

TD-201 Rev No. 00 Form No.		PRODUCT STANDARD HYDERABAD		GT10108																																																			
				REV.03																																																			
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<p align="center"><u>ACCEPTANCE REQUIREMENTS. - GAS TURBINE WHEEL SHAFT,</u></p> <p align="center"><u>COUPLING AND DISTANCE PIECE FORGINGS</u></p> <p>1. SCOPE</p> <p>1.1 This specification provides the engineering requirements for Gas Turbine wheel shaft, coupling and distance piece forgings. It supplements the general requirements for rotating forgings that are specified in Process Specification GT10047 and it must be used with GT10047 and the material specification called for on the respective forging drawing.</p> <p>1.2 This specification is applicable to the following compressor wheel forgings as follows:</p> <table border="1"> <thead> <tr> <th><u>IDENTITY</u></th> <th></th> <th><u>MATERIAL SPECIFICATION</u></th> </tr> </thead> <tbody> <tr> <td>MS3002</td> <td>Fwd. Stub Shaft</td> <td>B50A633-D8</td> </tr> <tr> <td></td> <td>Aft Stub Shaft</td> <td>B50A420-B8</td> </tr> <tr> <td></td> <td>2nd Stg. Wheel Shaft</td> <td>B50A420-B8</td> </tr> <tr> <td>MS5001</td> <td>Fwd. Stub Shaft</td> <td>HY19460</td> </tr> <tr> <td></td> <td>Distance Piece</td> <td>HY19467</td> </tr> <tr> <td>MS5002</td> <td>Fwd. Stub Shaft</td> <td>B50A420-B10</td> </tr> <tr> <td></td> <td>Aft Stub Shaft</td> <td>B50A420-B10</td> </tr> <tr> <td></td> <td>Wheel Shaft</td> <td>B50A420-B10</td> </tr> <tr> <td>MS6001</td> <td>Distance Piece</td> <td>HY19467</td> </tr> <tr> <td></td> <td>Aft Turbine Shaft</td> <td>HY19467</td> </tr> <tr> <td></td> <td>Fwd. Compressor Shaft</td> <td>HY19460</td> </tr> <tr> <td></td> <td>Load Coupling</td> <td>HY19460</td> </tr> <tr> <td>MS6001FA</td> <td>Fwd. Compressor Stub Shaft</td> <td>HY19460</td> </tr> <tr> <td></td> <td>Distance Piece</td> <td>HY19467</td> </tr> <tr> <td></td> <td>Aft Turbine Stub Shaft</td> <td>HY19467</td> </tr> <tr> <td></td> <td>Load Coupling</td> <td>HY19460</td> </tr> </tbody> </table>					<u>IDENTITY</u>		<u>MATERIAL SPECIFICATION</u>	MS3002	Fwd. Stub Shaft	B50A633-D8		Aft Stub Shaft	B50A420-B8		2nd Stg. Wheel Shaft	B50A420-B8	MS5001	Fwd. Stub Shaft	HY19460		Distance Piece	HY19467	MS5002	Fwd. Stub Shaft	B50A420-B10		Aft Stub Shaft	B50A420-B10		Wheel Shaft	B50A420-B10	MS6001	Distance Piece	HY19467		Aft Turbine Shaft	HY19467		Fwd. Compressor Shaft	HY19460		Load Coupling	HY19460	MS6001FA	Fwd. Compressor Stub Shaft	HY19460		Distance Piece	HY19467		Aft Turbine Stub Shaft	HY19467		Load Coupling	HY19460
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IDENTITY

MATERIAL SPECIFICATION

MS7001	Fwd. Compressor Shaft	B50A420-B11
	Fwd. Turbine Shaft	B50A368E, B50A420-B10
	Aft Turbine Shaft	B50A368E, B50A420-B10
	Load Coupling	B50A420-B10
MS7001F/ FA/EC	Fwd. Compressor Shaft	B50A420-B11
	Distance Piece	B50A368M
	Aft Turbine Shaft	B50A368E
MS7001FB	Fwd. Compressor Shaft	B50A420-B11
	Distance Piece	B50A368M
MS9001 G&H	Fwd. Compressor Spool Shaft	B50A818 G12
MS9001E	Fwd. Compressor Shaft	HY19460
	Fwd. Turbine Shaft	HY19467
	Aft Turbine Shaft	HY19467
	Load Coupling	HY19460
MS9001F/ FA/EC	Fwd. Compressor Shaft	HY19460
	Distance Piece	HY19467
	Aft Turbine Shaft	HY19467



- 1.3 Parts other than those specifically set forth above (Ref. Para. 1.2) which are ordered to the requirements of this specification should be referred promptly through BHEL , for clarification/resolution.
- 1.4 Unless otherwise specified, the requirements of this specification are applicable to all materials (Ref. Para. 1.2).


