गोपनीय एवं अधिकार सुरक्षित
इस प्रपत्र पर दी गई जानकारी भारत हेवी इलेक्ट्रिकल्स लिमिटेड की संपत्ति है इसे प्रत्यक्ष या अप्रत्यक्ष रूप से कम्पनी के हितो को नुकसान पहुँचाने के लिए कदापि उपयोग नही किया जावे

ALLOY STEEL FORGINGS - HARDENED AND TEMPERED

1. **GENERAL :**
This specification governs the quality of forged alloy steel forgings in Hardened & Tempered Condition.

2. **APPLICATION :**
Pole end plates, shafts and other components for generators.

3. **CONDITION OF DELIVERY :**
Forged, Hardened & Tempered in the "rough machined" condition. Forgings shall be commercially straight.

4. **COMPLIANCE WITH BHEL / NATIONAL STANDARDS :**

There is no Indian Standard covering this type of material.

5. **DIMENSIONS AND TOLERANCES :**
The dimensions and tolerances shall be as specified on the order/drawing, and shall not exceed these dimensions. A tolerance of 3 mm for finish has been provided in specifying the rough turned dimensions.

Any forging which is bent to interfere with its finishing to desired sizes shall be rejected.

6. **MANUFACTURES :**
Forgings shall be manufactured from steel produced by the open-hearth, electric or such other process as may be agreed to between the BHEL and the supplier. The steel shall be "Fully Killed".

Sufficient discard shall be made from each ingot to ensure freedom from pipe, segregation and other defects.

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. Forgings shall not be over heated.

Rev.01 Date: 29/09/2016 - Ref. of BHEL standard BP19389 is removed from Sr. No. 4 - Sr. No.11 ,Mechanical Properties UTS, elongation & Hardness updated 24/09/16. 29/5/2016 29/9/16	हाइडोजनरेटर इंजीनियरिंग विभाग भारत हेवी इलेक्ट्रिकल्स लिमिटेड		
	तैयारकर्ता	अनुमोदनकर्ता	जारी करने की दिनांक
	-Sd- ANUPAM KUMAR	-Sd- P.CHAUDHURI	14-07-2008

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The minimum reduction ratio when forgings are made out of ingots shall be 4:1.

The coupling or driven end of the shaft shall be indicated on the drawing. These ends shall correspond to the bottom of the ingot.

7. **HEAT TREATMENT :**

After forging and rough turning, the forgings shall be hardened & tempered. Forgings shall be free from uneven internal stresses, and shall have homogeneous grain structure.

Details of heat treatment shall be furnished to BHEL as and when called for.

8. **FREEDOM FROM DEFECTS :**

The forging shall be homogeneous, free from excessive hardness, slag spots, sand seams, blow holes, clinks, cracks or other imperfections.

9. **CHEMICAL COMPOSITION :**

The chemical composition of the material based on melt analysis shall comply with the following requirement.

Element	% Minimum	% Maximum
Carbon	0.19	0.25
Manganese	0.60	1.00
Silicon	-	0.35
Sulphur	-	0.03
Phosphorus	-	0.03
Nickel	0.35	0.75
Chromium	0.35	0.65
Molybdenum	0.15	0.25

Note : Carbon equivalent shall not be exceed 0.50 percent when calculated from the formula given below :

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

10. **TEST SAMPLES :**

10.1 Unless otherwise specified on the order/drawing, test samples shall be taken from each cast and each heat treatment batch. Test samples should be cut from the heat treated forgings by cold process only and shall receive no further heat treatment.

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Test samples shall be taken from locations indicated on the drawing, leaving enough material, if required, for testing at purchaser's end, integral with the forging.

10.2 When integral test pieces are not called for and it is not possible to destroy the forgings, separate test samples as mentioned on the order/drawing shall be provided from the blooms and billets from which the forgings are made. They shall be forged to the ruling section of the main forgings and shall be heat treated similarly and simultaneously with the forgings they represent.

10.3 Test samples shall be cylindrical in shape.

(a) Longitudinal / Radial test piece shall be taken from one end of the forging. Radial test piece may be taken from economic considerations.

(b) Tangential test piece shall be taken from other end of the forging.

(c) Test piece diameter shall be 10mm for HG 06004 min.
(as per IS-1608:1995, amd. No. 1, May 2002, table 5).

Test piece shall be cut as below :

(i) For solid forgings: at a distance of one-third radius or one-sixth diagonal from the outer surface.

(ii) For hollow forgings: midway between the inner and outer surface of the wall thickness.

11. **MECHANICAL PROPERTIES** : (Longitudinal)

The test pieces, shall show the following properties for all ruling sections. Test methods are specified below :

10.1 Tensile test : IS : 1608
10.2 Hardness test (Brinell) : IS : 1500
10.3 Mechanical properties

i)	Tensile strength (in any direction)	- 620 N/mm^2 Min
ii)	Yield strength (in any direction)	- 462 N/mm^2 Min
iii)	Elongation 5.65 " so gauge length long / Radial	- 16 % min
	Tangential	- 16% min
iv)	Reduction in area	- 40% min.
v)	Hardness (Brinnel) for reference only	190-260

Note: For an indication of the general quality of the steel, the broken test pieces shall show a fracture of uniform silky appearance free from granular black or brilliant specks, though this would not be criteria for rejection.

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12. **MAGNETIC PROPERTIES: (For information only).**

Magnetic Field Strength (H) A/m	Magnetic Induction (B) Minimum Tesla or Wb/m2
3400	1.39
6200	1.55
10400	1.70
14800	1.76

One sample of size Ø 13 x 50 shall be taken from the each P.F. and shall be submitted to BHEL for testing for B/H-Magnetisation properties, irrespective of whether supplier has got facilities or not for the same.

