



TD219
Rev.00

PLANT PURCHASING SPECIFICATION HYDERABAD

HY 194 67

REV. NO.03

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Cr-Mo-V ALLOY STEEL FORGINGS

1.0 GENERAL:

This specification governs the quality requirements of low alloy Cr- Mo-V steel forgings.

2.0 APPLICATION:

Suitable for turbine wheels, distance pieces, compressor aft shafts etc of Gas Turbines.

3.0 CONDITION OF DELIVERY:

- (1) Material Class A: For Turbine wheels and Compressor wheel 16th stage.
- (2) Material Class B: For compressor aft shaft and distance piece.

Material shall be procured in the forged, heat treated and rough machined condition.

4.0 COMPLIANCE WITH NATIONAL STANDARDS:

There is no national standard to cover this grade of material. However, this standard is based on class E and class M of B50A368 Rev.B of M/s. GE of USA.

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 ± 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 ± 1 mm on dimension, unless otherwise specified on the drawing.

6.0 QUALIFICATION TESTING:

The qualification of forgings shall be as per GT 10047 and the relevant part specification.

Revisions:

Modified mechanical properties.

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7.0 **MANUFACTURE:**

The steel shall be made by the basic electric arc furnace with either.

- a) ladle refining and vacuum treatment or
- b) consumable arc remelting (either VAR or ESR)

NOTE : The vacuum system shall have the capacity to maintain a vacuum of 2 Torr or lesser, for the time required to bring the gas content down to the desired level. For vacuum systems that can have a blank off pressure measurement made, the value must be 1 Torr or less.

8.0 **HEAT TREATMENT:**

8.1 Conditioning: This treatment is done prior to the Quality heat treatment to refine the structure and prevent flaking or other deleterious phenomena. The minimum treatment shall be a normalising cycle within the temperature range of 1010⁰ C to 1040⁰ C.

8.2 **Hardening:**

- Class A : 965 ± 15⁰ C.
- Class B : 955 ± 15⁰ C, Soaking 12 hrs min.

After Austenitizing, the forgings shall be water quenched to a temperature below 150⁰ C. The temperature control shall be such that uniform mechanical properties are achieved.

8.3 Tempering: Forgings shall be seperated in the tempering furnace and shall be positioned sufficiently high above the furnace floor to permit unrestricted flow of hot gases so as to achieve temperature uniformity on all surfaces of the forging. A suitable temperature shall be chosen to achieve the properties specified in clause 11.0

For Class A, minimum tempering time 12 hrs.

For Class B, double tempering is required

Cooling from the tempering temperature shall be done at a suitable rate to avoid temper embrittlement and to maintain a low level of residual stresses.

The position of the forgings in the tempering furnace shall be documented in the suppliers Manufacturing plan.

9.0 **TEST SAMPLES:**

9.1 Chemical Analysis: One sample shall be taken per melt for chemical analysis.

9.2 Mechanical Properties: Bore and Rim samples shall be tested for each production forging to check for uniformity of properties. For first piece qualification testing, relevant process specification may be referred to.

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10.0 CHEMICAL COMPOSITION:

The chemical analysis of the material shall be as follows:

CLASS A AND CLASS B

Element	C	Mn	Si	P	S	Ni	Cr	Mo	V	Cu	Fe
Min. %	0.25	0.55	-	-	-	0.35	0.90	0.90	0.20	-	Bal.
Max. %	0.33	0.90	0.35	0.012	0.010	0.55	1.35	1.50	0.30	0.35	-
Permissible Variation	±0.02	±0.03	+0.05	+0.008	+0.005	±0.05	±0.05	±0.03	±0.02	-	-
Aimed Content	0.29	0.70	-	LAP*	LAP*	0.45	$\frac{1.10}{1.15}$	-	0.25	LAP*	-

*LAP – Low As Possible.

NOTE: (1) Residual elements shall be held as low as possible and should comply with the maximum content given below. Elements which do not comply with the maximum content must be approved by materials Engg Section, BHEL, Hyderabad.

Element	Max. content	Aimed content
Antimony, max.	0.003	LAP
Arsenic, max.	0.020	LAP
Tin, max.	0.015	LAP
Aluminium, max.	0.025	LAP
Calcium, max.	0.010	LAP
Oxygen, max.	75 ppm	LAP
Hydrogen, max.	2 ppm	LAP
Nitrogen, max.	100 ppm	LAP

- (2) Both O₂ & H₂ levels are indicative of the effectiveness of the vacuum treatment. The supplier shall report the measurement on a sample obtained after vacuum processing operation.
- (3) Silicon content shall be 0.12% max. with the Vacuum Carbon De oxidation process.
- (4) Sulphur content of 0.005 max required for any material supplied to this spec which has been produced by any melting process other than consumable Electrode Remelt Process, VAR or ESR.
- (5) O₂, Ca & Al may be used to accomplish various phases of the melting operations. If used, however, O₂, Ca and Al levels shall be reduced to the required levels in the final forging.