2. APPLICABLE DOCUMENTS

- 2.1 The documents contained in process specification GT10047 , Section 2, apply to this specification.


3. DEFINITIONS

- 3.1 The definitions contained in process specification GT10047 Section 3 apply to this specification.



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<div style="display: flex; justify-content: space-between;"> <div style="width: 30%;"> <p style="writing-mode: vertical-rl; transform: rotate(180deg);"> COPYRIGHT AND CONFIDENTIAL The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company. </p> </div> <div style="width: 65%;"> <h3>4. <u>ENGINEERING REQUIREMENTS</u></h3> <p>4.1 <u>Forging Supplier-Process Qualification</u></p> <p>4.1.1 The forging supplier shall provide for each type of part the following information for BHEL review and approval:</p> <ul style="list-style-type: none"> - detailed processing plan - dimensional drawing showing the configuration during heat treatment - production test specimen locations and orientations in forging - type of test at each location. <p>4.1.2 A first piece qualification (FPQ) forging shall be required of a new supplier, a new plant of a current supplier, or when there is a significant change in the shape, the composition or the processing of the forging. This FPQ generally requires the destructive sectioning and evaluation of the forging; however, when the forging's configuration permits the deep seated characteristics to be measured with prolongations or trepans, BHEL can select alternative evaluation methods. When the forging supplier has made similar parts for BHEL GT or other departments, or Manufacturing Associates that have similar requirements, then Materials Engineering will review the results and will decide whether or not a qualification forging is required and if a destructive cut-up qualification is needed.</p> <p>4.1.2.1 Figures 1 and 2 are sketches of typical parts showing test locations for the qualification of mechanical properties capability.</p> <p>4.1.2.2 The precise location of each test specimen in relation to the heat treat envelope shall be recorded. Tables I and II - Part A further identify the tests required.</p> <p>4.1.2.3 <u>Ultrasonic Examination</u> - The interior quality of the forging must be evaluated after the forging supplier has machined forging to Sonic Shape per GT11162 requirements. Axial and radial ultrasonic inspections must be performed on all accessible surfaces per Specification GT10184 and GT10047 .</p> </div> </div>			
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COPYRIGHT AND CONFIDENTIAL The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company.		4.1.2.4 <u>Macro Cross-Section</u> - When a complete cut-up destructive qualification procedure is specified, an axial-radial cross-section of the qualification forgings shall be etched and photographs shall be taken to reveal grain flow and chemical segregation (Figure 1 or 2). Etch in accordance to Process Specification GT10185 .			
		4.1.2.5 <u>Hardness Survey</u> - When a complete cut-up destructive qualification procedure is specified, a hardness survey shall be made on the face of the axial-radial cross-section cut, and there must be a sufficient number of test positions to accurately reflect hardness; and therefore tensile strength uniformity. In addition, a surface hardness survey must be performed per Para. 4.2.2.3.			
		4.1.2.6 The microstructure and the grain size shall be determined for a sample obtained from all of the specified Qualification Forging testing locations, Tables I or II and Figures 1 or 2. The grain size shall be determined per specification ASTM E112 and the cleanliness rating per specification ASTM E45. The microphotographs shall be at 100X after etching with a 2 percent Nital solution. All metallographic examination results must meet the requirements of the appropriate material specification and they shall be contained in the Qualification Program Report.			
		4.1.2.7 <u>Forging Chemical Composition</u> - The chemical composition must be determined for one of the production part test locations and carbon check analyses for all of the other testing locations. All results shall be contained in the Qualification Program Report.			
		4.1.3 In order for the forging supplier to achieve qualification status for a specific forging, capability must be demonstrated for the consistent development of all BHEL required mechanical properties and material qualities. Important for the proof of capability is the production of a forging that exhibits the properties and qualities that are expected with the applied processing operations. A part of this expectation of capability is the development of characteristics that are similar to those that are developed in the same or similar forgings produced by other current forging suppliers. It follows that simply producing a forging that just meets the minimum requirements does not earn a supplier qualification status.			
		After a forging supplier achieves qualification status, this status might be extended to apply to other forgings that present the same or lesser degrees of difficulty during manufacture. Decisions regarding the expansion of qualification status to forgings will be made by BHEL.			
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<p>Production status, i.e. the authority to proceed with production forgings shall be given by BHEL.</p> <p>4.1.4 After BHEL has given process qualification to the Forging Supplier the manufacturing process will be considered "FROZEN" and deviations from it will be allowed only if written permission from Materials Engineering has been obtained.</p> <p>4.2 <u>Forging Supplier Production Wheels</u></p> <p>4.2.1 <u>Manufacture</u></p> <p>The maximum number of forgings in a furnace heat treatment batch will depend on the Supplier's austenitizing and/or tempering furnaces. This information and the typical positioning of the compressor wheel forgings in the different furnaces must be submitted in the appropriate Supplier Manufacturing Process Plan (MPP), or must be documented in a Supplier's standard Manufacturing Practices Instruction.</p> <p>Additional information to be reported in the MPP or contained in the standard Manufacturing Practices Instruction is the method of positioning each forging or a number of forgings in the water tank during the quenching operation.</p> <p>4.2.2 <u>Testing and Evaluation</u></p> <p>4.2.2.1 Test specimens must be obtained per Figure 1 or Figure 2 from the bore and rim test positions in each forging. Table I or Table II - Part B lists the required mechanical properties that must be determined and be reported in the Forging Supplier Certificate of Test.</p> <p>4.2.2.2 <u>BHEL Test Material</u> - The test rings shall be retained by the Supplier in accordance with GT10047 .</p> <p>4.2.2.3 A Brinell hardness test survey must be made on each forging and the results reported in the Forging Supplier Certificate of Test. All forgings must be tested on both end "axial-circumferential" faces and every 90 degrees for a total of eight tests.</p>			