13. **NON-DESTRUCTIVE TESTING (OPTIONAL) :**
When stated on the order/drawing, the forgings shall be ultrasonically tested to BHEL Corporate Standard AA 085 0101 for shafts and to AA 085 01 18 for other forgings. Acceptance Standard shall comply with category class mentioned in the standards & called for on the order/drawing.

Boroscopic test for central hole in case of shaft forging shall be carried out to AA 0850101 before application of antirust compound.

14. **TEST CERTIFICATES :**
Three copies of test certificates shall be supplied unless otherwise stated on the order. In addition, the supplier shall ensure to enclose one copy of the test certificate along with their dispatch documents to facilitate quick clearance of the material.

The following details shall be furnished in the test certificate

i) Reduction Ratio.
ii) Dimensional Inspection.
iii) Details of heat treatment.
iv) Chemical composition including trace elements.
v) Results of mechanical tests.
vi) Results of ultrasonic test.
viii) Microstructure examination report.

In addition, the supplier shall ensure to enclose one copy of the test certificate along with their despatch document to facilitate quick clearance of material.

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15. **INSPECTION AT SUPPLIER'S WORKS** :
Tests and inspection are to be conducted in the presence of purchaser's representative. The representative shall have free access at all times while the work on the contract is being performed. All facilities without charge to be provided to purchaser during inspection including provision of test specimen and its testing. If necessary supplier shall make necessary arrangement for carrying out the test elsewhere.

16. **REJECTION AND REPLACEMENT** :
In the event of any forging proving defective in the course of preparation, machining, testing or erection such forging shall be rejected, notwithstanding any previous certification of satisfactory testing and / or inspection.

The supplier shall undertake to replace the rejected forgings at his own cost and the rejected forgings shall be sent back to the supplier after fulfilling the commercial terms and conditions.

17. **PACKING AND MARKING** :
Forgings shall be suitably packed to prevent corrosion and damage during transit

Machined surfaces shall be properly protected with anti-corrosive compounds suitable for out door storage for a minimum period of six months. Each package or forging (when supplied separately) shall be legibly marked with the following information.

HG 06004 : Alloy Steel Forgings - Hardened & Tempered.
Our Order No.
Consignment or identification No.
Batch No.
Heat No.
Melt No.
Weight
Supplier's Name

18. **DOCUMENTS TO BE SUBMITTED ALONG WITH OFFER** :
Manufacturing process chart comprising of manufacturing sequence, forging sequence, calculation of forging ratio , heat treatment cycle with stage wise test schedule.

NOTE: WITHOUT THIS DOCUMENT, OFFER WILL BE CONSIDERED INCOMPLETE.

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ANNEXURE - I : RECOMMENDED TEST CERTIFICATE FORMAT FOR FORGINGS

Annexure - 1

Supplier's Name and Address

1. Customer
2. TC No. & Date
3. PO No.
4. Process of Malting Ingot
5. Deoxidisation Process
6. Forging Method
7. BHEL's Reference for Approval of Bloom
8. Discard : Top_____% Bottom ____%
9. Reduction : Ratio — ingot to Bloom, Bloom to Blank
10. Batch No.
11. Heat / Melt No.
12. Spec. No.
13. Test Bar Size & Nos.
14. Supplier of the Ingot/billet/ Bloom and TC reference

15. FORGINGS COVERED BY TEST CERTIFICATE

S.No.	Drawing No. & Item No.	Description	Quantity & Weight

16. CHEMICAL COMPOSITION (PERCENT)

Element	Min	C	Sr.	Mn	S	P											
As Per Speon	Max.																
Actual Values																	

17. HEAT TREATMENT
(To be accompanied by Recorder Chart, Whenever called for)

Condition	Heating Rate °C/hr	Temp °C	Soaking Time Hrs.	CoolingRate °C/hr	Cooling Medium

18. MECHANICAL PROPERTIES

As per Speon	Min / Max	T.S. N/mm2	Y.S. 0.5/ 2% Proof Stress	% Elongation 5.65 GL	% R.A. Min	Hardness BHN (Min.3 values	Impact value Joules	Bend Test: Angle of bend	Bend Test: Dia of mandral	Bend Test: Result
Actual Values										
19. SURFACE FINSIH (When called for in the order/drg)										
20. DIMENSIONAL INSPECTION										

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21. NON-DESTRUCTIVE TESTS

Nature of Test	Acceptance level	Instrument used	Range	Results	Any other detail
Ultrasonic					
Radiographic					
Dye penetrant/Magnetic Particle					

22. METAL LOGRAPHIC EXAMINATION

(To be conducted if called for and photo micrographs to be attached alongwith support)

Location of Sample	Element used	Magnification	Constitute observed	Relative %	
Microstructure	Macrotech	Inclusion Rating			

23. IDENTIFICATION OF FORGINGS AS PER PURCHASE SPEC.

We hereby certified, that the items mentioned above have been tested and inspected in our presence and are found to be in accordance with drawings.

SIGNATURE, NAME & SEAL OF THE
INSPECTING OFFICER
DATE

SIGNATURE : NAME & SEAL OF THE
CHEIF OF QUALITY CONTROL /
CHIEF METALLURGIST OF THE SUPPLIER
DATE

24. INSTRUCTIONS

a) Details of all heat treatment processes carried out should be furnished sequentially in new.
b) Test certificates are to be furnished as per Purchase order and specification, in A4 size preferably in transparent paper.
c) All the entries including signature should be in black colour ink.
d) If testing is done by outside agencies, the original TCs shall be furnished
e)The actual TC may run into more than one A4 size paper, if needed, to facilitate filling up details.