

# **Test Schedule for Metallic Materials**

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Manufacturing Plant	
Company Name	
Material Specification	
Alloy Grade	
Alloy Type	
Supply condition	
Heat treatment condition	
Size range	
Application	Military Aircraft and Aero Engine Applications

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## 1.0 <u>SCOPE</u>

1.1 This Test schedule establishes the airworthiness qualification testing requirements for

Size (Dia/Section Size mm)	Operation

#### Table 1: Size Ranges

1.2 Equivalent International Material Specification/Grades:

#### Table 2: List of Equivalent Grades

Material Specification	Grade

1.3 All reference documents are in their latest revision unless noted otherwise in another Table.

#### 2.0 APPLICATION

2.1 These products have been used typically in the aerospace sector due to the costeffective nature and versatility of the alloy------

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#### 3.0 SUPPLY CONDITION

#### 4.0 CHEMICAL ANALYSIS

4.1 For chemical analysis three samples shall be taken from each melt.

4.2 The sample shall be tested for the chemical composition by Spectro/Leco Analyser as per ASTM E 1251 / as applicable.

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Elements (wt %)	MIN	MAX

#### Table 3: Chemical Composition (wt. %)

#### 5.0 MANUFACTURE

#### 5.1 Ingots:

- 5.1.1 Raw Materials:
- 5.1.2 Ingot Moulds:
- 5.1.3 Identification:
- 5.2 Forged/ Rolled Bars/ Flats/ Sheets/ Rods/Wires:

#### 6.0 HEAT TREATMENT

- 6.1 Annealing:
- 6.2 Hardening & Tempering:

#### 7.0 COUPON LEVEL TESTING

#### Table 4: Testing required for Forgings stocks/Additive

Test	Testing Method	Direction of Samples (X - Horizontal, Y - Inclined at 45° and Z - Vertical)	Acceptance Criteria as per relevant material standard	No of samples to be tested	Compliance (Test pass/fail) with remarks, if any
Tensile test at room temperature	ASTM E8	Decided in LTCC	As per Material Specification	Decided in LTCC	
Brinell Hardness	ASTM E10	Decided in LTCC	As per Material Specification	Decided in LTCC	

#### manufacturing/Castings/Forgings

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Microstructure	ASTM E3&E407	Decide LTCC	ed in	As per Material Specification	Decided in LTCC		
Chemical composition	Relevant ASTM standard	Decide LTCC	ed in	As per Material Specification	Decided in LTCC		
Residual stress	XRD technique (ASTM E 2860)	Decide LTCC	ed in	Decided in LTCC	Decided in LTCC		
FPT	Relevant ASTM standard	100% surfac covera the pa	e age of irt	Mil S 1907 Gr B for critical part Gr C for non- critical part	All parts to be tested 100%	5	
MPI (Applicable for steel except austenitic stainless steel or nonmagnetic steel)	Relevant ASTM standard	100% surfac covera the pa	e age of irt	Mil S 1907 Gr B for critical part Gr C for non- critical part	All parts to be tested 100%		
X ray CT Scan	BS EN 16016	100% covera the pa	age of Irt	AMS 2175 Gr A or Gr B for critical part Gr C for non- critical part	All parts to be tested 100%	5	
Tensile test at elevated temperature	ASTM E 21	Decide LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC		
Low cycle fatigue	ASTM E 606	Decido LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC		
High cycle fatigue	BS 3518 Part 2 or relevant ASTM Specification	Decido LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC		
Stress rupture test	ASTM E 139	Decide LTCC	ed in	As per Material Specification	Decided in LTCC		
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			or Test			
			generation Purpose			
Creep	ASTM E139	Decided in LTCC	As per Material Specification or Test generation Purpose	Decided in LTCC		
Thermal fatigue	ASTM STP 465	Decided in LTCC	As per Material Specification or Test generation Purpose	Decided in LTCC		
Stress corrosion cracking	ASTM G 47	All 3 directions required	As per Material Specification or Test generation Purpose	3 per each direction		
Salt spray test	ASTM G 44	Decided in LTCC	As per Material Specification or Test generation Purpose	Decided in LTCC		
Electrical conductivity test	ASTM E 1004	Decided in LTCC	As per Material Specification or Test generation Purpose	Decided in LTCC		
K1c Fracture toughness test	ASTM E 399	Decided in LTCC	As per Material Specification or Test generation Purpose	Decided in LTCC		
Combined smooth and notch tensile test	ASTM E 292	Decided in LTCC	As per Material Specification or Test generation Purpose	Decided in LTCC		
Notch tensile test	ASTM	Decided in LTCC	As per Material	Decided in LTCC		
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				Specification or Test generation Purpose				
Shear test	DIN 50141	Decid LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Impact test at room or subzero temperature	ASTM E 23	Decid LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Intergranlar corrosion	ASTM A 262	Decid LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Pin on Disc wear test	ASTM G 99	Decid LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Pitting corrosion	ASTM G 46/ G48	Decid LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Exfoliation corrosion	ASTM G34	Decid LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Inclusion rating	ASTM E 45	Decid LTCC	ed in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Grain morphology and size	EBSD - ASTM E 2627	Decid LTCC	ed in	As per Material Specification	Decided in LTCC			
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				or Test generation Purpose				
Texture study	EBSD - ASTM E 2627	Decic LTCC	led in ;	As per Material Specification or Test generation Purpose	Decided in LTCC			
Depth of decarburization	ASTM E 1077	Decic LTCC	led in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Flexural test	ASTM D 790	Decic LTCC	led in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Compression test	ASTM E 9	Decic LTCC	led in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Hot salt corrosion	ASTM G 41	Decic LTCC	led in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Crevice corrosion	ASTM G 78	Decic LTCC	led in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Fretting wear	ASTM G 133	Decic LTCC	led in	As per Material Specification or Test generation Purpose	Decided in LTCC			
Poisson ratio	ASTM E 132	Decic LTCC	led in ;	As per Material Specification or Test	Decided in LTCC			
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				generatior Purpose	n		
Retained austenite	ASTM E 975	Decided LTCC	in	As p Material Specificat or T generation Purpose	per ion est n	Decided in LTCC	