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<div>COPYRIGHT AND CONFIDENTIAL</div> <div>The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company.</div>		<div>4.2.2.4 <u>Ultrasonic Examination</u> - The interior quality of the forging must be evaluated after the Forging Supplier has machined forging to Sonic Shape per GT11162 requirements. Axial and radial ultrasonic inspections must be performed on all accessible surfaces per specification GT10184 and GT10047 .</div> <div>4.2.2.5 The microstructure and the grain size shall be determined from a specimen from each production piece test location, and they shall meet the requirements of the appropriate material specification. The grain size as determined per ASTM E112 shall be reported. Photomicrographs shall be contained in the Certificate of Test to document <u>any unusual features</u> that are observed during the metallographic examination.</div> <div>4.2.2.6 The mechanical properties, hardness values and all other quality attributes measured must meet the requirements of the applicable material specification.</div>					
		<div>5. <u>GE ENERGY QUALITY ASSURANCE TESTING</u></div>					
		<div>5.1 <u>Magnetic Particle Inspection</u> - All accessible surfaces of the forging shall be magnetic particle inspected in the finish machined state. If the part is spin tested, it shall be magnetic particle inspected after spin testing. The magnetic particle inspection shall be per specification GT10146 .</div> <div>5.2 All accessible surfaces of the forging shall be ultrasonic inspected in the sonic shape configuration per GT11162 and required are axial and radial examinations per Specification GT10184 .</div> <div>Forgings that are spin tested must be again ultrasonic examined after all spin tests are completed. Required is an axial ultrasonic examination of the bore region which is defined as from the bore surface and outward radially for a distance of 6 inches.</div> <div>5.3 <u>Spin Testing</u> - MS6001, MS7001E and MS9001E 17th stage aft compressor stub shafts shall be spin tested per the requirements of specification GT10186 .</div> <div>5.4 <u>Supplemental Material Acceptance Testing</u> - The Purchaser has the right to make any additional non-destructive tests, chemical analyses or mechanical properties tests that are considered necessary to demonstrate that the forging meets the requirements of this specification and the needs of the intended compressor wheel application. Forgings failing these tests will be the responsibility of the forging supplier.</div>					
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TABLE I

