the same material in the past.

The MPP shall include the stage wise detailed Manufacturing process (with control parameters at each stage) and Testing Plan (MTP) indicating the steel melting processes, ingot dimensions, forging process, forging ratio, heat treatment plan, sketches showing test sample locations and stages of inspection etc.

No process parameter changes are permitted without written approval of BHEL for subsequent supplies once the MPP referred above is frozen.

BHEL may incorporate additional tests in the purchase order depending upon review of the capabilities / experience of the new vendor during first time supplies of this material to BHEL.

16.0 INSPECTION AT SUPPLIER'S WORKS:

16.1 BHEL representative shall have free entry and access to all areas where the manufacture of the bars is carried out. All reasonable facilities shall be extended to him including labour wherever necessary.

16.2 BHEL representative shall be given sufficient advance intimation to witness the various processes, tests, etc. Punching and identification of test coupons and forging and execution of various tests shall be done in presence of BHEL representative.

17.0 TEST CERTIFICATE:

Five copies of test certificates giving the following details shall be furnished.

- a) BHEL specification No: HY 10994 / Rev.05
- b) BHEL Order No.
- c) Size.
- d) Melt No. (Along with process of steel melting/refining).
- e) Results of chemical analysis along with the H₂ content report.
- f) Results of Mechanical Tests.
- g) Results of hardness test on bars.
- h) Results of NDT.
- i) Inclusion content of steel.
- j) Details of heat treatments.

The test certificate shall be signed by the chief of Inspection /Chief Metallurgist of the firm and duly signed by BHEL nominated inspector.



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18.0 MARKING AND PACKING:

The following details shall be legibly stamped on each bar on one of the end face.

- a) HY 10994 Rev.05
- b) Manufacturer's Mark.
- c) Melt No. /size.
- d) BHEL Inspector's stamp.

The bars shall be suitably protected from damage during transport.

19.0 REJECTION AND REPLACEMENT:

In the event of the bar material proving defective in the course of further processing at BHEL, the same shall be rejected notwithstanding any previous acceptance.

The supplier shall replace the rejected material at his own cost and the rejected bars shall be returned after all the commercial conditions are satisfied.