

## Specifications of Impeller forgings

**Material Specification: HY19391**

**Grade: V X12 Cr13 G**

**Dimensions: OD 830 X ID 370 X Thickness 120 (all are in mm)**

Quantity: 2 No's.

(Please find the attachment for material specification HY19391)

**Material Specification: HY19395**

**Grade: 2 S144- MDN 59**

**Dimensions: OD 450 X ID 210 X Thickness 75 (all are in mm)**

Quantity: 2 No's

(Please find the attachment for material specification HY19395)

For Technical clarifications please contact :

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**PLANT PURCHASING  
SPECIFICATION  
HYDERABAD**

**HY19391**

Rev. No.04

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**ELECTROSLAG REFINED STAINLESS STEEL IMPELLER FORGINGS, ANNEALED**  
**(GR: V X 12 Cr 13 G)**

**1.0 GENERAL :**

This specification governs the quality requirements of Electroslag refined, stainless steel impeller forgings.

**2.0 APPLICATION :**

These forgings are used for the manufacture of welded impellers of centrifugal compressors.

**3.0 CONDITION OF DELIVERY :**

The forgings shall be supplied in annealed condition. Forgings shall be rough machined unless otherwise specified in drawing.

**4.0 COMPLIANCE WITH NATIONAL/INTERNATIONAL STANDARDS :**

The forgings shall in general comply with UNI-6901, X12 Cr 13, with the following specific/ additional requirements.

**5.0 DIMENSIONS AND TOLERANCES :**

**5.1 Dimensions:** The dimensions shall be as specified on the drawings/order.

**5.2 Tolerances:**

- a) For finish machined component drawings, the extra allowance of  $3\pm 1$ mm per surface shall be provided for finish machining at BHEL.
- b) For rough machined forging drawings, necessary finish machined allowance is included in the dimensions. Hence extra allowance is not required. The tolerance shall be  $\pm 1$  mm on dimension, unless otherwise specified on the drawing/order.

**6.0 MANUFACTURE :**

**6.1** The steel used shall be fully killed and shall be manufactured by basic electric process. The steel shall subsequently be refined through ESR process. Any other process of steel melting and refining shall be mutually agreed upon.

**Revisions:**

Upgradation of the technical requirement.  
Modified Clauses 1.0, 6.0 & 11.0

**Issued :**

**STANDARDS ENGINEERING DEPARTMENT**

**Rev. No. 04**

**Amd. No.**

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MANAGER  
MATLS. ENGG.

AGM (ENGG.)

AUG. 1982

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The actual gas content shall be analysed and reported. Hydrogen content shall be less than 1.5 ppm.

- 6.2** If ingots are used for forgings, sufficient discard shall be given from top and bottom of the ingot to ensure freedom from piping, segregation and other injurious defects.
- 6.3** The degree of forging shall be minimum 4 if ingots are used as forging stock and minimum 1.5 if blooms/billets are used as forging stock. It has to be ensured that cast structure is completely broken into fine grain structure.

Note: The hub and shroud forgings shall be forged from the raw material of same melt.

**7.0 HEAT TREATMENT:**

The Forging shall be supplied in annealed condition. The recommended heat treatment for the test samples shall be as follows. No deviations in heat treatment temperatures are permitted.

**Hardening:** Heating to 970-1000°C, soaking 4 hours and quenching in oil. Water quenching is not permitted.

**Tempering:** Heating to min. 600°C, soaking 3 hours and cooling in still air.

**8.0 SURFACE FINISH:**

The Surface finish of rough machined forgings shall be 6.3 microns (r.m.s).

**9.0 FREEDOM FROM DEFECTS:**

Forgings shall be sound and free-from cracks, flakes, cavities and other harmful defects.

**10.0 CHEMICAL COMPOSITION:**

The steel shall conform to the following Chemical Composition.

Element		C	Si	Mn	Cr	Ni	S	P	S+P	H <sub>2</sub>
Ladel analysis	Min	0.09	-	-	11.5	-	-	-	-	ppm
	Max.	0.15	1.0	1.0	14.0	1.0	0.020	0.020	0.035	1.5
Variation in product analysis		±0.01	±0.05	+0.03	±0.15	+0.03	+0.003	+0.003	-	-

