SPECIFICATION FOR ALLOY 617M ROTOR FORGING

1.0 GENERAL

This specification governs the quality of forgings of grade Alloy 617M.

2.0 APPLICATION

For forging of steam turbine shaft.

3.0 COMPLIANCE WITH NATIONAL/INTERNATIONAL STANDARDS

Based on VDTUV Data Sheet 485, ASME SB-564 (non-destructive examinations).

4.0 CONDITION OF DELIVERY

Forged, solution annealed and machined condition as per the ordering drawing no. TEST-RIG-006-617M.

5.0 DIMENSION AND TOLERANCES

Forgings shall be supplied to the dimensions and tolerances as per the ordering drawing no. TEST-RIG-006-617M.

6.0 MANUFACTURING

6.1 GENERAL REQUIREMENTS

Before starting the production the manufacturer shall submit a flow chart of the manufacturing sequence for the forging.

6.2 MELTING PROCESS

Alloy 617M shall be produced by using vacuum induction melting (VIM) followed by vacuum arc remelting (VAR) or electro slag refining (ESR). Any other suitable melting and remelting processes shall be used only after approval from the purchaser.

6.3 FORGING PROCESS

Overall forging ratio (ratio of reduction) calculated in accordance with Annexure - II shall be greater than 3. The forging ratio employed shall be included in the test certificates. There shall be sufficient ingot discard to ensure elimination of shrinkage cavities and segregation. A record of ingot weight and discard percentages shall be provided for information purpose. Forgings shall be manufactured as close as practicable to finish shape and size. It is important to maintain the axial center of the forging in common with the axial center of the ingot.

6.4 HEAT TREATMENT

The material shall be supplied in solution annealed condition with heat treatment suitable to provide grain size as per clause 7.2.5. The minimum heat treatment temperature shall be 1100°C. Before starting the quality heat treatment, the manufacturer shall submit sketch with the dimensions for heat treatment for information. The heat treatment temperature and time shall be recorded and the records shall be made available to the inspection agency.

6.5 MACHINING

The surface condition shall meet the requirements of various non-destructive examinations.

7.0 PROPERTIES AND TESTS

7.1 CHEMICAL COMPOSITION: Heat Analysis in weight%

The material shall conform to the chemical composition (in weight %) limits specified in Table-1. The chemical analysis shall be carried out as per ASTM E-350 or equivalent method.

Table -1: Chemical composition (in weight %) of Alloy 617M

Element	Cr	Fe	Mn	Mo	Co	Al	C	Cu
Wt.%	21.0 - 23.0	≤ 1.5	≤ 0.3	8.0 - 10.0	11.0 - 13.0	0.8 - 1.3	0.05 - 0.08	≤ 0.05

Element	B	Si	S	N	Ti	V	Nb	Ni
Wt.%	0.002-0.005	≤ 0.3	≤0.008	≤0.05	0.3-0.5	≤ 0.6	≤ 0.6	Bal.

7.2 MECHANICAL PROPERTIES

7.2.1 Tangential or Radial Specimens:

The manufacturer shall test tangential or radial test specimens taken from forgings after heat treatment. The location of tensile specimens shall be as per ordering drawing. Test samples shall be taken at least 40mm below the heat-treatment contour.

The following properties shall be achieved at room temperature:

0.2% Proof strength: ≥ 300 N/mm^2

Tensile strength: ≥ 650 N/mm^2

% Elongation (L = 5.65√A) ≥ 30%

% Reduction in Area : for information purpose.

Impact (at 20°C) Charpy V Notch: ≥ 120J (average of 3 values with lowest value shall be ≥ 90J)

Additionally, tensile test at 720°C to be carried out and report shall be submitted for information.

7.2.2 Axial Sample:

An axial core of dia ≥ 60mm is to be taken out from the location marked in the drawing. The position of the rotor in the forged ingot shall be such that the axial core lies on the top side. Axial trepanned core shall be tested in accordance with Standard no AA0850155. Following properties shall be achieved in the radial direction-

0.2% Proof Stress ≥ 280 N/mm^2,

% Elongation: ≥ 27%

Tensile strength, % Reduction in Area and Impact (3 values) shall be reported for information. The balance sample, duly identified, shall be sent to BHEL along with rotor. (Preferably kept in axial bore and suitably plugged).