REQUIRED MECHANICAL PROPERTIES TESTING⁽¹⁾
(REFER TO FIGURES #1, 2 AND 3)

A. Qualification Forging Properties Testing⁽⁶⁾

Test Ring Location	R.T. Tensile	CVN Energy ⁽²⁾		CVN ⁽³⁾ FATT
		@ 0°F	@ R.T.	
R1 Rim Ring	2X ⁽⁴⁾	1X	2X	1X
R2 or R2A Rim Ring ⁽⁵⁾	2X ⁽⁴⁾	1X	2X	1X
1 Mid Radius or Bore	2X ⁽⁴⁾	1X	2X	1X
2 Mid Radius or Bore	2X ⁽⁴⁾	1X	2X	1X
3 Mid Radius or Bore	2X ⁽⁴⁾	1X	2X	1X

B. Production Wheel Forging Requirements⁽⁶⁾

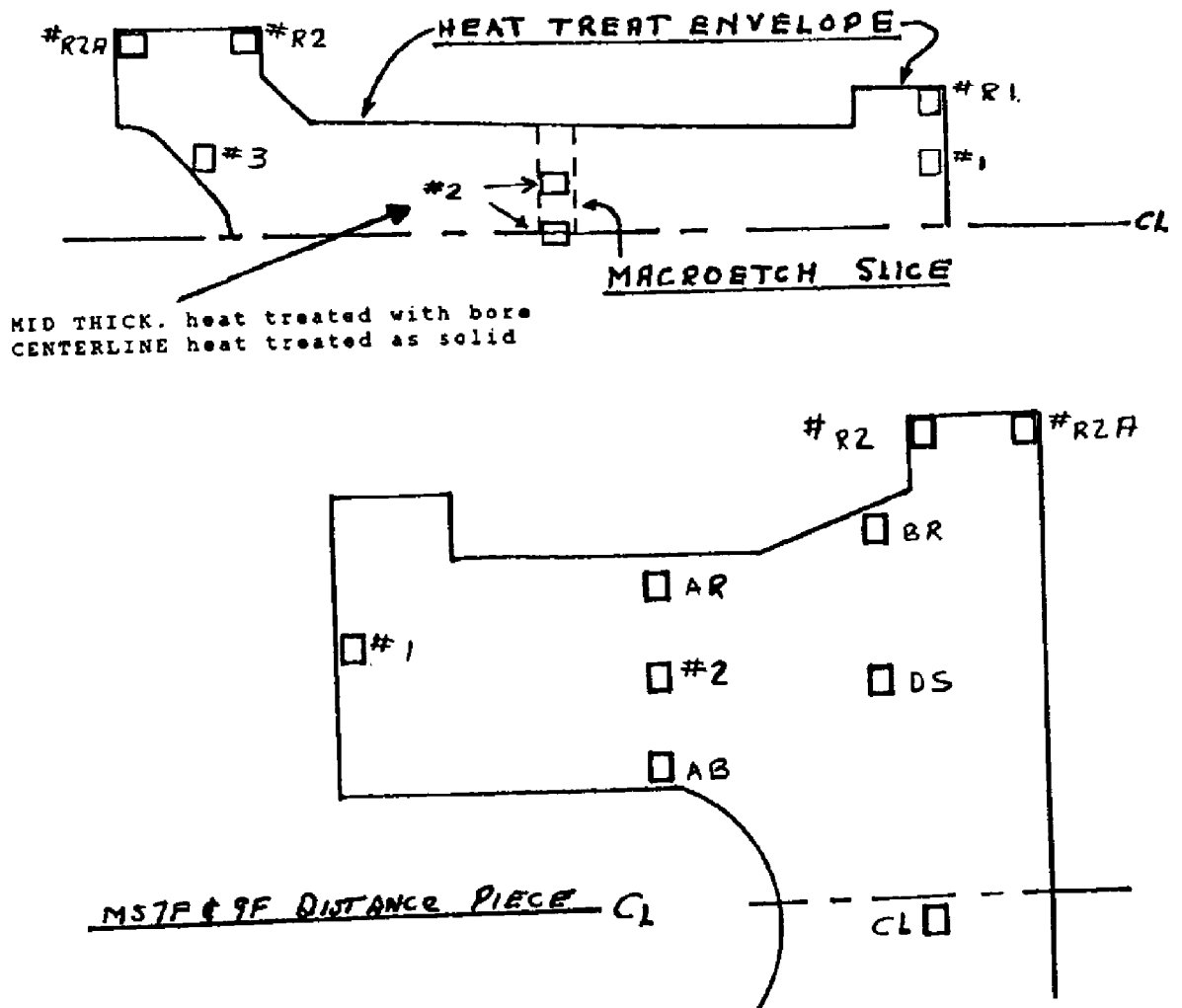
Test Location	R.T. Tensile	CVN Energy ⁽²⁾		CVN ⁽³⁾ FATT
		@ 0°F	@ R.T.	
R2 or R2A ⁽⁵⁾	1X	1X	2X	1X
1 or R1 ⁽⁵⁾	1X	1X	2X	1X

