ACCEPTANCE REQUIREMENTS - SHROUD, DIAPHRAGM, RETAINING RING AND RETAINING RING HORIZONTAL JOINT BLOCK LUG FORGINGS

1. SCOPE

1.1 This Part Process Specification provides the Engineering Requirements to forgings for gas turbine shrouds, diaphragms, retaining rings, nozzle support rings and retaining ring horizontal joint block lugs.

1.2 This Part Process Specification supplements the requirements of the Part Drawing, the Material Specification for the particular forging, and the General Process Specification for ring forgings (GT10613).

1.3 In case of conflict, the order of precedence shall be as follows.

- Purchase order
- Part Drawing
- This part process Specification
- General Requirements Specification
- Material Specification

1.4 Communication

1.4.1 External Supplier (See Definition)

Bharat Heavy Electricals Limited (BHEL) company -GT Purchase dept is the authorized agency for all the communication between BHEL & Supplier (using this spec). Any additional information or clarification shall be requested through the GT Purchase department for resolution by GT Engineering.

1.4.2 Internal Supplier (See Definition)

All Manufacturing and allied departments using this specification shall communicate to GT Engg department for any clarification / additional information.

1.5 Requests For Deviations - Requests for deviations to the requirements of this specification shall be submitted to GT Engineering for suitable resolution through Non-conformance report (NCR)

2. APPLICABLE DOCUMENTS

2.1 The following documents shall form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue shall apply.

2.1.1 BHEL Material Codes

HY19396 (Type 304SS)	Chromium-Nickel Austenitic Stainless Steel Forgings
HY19466 (Type 410SS)	Chromium Martensite Stainless Steel Forgings
HY19464 (A286)	Nickel Chromium Alloy Steel Forgings
HY10986 (Haynes HR120)	Nickel-Iron-Chromium Alloy
GT10610	Visible Dye Penetrant Testing
GT10614	Ultrasonic Testing of Forged and Wrought Parts
GT10613	General Requirements - Small Forgings

2.1.2 American Society for Testing and Materials

A473, Type 310 (310 S.S.) - Standard Specification for Stainless Steel Forgings

A473, Type 347 (347 S.S.) - Standard Specification for Stainless Steel Forgings

A370 - Standard Methods and Definitions for Mechanical Testing of Steel Products

A788 -Standard Specification for Steel Forgings, General Requirements

E139 - Standard Practice for Conducting Creep, Creep Rupture, and Stress Rupture Tests of Metallic Materials

E353 - Method for Chemical Analysis of Stainless Heat Resisting, Maraging and Other Similar Chromium-Nickel Iron Alloys

2.1.3 Aerospace Material Specification

AMS 5662 (718) - Nickel Alloy, Corrosion and Heat Resistant, Bars, Forgings And Rings 52.5Ni-19Cr-3.0Mo-5.1Cb-0.90Ti-0.50Al-18Fe

3. DEFINITIONS

The definition in general process specification for ring forgings GT10613 and apply to this specification.

3.3 Documentation

3.3.1 Manufacturing Process Plan (MPP) - BHEL approved, detailed, step-by-step list of operations by which the parts are planned to be processed, tested and inspected.

3.3.2 Qualification Package - First Piece Qualification documentation containing the results of the tests and inspections performed on the First Piece as required for qualification.

4. QUALIFICATION REQUIREMENTS

4.1 A comprehensive evaluation for First Piece Qualification (FPQ) shall be required of a new Supplier, or when there is a significant change in the approved MPP or if a Supplier has not performed this process within the two years prior to Purchase Order placement.

4.2 FPQ shall, as a minimum, include the following:

4.2.1 An MPP approved by purchaser prior to initiation of the FPQ.

4.2.2 Non-destructive test data.

4.2.3 Certificate of Conformance, include chemistry, metallurgical and mechanical data.

4.2.4 Qualification Samples - FPQ samples shall be provided as requested.

4.3 Qualification Package - The Supplier shall submit two (2) copies of the FPQ documentation for review/approval.

4.4 Upon receipt of written approval for FPQ, the Supplier is approved for production of the qualified part. The MPP shall be "FROZEN", not to be changed without approval of a new MPP.

4.5 The qualification requirements in the General Process Specification (GT10613) for ring forgings also apply to this specification.

5. PRODUCTION PROCESS REQUIREMENTS

5.1 It shall be the responsibility of the Supplier to understand thoroughly the work scope and all documentation needed to complete the work. This responsibility shall apply to the prime Supplier for any or all operations performed by sub-tier Supplier (s).