Additionally, hot tensile test at 600°C and 720°C shall be carried out from axial core sample and report shall be submitted for information.

7.2.3 Retest

When mechanical test results do not meet the requirements, retesting can be carried out

for the test for which results are not satisfactory. Two retests shall be performed for each unsatisfactory result obtained with specimens taken close to the region from where earlier defective specimens were taken and failing which the part will be rejected.

7.2.4 Re-heat-treatment

The forgings rejected on the basis of unsatisfactory results for one or more mechanical tests may be re-heat-treated, the condition for which shall be described in the test report. All the mechanical tests with the same number of tests specified for the original forging shall be repeated. No more than two re-heat treatment shall be allowed.

7.2.5 Grain Size

Grain Size shall be checked and following shall be acceptance criteria:
At Surface (Location T1 & T2 in drawing): Grain size distribution in the forging shall be within the ASTM grain size nos. 2 or finer, occasionally up to 0.
At Center (Location T3) 0 or finer, occasionally 00.

7.3 NON DESTRUCTIVE EXAMINATION

7.3.1 Surface Examination – Surface Defects

Forgings shall be visually examined. Their surface shall be plain, uniform and free from wrinkles, overlaps, tears, cracks and any other injurious defects. After cutting to as-delivered dimensions, the edges shall be visually examined. There shall be no cleavage or lamination. If the above mentioned examinations detect defects in the forgings, they cannot be accepted as it is, and the requirements of section 7.3.4 and 11.0 of this specification shall apply.

7.3.2 Liquid Penetrant Inspection

Forging shall be subjected to 100 % liquid penetrant inspection. The test procedure and acceptance shall be as per supplementary requirements stated in ASME SB-564.

7.3.3 ULTRASONIC EXAMINATION

Forging shall be subjected to 100% ultrasonic examination by longitudinal wave technique. The test procedure shall be as per supplementary requirement stated in ASME SB-564 except that the flat – bottomed reference hole of 4 mm diameter shall be the acceptance criteria for radial. The examination shall be carried out axially on both the sides and circumferentially. Flat – bottomed reference hole of 6 mm diameter shall be the acceptance criteria for axial.

Additionally, ultrasonic examination shall also be carried out with flat – bottomed reference hole of 3 mm diameter radially and indications, if any, shall be reported for information only.

7.3.4 Removal of Unacceptable Areas

Small surface defects may be removed by grinding or chipping provided the thickness remains locally within the part tolerances. The supplier may propose removing larger

defects by the same method. In this case, the supplier shall present a report to the purchaser giving a detailed description of the detected defects (location, size, seriousness). This proposal shall be accepted only if the purchaser judges the remaining thickness to be sufficient with the safety coefficients applied to the equipment design taken into account. No weld repairs are acceptable.

7.4 DIMENSIONS & TOLERANCES

Dimensions and tolerances shall be as per purchase order / ordering drawing.

8.0 MARKING

The supplier shall mark each forging with identification number. This is to be punched on the front face of the forging (as marked in the respective drawing), at reference clock position 12 and is to be bordered with oil paint. This shall be confirmed with authorized work inspector's stamp next to the identification number.

9.0 DOCUMENTATION:

The supplier shall furnish 4 copies of test certificates unless and otherwise stated on the order. The test certificates shall bear the following information:

Purchaser's Reference:

a) Purchase order number
b) Drawing number
c) Specification number

Supplier's Reference:

a) Name of supplier
b) Material designation
c) Melt Number, melting & refining process
d) Details of ingot & forging process: Dimension, ingot weight, forging process and Forging reduction ratio.
e) Details of heat treatment, method of cooling, actual time and temperature sequence, soaking time, cooling conditions (cooling rate)

Test Results:

a) Melt analysis & check analysis along with tramp elements.
b) Mechanical test results (all individual values & test piece locations are to be indicated).
c) Results of Residual stress measurement.
d) Results of Liquid penetrant examination.
e) Ultrasonic examination results (type of instrument, test probe, adjustment and test sensitivity are to be mentioned).
f) Dimensional data sheet about the dimensional inspection.