NOTES TABLE I:

- (1) All specimens must be in the tangential or circumferential direction. The Charpy V-notch specimens must have the root of the notch parallel with the centerline of the forging and the notch opening facing the bore.
- (2) Required Charpy V-notch test temperatures for HY19467 forgings are room temperature and 0° F. For HY19460 and HY19462 forgings, the required test temperature is R.T., and is for information purposes only.
- (3) The FATT must be estimated from a minimum of four specimens tested at different temperatures. The test temperatures must be selected in a manner that will result in a high probability that two test temperatures are above the FATT at 50 percent and two test temperatures are below.
- (4) The tangential tensile test locations are to be 180 degrees apart.
- (5) The forging supplier has the option of testing forgings that are 36 inches long or less at any one of three test locations. These test locations are R2 or R2A or R1. Forgings that are greater than 36 inches long must be tested at two locations. These test locations are R2 or R2A and 1 or R1.
- (6) Hardness testing is required for all qualification and production forgings and it must respectively be performed per Paras. 4.1.2.5 and 4.2.2.3.

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FIGURE 1
TEST SPECIMEN LAYOUT FOR MECHANICAL PROPERTIES
TESTING SHAFT & COUPLING FORGINGS♣



♣ Alternate mechanical properties testing plans might be approved in the Supplier's Manufacturing Process Plan (MPP).

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<p>NOTES FOR FIGURE 1:</p> <p>(1) <u>Specimens R1, R2 and R2A</u> - (.75" x .75" Nominal Cross Section Ring). The center of the test rings must be .50" to .75" inches below the respective adjacent as-heat treated surfaces.</p> <p>(2) <u>Specimens #1, #2 and #3</u> - The test specimen centers are to be near the mid radius of the forging at the respective axial locations and in bored forgings the centers shall be .50" to .75" from the bore surface.</p> <p>Specimen #2 shall be near the mid length of the forging while Specimens #1 and #3 shall be at each end of the forging and have the specimen centers .50" to .75" below the adjacent as-heat treated surfaces.</p> <p>(3) Specimens #AR, #AB and #BR shall have the specimen centers .50" to .75" below the adjacent as-heat treated surfaces. The locations of specimens #AR, #AB, #BR, #DS and #CL shall be per the approved qualification manufacturing processes plan.</p>			
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COPYRIGHT AND CONFIDENTIAL The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED, It must not be used directly or indirectly in any way detrimental to the interest of the company.	<p align="center">FIGURE 2 TEST SPECIMEN LAYOUT FOR MECHANICAL PROPERTIES TESTING OF FWD. SPOOL FORGINGS</p> <p align="center">9H FWD SPOOL FORGING - STAGES 1 to 4</p> <p align="center">The actual number and location of the deep seated testing positions will be determined after review of the forging manufacturers planned forging practice and heat treatment configuration. The number will likely be more than the two shown in this sketch.</p> <p>NOTES FOR FIGURE 2:</p> <ol style="list-style-type: none">(1) <u>Specimens R and M</u> - (.75" x .75" Nominal Cross Section Ring). The center of the test rings must be .50" to .75" inches below the respective adjacent as-heat treated surfaces.(2) <u>Specimens A and B</u> - The test specimen centers are to be near the mid radial position of the forging at the respective axial locations. The precise location of test locations A, B and any additional deep seated rings shall be per the approved FPQ Manufacturing Plan.		
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