5.2 This process shall be conducted in accordance with a documented Frozen MPP. The Supplier shall monitor the actual process, compare the process to the MPP and report to the Purchaser

5.3 The MPP shall include as a minimum, the following information:

- Supplier Name, Supplier Code Number (As applicable)
- Date
- Applicable Drawing Numbers (if applicable)
- All Material and Process Specifications (other) , including revision level
- Supplier documents (indicate proprietary, non-proprietary)
- Chemistry
- Forge Practice
- Forge Temperature
- Heat Treatment
- Heating and Cooling Rates
- Machining
- Welding
- Tests and Inspection
- NDT Procedures
- Identification

5.4 The production process requirements for ring forgings shall be as specified in Section 5 of this Part Process Specification, the General Process Specification for ring forgings (GT10613) and as specified by the applicable Material Specification.

5.5 Melting

5.5.1 Stainless Steels - The stainless steels shall be melted by one of these processes: electric-furnace with separate degassing and refining, vacuum-furnace, or one of the former followed by vacuum or electroslag-consumable remelting. A sufficient discard shall be made to secure freedom from injurious pipe and undue segregation.

5.5.2 HR120 Alloy - The alloy shall be melted using the basic electric furnace and the electro-slag re-melt processes.

5.5.3 A286 Alloy - The alloy shall be melted using either Basic Electric Furnace or Vacuum Induction process plus a re-melt process either Vacuum Arc Re-melt or Electro Slag Re-melt process.

5.5.4 718 Alloy - The alloy shall be melted in accordance with the material specification AMS 5662.

5.6 Heat Treatment

5.6.1 ASTM A473, Type 310 and ASTM A473, Type 347 and SS304 Forgings

5.6.1.1 Solution Heat Treatment

5.6.1.1.1 Solution heat treat the forgings at 1038°C minimum.

5.6.1.1.2 Still air cool the forgings from the 1038°C minimum solution temperature to room temperature. If desired, the cooling rate of the forgings may be increased when their maximum metal temperature reaches 204°C or lower by using fans to blow air at the forgings.

5.6.2.1 Stress Relief Treatment

5.6.2.1.1 Shroud, diaphragm and retaining ring forgings shall be stress relieved after the Supplier has completed all rough machining operations. The stress relief shall be done as specified below.

5.6.2.1.2 Place the forgings in a furnace whose temperature is a maximum of 927°C

5.6.2.1.3 Heat the forgings to a metal temperature of 885±3.8°C . Heating rate is not specified.

5.6.2.1.4 Hold the forgings at a metal temperature of 885±3.8°C for three hours.

5.6.2.1.5 Still air cool the forgings from 885±3.8°C to room temperature. If desired, the cooling rate of the forgings may be increased when their maximum metal temperature reaches 204°C or lower by using fans to blow air at the forgings.

5.6.2 HY19466(SS410), HR120, A286 & AMS 5662 (718) FORGINGS

5.6.2.1 Perform solution and age harden or temper heat treatments per the applicable material specifications.

5.6.2.2 Stress Relief Treatment - When more than 1/8" of stock is machined off after the final property heat treatment (per Para.5.3.2.1), the forgings shall be stress relieved after the machining. The stress relief shall consist of heating to a temperature no lower than 10°C below the final property heat treatment temperature, holding at temperature for eight hours and then still air cooling to room temperature. If desired, the cooling rate of the forging may be increased when their maximum metal temperature reaches 204°C or lower by using fans to blow air at the forgings.

5.6.3 The forgings shall be properly supported throughout the heat treatments to minimize distortion.

5.6.4 Precautions and adequate thermocouples shall be used to assure that specified metal temperatures are adhered to.

5.6.5 The heat treatments may cause oxide layer to be present on the forging surfaces. The oxidation layer shall be removed by a mean such as sand blasting prior to shipment of the forgings.

5.7 Tests - The supplier shall test and inspect production ring forgings for gas turbine shrouds, diaphragms, retaining ring horizontal joint lug blocks and retaining rings as specified in Para. 6.2 of this Specification.

5.8 Packaging, Shipping and Marking - The packaging which the Supplier uses when shipping shroud, diaphragm and retaining rings to the purchaser shall be strong enough so the packaging does not break, and no damage occurs to the rough machined shroud, diaphragm and retaining rings which will be within 0.060" of final dimension on some surfaces. The requirements for shipping pallets for shroud, diaphragm and retaining rings are as follows:

(1) pallet runners 4" X 4" min.

(2) four cross slats (1" X 6" min.) positioned within 48" of both ends of the pallet.