**Note:** Cr equivalent shall be less than 8.4  
 (Cr.-eq. = Cr +2Si +1.5Mo +5V +5.5Al -Ni -5Mn -30C -25N)



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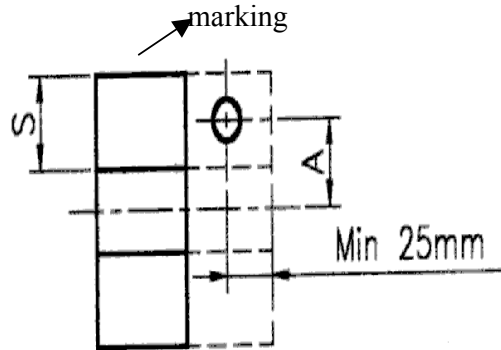
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**11.0 TEST SAMPLES:**

One test coupon per melt shall be taken for heat treatment as per clause 7 and to prove the mechanical properties as given in clause 12. For extracting test coupon, one forging per melt shall be given additional thickness and mechanical properties shall be proved on such test coupons in Tangential direction. The remaining test coupon shall be sent to BHEL with proper identification marks for further testing.



	S ≤ 50mm	S > 50mm
A	½ S	1/4s(Min)

11.2 Whenever, impeller discs are forged using the raw material procured as per HY10995, the heat treatment and mechanical tests on the test coupons need not be carried out.

**12.0 MECHANICAL PROPERTIES:**

12.1 The heat treated test samples shall have the following mechanical properties.

Tensile Strength N/mm <sup>2</sup> (Kgf/ mm <sup>2</sup> )	0.2% proof stress N/mm <sup>2</sup> (Kgf/ mm <sup>2</sup> )	Elongation % min L=5.65 SO	Impact Strength, Min (5mm 'U' notch) J( kgf/cm <sup>2</sup> )AT ROOM TEMPERATURE	Hardness BHN
930 max. (95 max.)	640-740 (65-75)	14	20 (14)	240 to 260

**Note:**

- 1) Tensile test shall be performed as per IS :1608 or any reputed National Standard.
- 2) The charpy impact test shall be performed on a 5mm 'u' Notch in accordance with IS:1757 or any reputed National Standard.  
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 min. value, but in no case lower than 2/3<sup>rd</sup> of the specified min. value. All the three value shall be reported

12.2 **Hardness:** All the forgings in annealed condition shall be tested for hardness. Hardness shall be 207 BHN max. All the values shall be reported in Test Certificate.

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**13.0 NON-DESTRUCTIVE TEST:**

**13.1 Ultrasonic test:** Forgings shall be subjected to ultrasonic testing as per ASTM: A388 (BHEL Standard AA 0850118) and acceptance norm shall be category 1 of AA0850118.

**13.2 Liquid penetrant test:** All the forgings shall be subjected to liquid penetrant test as per ASTM E165 (BHEL standard AA0850131). Cracks, seams, laps and porosity defects are not acceptable.

**14.0 TEST FOR CLEANLINESS:**

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 III for inclusion type A,B,C & D.

**15.0 MICROSTRUCTURAL EXAMINATION:**

The steel shall not have more than 2 % free ferrite when measured in the hardened and tempered sample. The same shall be reported in the test certificate.

**16.0 RETESTS:**

If any of the selected test samples fail to meet the specified requirements due to some mechanical reasons, another specimen may be taken..

In the event of failure due to heat-treatment one reheat-treatment, may be carried out.

**17.0 INSPECTION AT SUPPLIER'S WORKS:**

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

**17.2** 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.

**17.3** Unless otherwise indicated in the enquiry/order; LRIS shall be BHEL representative for inspection activities mentioned in cl. Nos. 17.1 & 17.2

**18.0 TEST CERTIFICATE:**

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

- a) BHEL specification No: HY 19391 / Rev.04
- b) BHEL Order No.
- c) Melt No
- d) Results of chemical analysis.



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- e) Results of Mechanical Tests.
- f) Results of hardness test on forgings.
- g) Results of NDT.
- h) Inclusion content of steel.
- i) Details of heat treatments.

**18.2** The test certificate shall be signed by the chief of Inspection /Chief Metallurgist of the firm and duly signed by LRIS..

**19.0 MARKING AND PACKING :**

**19.1** The following details shall be legibly stamped on each forging in such a position so as not to injure the usefulness of the forgings.

- a) HY 19391 Rev.04
- b) Manufacturer's Mark.
- c) Drawing No.
- d) Melt No.
- e) Serial No. of the forging.
- f) BHEL Inspector's stamp

**19.2** The forgings shall be suitably protected from damage during transport. In the case of imported forgings, the packing shall be sea worthy.

**20.0 REJECTION AND REPLACEMENT:**

In the event of the forging 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 forging at his own cost and the rejected forging shall be returned after all the commercial conditions are satisfied.

**21.0 REFERRED STANDARDS:**

- UNI - 6901
- IS:1608
- IS:1757
- ASTM A 388 (AA0850118)
- ASTM A 275
- ASTM E 45 Pt.III for type A,B,C,D.