10.0 CLEARANCE FOR DELIVERY:

The entire results of test performed are deciding factors for the clearance of the delivery. The purchaser shall evaluate the total results with respect to intended operational requirements for the forging and judge accordingly the permissibility of deviations (if any) of the properties of the piece required.

The clearance does not relieve the manufacturer from the responsibility for hidden impermissible defects, which may be found later on.

11.0 DEVIATIONS:

Deviations from this Purchase Specification (if any), which may arise during manufacturering, shall be submitted to the purchaser in writing giving full details of the deviations. Acceptance of concession request will be at the sole discretion of the purchaser.

12.0 PACKING & DISPATCH:

Before dispatch, the forging shall be suitably packed to prevent corrosion and damage during transit.

The forging shall be coated with oil, covered with polythene sheets and waterproof paper and then packed in a sea-worthy export wooden crate. Shipment of forgings shall be done after conducting all tests as mentioned above in the presence of purchaser's authorized representative and after all the test reports are scrutinized by the purchaser and accepted. Shipment of the forging shall be made only after obtaining the written "Shipment Release' from the purchaser.

13.0 CROSS REFERRED STANDARDS

VD TUV Data Sheet 485, ASME SB-564,ASTM E-350, AA0850155

14.0 DELIVERY PERIOD

The Forging enquired forms a part of a Government of India funded Project (Scheme) and the delivery period mentioned below has been derived keeping in view of the Scheme completion date. Vendor shall comply with this required period. Vendor should quote time period separately for 'Supply' of equipment

Supply period: Duration shall be counted from the date of Purchase Order (PO). Vendors are required to indicate the best delivery period i.e., Order Acceptance, submission of process plans etc., should not be linked to the delivery period. Supply period indicated by vendor should include reasonable time required for approval of documents and other inputs from BHEL. In the Techno-Commercial Bid, the vendor shall submit milestones for various activities in co-relation with Supply quoted by him.

DELIVERY PERIOD (in Weeks) AS DESIRED BY BHEL (PO date to delivery date to BHEL-HEEP, RANIPUR, HARIDWAR, UTTARAKHAND 249403 Stores): **36 Weeks**

DELIVERY PERIOD (in Weeks) OFFERED BY VENDOR (PO date to delivery date to BHEL-HEEP, RANIPUR, HARIDWAR, UTTARAKHAND 249403 Stores):_____

Annexure I

FORGING RATIO

A.1 Definitions

The forging direction is the direction, in each portion of the forged part, in which the forging operations produces maximum elongation. The part is said to be forged either in a longitudinal or transverse direction depending upon whether this direction is parallel or perpendicular to the ingot axis. As a rule, the forging ratio represents, for each portion of the part, the ratio between the lengths of an element of the metal, measured parallel to the forging direction, after and before forging operation.

A.2 Overall Reduction Ratio

The longitudinal reduction ratio of the forged part is equal to the product of the longitudinal reduction ratios for each successive forging operation. The overall ratio of reduction is equal to the product of the longitudinal reduction ratio and the transverse reduction ratio.

A.3 Parts Fabricated by Upsetting or Flattening

The reduction ratio for upsetting or flattening by application of a load parallel to the axis of the ingot, is equal to the ratio between the cross section of the forging after and before the upsetting or flattening operation, or to the ratio between the thickness of the forging before and after the upsetting or flattening operation. By convention, the overall ratio of reduction of a part is the product of the individual reduction ratio and the square root of the longitudinal reduction ratio of the blank prior to upsetting or flattening. If during the forging operation, the blank is subjected to an intermediate upsetting operation, the reduction ratio for the upsetting operation shall not be included in the overall reduction ratio.