(3) pallets larger than the OD of ring forging

(4) two rings max. per pallet

(5) pallet loads 5000 pounds max.

(6) mark rings "pads required if chained down"

(7) stamp identification per the General Process specification (GT10613) on the OD of ring forgings

(8) orient ring forgings on pallet so the ring identification can be read by a fork truck driver, i.e. identification toward the open end of the pallet.

5.9 Deviations - Any deviation from the requirements of this Specification shall be submitted by NCR for Engineering disposition before the item is shipped.

6. INSPECTION/TEST PROCEDURES AND REQUIREMENTS

6.1 First Piece Qualification (FPQ)

6.1.1 The Supplier shall perform the following tests and inspections on each first piece ring forging.

* 6.1.1.1 Brinell Hardness - Measure hardness per ASTM A370 at three locations on the top surface, 120° apart. Measure hardness at the three locations on bottom surface, 120° apart, offset from readings on top surface by 60°. The hardness results of a forging shall meet the requirement of the applicable material specification. The Brinell hardness of SS410 material shall be 197-255. The Brinell hardness of ASTM A473, Type 310 and ASTM A473, Type 347 shall be reported for information.

6.1.1.2 Red Dye Penetrant Inspection - Red dye penetrant inspect all surfaces of each forged ring per GT10610. The ring forgings shall be in the finish machined condition when inspected. If any unacceptable indications are found, NCRshall be rasied.

The criteria for the red dye penetrant inspection is as follows:

6.1.1.2.1 Only indications with major dimensions greater than 0.38MM are relevant.

6.1.1.2.2 Linear indications are defined as single indications whose length is greater than three times their width.

Single linear indications greater than 1.5MM long are unacceptable regardless of location.

6.1.1.2.3 Closely spaced groups of indications shall be treated as follows:

(1) Two adjacent indications are considered to be interactive and part of a given group when they are closer than three times the maximum dimension of the smaller indication.

(2) Once established, a given group shall be considered the same as a single indication regardless of the number of individual indications in the group.

(3) The maximum allowable indication is as follows:

MAXIMUM INDICATION SIZE, MM			
GAS TURBINE	GAS PATH AREA OF SHROUD	REMAINING AREAS OF SHROUD	ALL AREAS OF DIAPHRAGMS & RETAINING RINGS
MS-6001	1.8	3.2	3.2
MS-7001	2.5	4.6	4.6
MS-9001	3.0	5.5	5.5

6.1.1.3 Ultrasonic Inspection - Ultrasonic test entire ring forging per GT10614. The ring shall be machined before being ultrasonic inspected. The surface finish and shape of the forgings shall meet the requirements of GT10614.

6.1.2 The Supplier shall perform the following tests on one first piece ring per drawing number/part number, unless permission to deviate is given in writing by GT Engineering. Material for destructive tests, such as tensile, chemistry and micro shall be obtained either by increasing the width of the ring forgings or from excess stock, so as to produce a 360 degree testing prolong (or ring) as shown in the sketch below.

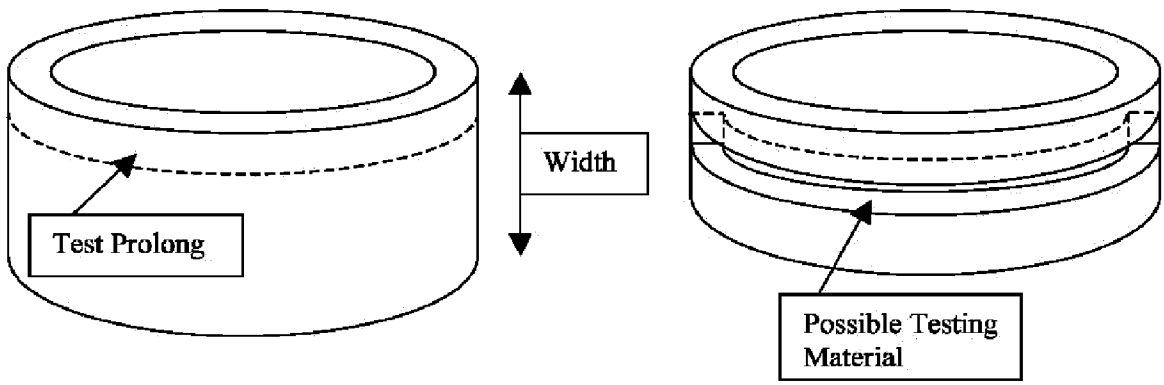

FIGURE 1

The testing material shall be integral with the ring forging during all heat treatments except the stress relief treatment applied to the forgings after machining (see Paras. 5.2.2 and 5.3.2). The testing material shall be parted off from the ring forging before the stress relief is applied.