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**ELECTRO SLAG REFINED PRECIPITATION HARDENED  
STAINLESS STEEL IMPELLER FORGINGS  
(GR : 2 S 144)**

**1.0 GENERAL:**

This specification governs the quality requirements of Electro slag refined precipitation hardening stainless steel impeller forgings.

**2.0 APPLICATION:**

These forgings are used for manufacture of Centrifugal Compressor welded Impellers and pump components.

**3.0 CONDITION OF DELIVERY :**

The forgings shall be supplied in softened condition. Forgings shall be rough machined unless otherwise specified in the drawing.

**4.0 COMPLIANCE WITH NATIONAL STANDARD :**

The forgings shall in general comply with the latest version of BS-2S144 with the following specific / additional requirements.

**5.0 DIMENSIONS AND TOLERANCES :**

**5.1 Dimensions:** The dimensions shall be as specified on the drawings.


**5.2 Tolerances:**

- a) For finish machined component drawings, the extra allowance of  $3 \pm 1$  mm per surface be provided for finish machining at BHEL.
- b) For rough machined forging drawings, necessary finish machined allowance is included in the dimensions. Hence extra allowance is not required. the tolerance shall be  $\pm 1$  mm on dimension, unless otherwise specified on the drawing.

**Revisions:**  
Modified clause 6.0 and clause 13.2

**Issued :**  
**STANDARDS ENGINEERING DEPARTMENT**

Rev. No	Rev. Date:	Revised:	Prepared:	Approved:	Date of 1 <sup>st</sup> issue:
02	APR. 2005	SR.ENGR./ MES	MANAGER/MES	AGM (ENGG.)	JUL., 1982.

HY19395	<b>PLANT PURCHASING SPECIFICATION HYDERABAD</b>	
Rev. No. 02		
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<p><b>6.0 MANUFACTURE:</b></p> <p>6.1 The steel used shall be fully killed and shall be manufactured by basic electric process and shall subsequently be refined through ESR process. Any other process of steel melting &amp; refining shall be mutually agreed upon.</p> <p>6.2 The actual gas content shall be analysed and reported. Hydrogen content shall be less than 1.5 PPM. Sufficient discard shall be given from top and bottom of the ingot to ensure freedom from piping, segregation and other injurious defects.</p> <p>6.3 Forgings shall be made 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 the ingots.</p> <p><b>Note:</b> The hub and shroud forgings shall be forged from the raw material of same melt.</p> <p><b>7.0 HEAT TREATMENT:</b></p> <p>Forgings shall be supplied in softened condition (aged at 620°C, soak for 2 hrs min. followed by air cooling). However the recommended heat treatment for the test samples shall be as follows:</p> <p>a) Solution Treatment: Heat uniformly at a temperature range of 1000-1050°C for not less than 30 minutes followed by cooling in air to room temperature.</p> <p>b) Conditioning : Heat uniformly at a temperature range of 750°C-850°C for not less than 2 hours, followed by cooling in air to room temperature.</p> <p>c) Final Ageing: Heat to a temperature of 450 ±10°C for not less than 2 hours, followed by cooling in air to room temperature.</p> <p><b>8.0 SURFACE FINISH:</b></p> <p>The Surface finish of rough machined forgings shall be 6.3 microns (r.m.s).</p> <p><b>9.0 FREEDOM FROM DEFECTS:</b></p> <p>Forgings shall be sound and free-from any cracks, flakes, cavities and other harmful defects.</p> <p><b>10.0 CHEMICAL COMPOSITION:</b></p> <p>The steel shall conform to the following Chemical Composition.</p>		

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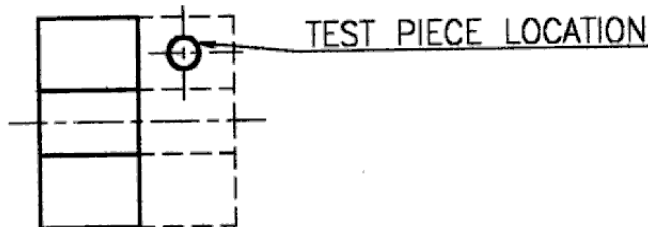
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Element	C	Si	Mn	Cr	Ni	Cu	S	P	Mo	Nb	H2 ppm	
Ladle Analysis	Min.	-	-	-	13.20	5.00	1.20	-	-	1.20	0.10	-
	Max.	0.07	0.60	1.00	14.70	5.80	2.00	0.025	0.035	2.00	0.40	1.5
Permissible variation in product Analysis	+0.002	+0.05	+0.03	±0.15	±0.10	±0.10	+0.005	+0.005	±0.05	±0.05	-	

**11.0 TEST SAMPLES:**

**11.1** One test coupon per melt shall be taken for heat treatment as per clause 7 and to prove the mechanical properties as given in clause 12. For extracting test coupon, one forging per melt shall be given additional thickness and mechanical properties shall be proved on such test coupons in Tangential direction. The remaining test coupon shall be sent to BHEL with proper identification marks for further testing.