11.0 MECHANICAL PROPERTIES:

The mechanical properties for bore, rim and deep seated samples shall be as follows:

Class of Material	Location	Tensile Strength N/mm ² (ksi)	0.2% Yield Strength N/mm ² (ksi)	%Elongation L=50mm min.	%Reduction in Area min.	Brinell Hardness 3000kg load
Class A	Bore and Rim	Note (5)	634-714 (92-102)	18	50	230-290
	Deep Seated* Note (1)	Note (5)	634-714 (92-102)	15	30	230-290
Class B	All locations	Note (5)	620-678 (90-98)	18	50	220-265

- NOTE
1. Deep seated samples are required only for first piece qualification.
 2. Unless otherwise specified tensile test bars are taken in tangential direction.
 3. The difference between values for two rim test ring specimens must not exceed 35N/mm² (5ksi) for 0.2 percent yield strength.
 4. The difference between the values for the two bore test ring specimens must be equal to or less than 35N/mm² (5 KSI) for the 0.2 percent yield strength.
 5. The tensile strength values for the forging shall be reported in test report for information only.
 6. The 0.02% yield offset shall be reported for information purposes only.
 7. The BHN values must be within a range of 20 BHN points within the forging.
 8. The 0.2 percent yield strength uniformity values calculated from (3) and (4) above must be reported in the test certificate.
 9. 0.2% yield strength shall be aimed to the lower side of the acceptable value mentioned above.
 10. Any deviation from the above mentioned conditions shall be reported in writing, to Materials Engg Section, BHEL, Hyderabad for approval before proceeding further with production of the forging..



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12.0 CHARPY V NOTCH TEST:

The charpy V Notch Toughness shall be as follows:

Class	Location of Test piece	Min. Energy at 0°F (-18°C) J ft-lbs	Min. Energy at R.T. J ft-lbs	Min. Energy at 130°F (54°C) J ft-lbs	Max. FATT °F (°C)
A	Surface	34 25	70 50	102 75	0 -18
	Deep seated (Note-1)	14 10	27 20	41 30	200 93
B	Surface	34 25	70 50	102 75	0 -18
	Deep seated or Bore (Note-1)	14 10	27 20	49 35	175 80

Note (1) : Deep seated samples are required only for first piece qualification.

13.0 STRESS RUPTURE REQUIREMENTS:

The stress rupture tests shall be done in accordance with ASTM E 139. The tests shall have the following parameters.

Test temperature - 593° C (1100° F)

Stress - 240N/mm2 (35ksi)

Time to failure, min. - 35 hrs.

Test bars shall be machined and tested in accordance with requirements of GT 10047. Method to accelerate specimen failure after test life of 100 hrs. is also specified in GT 10047.

14.0 METALLOGRAPHY:

Samples taken in accordance with GT10047 shall exhibit a tempered bainitic structure with prior austenitic grain size of ASTM 3 or finer.

15.0 NON-DESTRUCTIVE TESTING :

Non-destructive testing shall be carried out in accordance with the process specification GT 10047. Acceptance norms shall be as per applicable part specification and drawing.

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16.0 RETESTS:

If any of the selected specimens fail to meet the specification due to some mechanical reasons, retesting shall be performed on double the number of specimens selected randomly from the same lot. All the retested samples shall meet the specified minimum requirements. In the event of failure due to heat treatment only two more reheat treatment cycles shall be permitted, However retempering is not considered as a repeat heat treatment.

17.0 SCOPE OF THIRD PARTY INSPECTION:

Wherever, separate quality plan is not attached, the scope of third party inspection shall be as follows:

1. Review of supplier's declared chemical composition.
2. Selection of test samples for mechanical tests and witness of mechanical tests.
3. Witness of all NDT tests as applicable.
4. Review of HT charts.
5. Dimensional inspection.

18.0 TEST CERTIFICATES:

Five copies of the test certificates shall be furnished bearing the following details:

- a) Material specification No. HY19467 Rev. 03
- b) BHEL Order No.
- c) Item Description
- d) Drg. Number
- e) Manufacturer's Name
- f) Melt Number.
- g) Heat treatment details
- h) Results of all tests stipulated in this specification.

19.0 MARKING AND PACKING:

Each forging shall carry the following details:

- a) HY19467 Rev. 03
- b) BHEL Order No.
- c) Melt No.
- d) Serial No. of forging
- e) Drg. No.
- f) Supplier's Name

The forgings shall be suitable packed to prevent any sort of damage during transit.