6.1.2.1 Tensile Test - The test shall be performed in accordance with the applicable material specification. Tensile specimens shall be taken tangentially, midway between ID and OD, and positioned as close as possible to what will be the final machining surface of the part. The tensile properties shall meet the requirements of the applicable Material Specification. HY19466 only specifies yield strength requirement, but tensile strength, elongation and reduction of area shall be reported for information.

6.1.2.2 Stress Rupture - The test shall be conducted in accordance with ASTM E139 specification when the applicable material specification requires the test. The test frequency, quantity and the results shall meet the requirements of the applicable material specification.

6.1.2.3 Microstructure - Grain size and microstructure shall be determined and meet the requirements in accordance with the applicable Material specification. Prepare at least one metallographic sample from the testing material taken per Para. 6.1.2. The metallographic sample shall have a polished surface at least ½" x ½" for examination, and be oriented tangentially. The photomicrograph suitably identified shall be included in the First Piece Qualification Report. The metallographic mount suitably identified shall be submitted to purchaser for evaluation.

6.1.2.4 Product Chemical Analysis - Determine weight percent of all elements specified by the applicable material specification. The test material shall be cut from one end of the tensile bar blank which has been cut per Para. 6.1.2.1. The product chemical analysis shall conform to the material specification requirements within the permissible variations given in ASTM A788.

6.1.3 The tests and inspections as specified in Paras. 6.1.1.1 through 6.1.1.3 and 6.1.2.1 through 6.1.2.5 of this specification shall be performed for retaining ring horizontal joint block lug forgings (subsequently called joint block lug). Material for destructive tests, such as tensile, chemistry and microstructure shall be obtained by increasing the width of the block forging, so as to produce a test prolong as shown in the sketch below.