**11.2** Whenever impeller discs are forged using the raw material procured as per HY 10994, the heat treatment and mechanical tests on the test coupons need not be carried out.

**12.0 MECHANICAL PROPERTIES:**

1. Heat treated test samples shall conform to the following mechanical properties.

Tensile Strength N/mm <sup>2</sup>	0.2% Proof Stress, N/mm <sup>2</sup> min.	% Elongation L=5.65 √So min.	Impact Strength min. (at room temperature) 5mm 'U' notch J
1130-1330	1030	12	20 (J)

2. All the forgings shall be tested for hardness values at least at three locations and the hardness shall be 331 BHN maximum. The hardness values for each forging shall be reported in the test certificate.

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- Note:**
- 1) The tensile tests shall be performed as per IS:1608 or any reputed National Standard.
  - 2) The Charpy Impact test shall be performed on 10x10x55mm specimen with a 5mm 'U' Notch.

The minimum Impact value specified shown above is the average of three samples at the same location. Only one value can be the minimum value specified, but in no case less than 2/3<sup>rd</sup> of the same. All the three values shall be reported in the test certificate.

### 13.0 NON-DESTRUCTIVE TESTS:

**13.1 Ultrasonic Test:** Forgings shall be subjected to ultrasonic testing as far as technically feasible as per ASTM A388 (BHEL Standard AA 0850118), and following shall be the unacceptable defects (category 1 of AA0850118)

- i) Cracks, Flakes, Seams and Laps.
- ii) Defects giving indications larger than that from 2mm diameter equivalent flaw.
- iii) Groups of defects with maximum indication less than that from a 2mm diameter equivalent flaw which cannot be separated at testing sensitivity of the back echo is reduced to less than 70%.
- iv) Defects giving indication of 1 to 2mm diameter equivalent flaw separated by a distance less than four times the size of the larger of the adjacent flaws.

**13.2 Liquid penetrant test:** All the forgings shall be subjected to liquid penetrant test as per ASTM E165 (BHEL Standard AA0850131). Cracks, laps, seams and porosity defects are not acceptable.

### 14.0 TEST FOR CLEANLINESS:

The inclusion contents of the steel shall not be greater than class-2 of ASTM:E45 Plate III.

### 15.0 RETESTS:

If any of the selected test samples fail to meet the specified requirements due to some mechanical reasons another specimen may be taken.

In the event of failure due to heat treatment another reheat treatment may be done. Maximum two reheat treatments are permitted.



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**16.0 INSPECTION AT SUPPLIER'S WORKS:**

**16.1** BHEL representative shall have free entry & access to all areas where the manufacture of the forgings is carried out. All reasonable facilities shall be extended to him including labour wherever necessary. Sufficient advance intimation shall be given to the representative to witness the various processes, tests etc. Identification of test coupons & forgings and execution of various tests shall be done in his presence.

16.2 Unless otherwise indicated in the enquiry, Lloyds shall be the BHEL representative for inspection activities mentioned at 16.1.

**17.0 TEST CERTIFICATE:**

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

- a) BHEL Specification No: HY19395/Rev .02
- b) BHEL Order No.
- c) Melt No. and Piece No.
- d) Results of chemical analysis
- e) Results of Mechanical Tests/hardness tests
- f) Results of NDT
- g) Inclusion content of steel.
- h) Details of heat treatment cycle followed.

**17.2** The certificates shall be duly signed by chief of Inspection/Chief Metallurgist of the mill and BHEL representative.

**18.0 MARKING AND PACKING:**

The following details shall be legibly stamped on each forging in such a position so as not to injure the usefulness of the forgings.

- a) HY 19395/Rev.02
- b) Manufacturer's Mark.
- c) Drawing No.
- d) Melt No.
- e) Serial No. of the forging
- f) Inspector's Stamp

The forgings shall be suitably protected from damage during transport.

**19.0 REJECTION AND REPLACEMENT:**

In the event of the forging proving defective during the course of further processing or testing, such material shall be rejected and the supplier shall make immediate arrangements to replace the same free of cost, and the rejected forgings shall be returned after all the commercial conditions are satisfied.