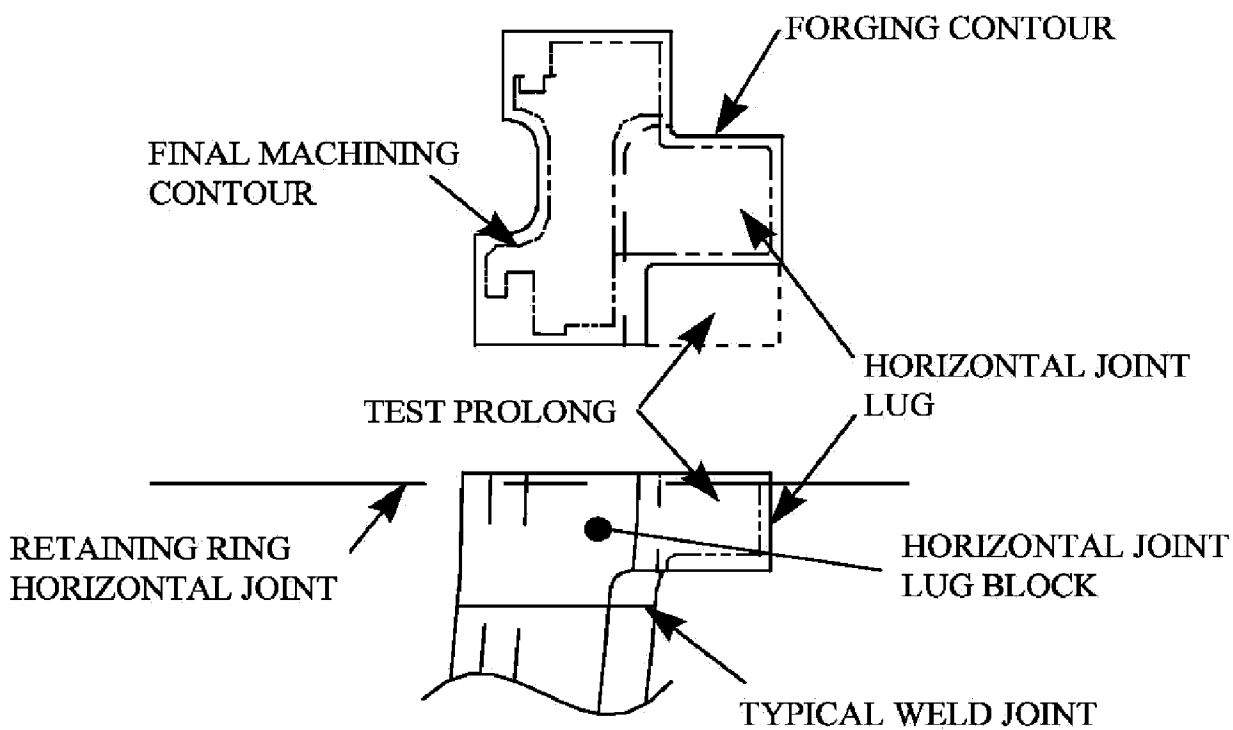

FIGURE 2 - RETAINING RING HORIZONTAL JOINT BLOCK LUG

The test prolong material shall be integral with the forged block lug during all welding and heat treatments except the stress relief treatment applied to the finished forging after machining. The test prolong material shall be removed from the block lug prior to stress relief but shall be set on top of the forging during stress relief.

6.1.4 The Purchaser may perform audit tests on the first piece parts and on the test prolong material which represents the parts. The supplier shall retain the excess first piece test prolong material for minimum of three months, so that audit tests can be run. The extent of the audit testing shall be specified by GT Engineering.

6.2 Production Parts

6.2.1 The following inspections and tests shall be performed for production ring and joint block lug forgings.

6.2.1.1 Heat Chemistry Analysis - A chemical analysis shall be made on each heat of alloy to determine the elements specified under Chemical Composition in the applicable material specification. The analysis shall be made on material taken not less than 1/4" beneath the surface of a test sample taken during pouring of the heat.

6.2.1.2 Tensile Tests - Tensile test one forging per each drawing number/heat/heat treat lot in accordance with the applicable material specification. Tensile properties shall meet the applicable material specification requirements.

6.2.1.3 Stress Rupture - Test one forging per each drawing number/heat/heat treat lot in accordance with the applicable material specification when the applicable material specification requires the test. The stress rupture property of the forging shall meet the requirements of the applicable material specification.

6.2.1.4 The tensile and stress rupture specimens shall be taken from test prolong material in the same way (location and orientation) as described in Para. 6.1 for FPQ. The test prolong material shall have been exposed to every heat treat cycle that the forging has been exposed to, including stress relief cycles.

6.2.1.5 Brinell Hardness Test - Three Brinell hardness measurements shall be performed on the top surface of each ring, 120° apart per ASTM A370. The hardness of the forgings shall meet the requirement of the applicable material specification. The Brinell hardness of SS410 forgings shall be 197-255. The Brinell hardness of SS304 forgings shall be Brinell 150 maximum.

6.2.1.6 Nondestructive Testing - NDT tests shall be conducted for every forging. Less test frequency on a sampling basis must be documented in the Manufacturing Process Plan and approved by GT-Engineering.

6.2.1.6.1 Red Dye Penetrant Inspection - Per Para. 6.1.1.2

6.2.1.6.2 Ultrasonic Inspection - Per Para. 6.1.1.3

6.3 Certification - The Supplier shall make all tests specified under Inspection/Test Procedures and Requirements for production parts (Para. 6.2) and report the results on a Certificate of Test. All of the forgings represented by a given Certificate of Test shall have the same drawing number, heat number and heat treat lot. The Certificate of Test shall include as a minimum the following:

(1) Supplier name and address

(2) Date

(3) Purchase order number

(4) Material specification number, revision number, and material grade.

(5) Forging drawing number, part number and revision number or letter if applicable.

(6) Mill heat number and chemical analysis of elements specified in the Material Specification. Material source if the forging supplier is not the basic producer of the steel.

(7) Tensile test data and serial number of parts tested.

(8) Brinell hardness data indicating test location where applicable.

Record of all heat treatment conditions (time, temperatures and cooling rates).

(9) Supplier Process Plan identification number and revision level and date.

(10) Part Process Specification identification number, revision level and date.

(11) General Process Specification identification number, revision level and date.

In addition to the Certificate of Test, the Certification package shall include the following:

(1) Approved Non-Conformance report (NCR) which pertain to the parts covered by the Certificate of Test.

The Supplier shall prepare copies of the certification package and send them to the Purchaser as specified in the purchase order.

6.4 Audit

6.4.1 The Purchaser reserves the right to periodically audit the Supplier's facilities and practices. Such audits shall not relieve the Supplier from the responsibility of producing the material in a suitable condition.

7. ADDITIONAL NOTES

NONE

RECORD OF REVISIONS

Rev. No.	Date	Revision Details	Revised	Approved
00	29.4.99	FIRST MADE	—	—
01	31.08.21	Revised as per latest OEM spec. Rev-G	CNK	KDG