# 8.0 RAW MATERIAL POWDER TESTING (For Additive Manufacturing)

#### Table 5: Powder Testing

Test	Testing standard or Method	Acceptance Criteria as per Powder
		Specification or
		finalized after 3
		batches testing
Powder Source		
Powder type (Virgin /Reuse)	-	
Particle size	SEM	
Particle size distribution	Laser particle size	
	analyzer or Sieve	
	analysis	
Apparent density (Hall flow	ASTM B 212	
meter)		
l ap density	ASTM B 527	
Flow rate (Hall flow meter)	ASTM B 214	
02	ASTM E1409	
N2	ASTM E1409	
H2	ASTM E1447	
Powder chemical	ASTM E2371 /	
composition	ASTM E539	
Powder porosity (optional)	Gas Pycnometry or	
	CT X Ray Scan	
Particle shape	SEM	

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#### 9.0 MACROSTRUCTURE INSPECTION

9.1 Macro etch test shall be carried out on two samples as per ASTM A 604 / as applicable.

#### 10.0 ULTRASONIC INSPECTION for Forging/Mill Forms

#### Table 6: Details on acceptance standard as per AMS 2630/2631/2154

Quality class	Single disconti nuity FBH size (max)	Multiple discontinuiti es FBH size (max)	Linear Discontinuity FBH size (max)	Loss of back wall reflectio n % (max)
As per				
Customer				
requirement				

#### **11.0 VISUAL INSPECTION**

11.1 The surface of the bars shall be inspected visually for deep scratches, cracks, seams, burnt spot, excessive scale and rust. It should be free from porosities, laps or any other foreign material.

#### 12.0 RADIOGRAPHIC INSPECTION for Casting /Mill Forms

- 12.1 Radiographic inspection shall be conducted in accordance with ASTM E 1742
- 12.2 Acceptance of Radiography test as per AMS 2175 Quality Class/ as per Customer requirements

#### 13.0 DIMENSIONAL INSPECTION

13.1 As per Drawing requirements

#### 14.0 <u>APPROVAL</u>

- 14.1 Developing agency shall establish the control factors of processing, which would yield products meeting the respective requirements of this schedule consistently for bars. These shall constitute the approved manufacturing procedures for each product and shall be used for subsequent production of products. If necessary to make any change in factors of processing which could affect quality or consistency in properties of the product, vendor shall submit a detailed statement of the revised operations for re-approval.
- 14.2 Control factors for producing the product include, but not limited to the following:

-Melting procedure

-Ingot reduction ratio

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-Forging/Rolling procedure

- -Working temperature range
- -Intermediate size, discard, dressing
- -Heat treatment
- -Inspection procedure

#### 15.0 <u>RECORDS</u>

#### 15.1 Maintenance of facilities

- 15.1.1 Developing agency shall keep record demonstrating the facilities used to produce, control and measure and the tests of the respective product during approval. It should be properly maintained and also checked at stage intervals against acceptable standards of accuracy.
- 15.1.2 The facilities such as heat treatment, melting furnace and measuring/testing equipment must be calibrated and the calibration record should be produced on demand by Airworthiness agency.
- 15.1.3 In case of heat treatment / preheating furnaces, a uniform temperatures zone should be specified with temperature variation therein the process.

#### **15.2 Process Sheets**

- 15.2.1 Developing agency shall prepare and maintain documented instruction defining the processing methods and routing in the manufacturing cycle for producing the respective products.
- 15.2.2 Process sheet should capture info on the melt calculation, master alloy used, furnace, raw material and its sources, any recycled material used, ingot preparation, ingot casting, homogenization treatment (if required), mill form fabrication (rolling/forging), complete details of forging/rolling process.

#### 15.3 Traceability

15.3.1 Each vendor shall maintain records to produce traceability of the forged/rolled bars back to particular melt. Disposition of all stock shall be maintained by the vendor (e.g., scrapped for cause, supplied to etc.). Record shall be maintained at least ten years.

#### 15.4 Report

- 15.4.1 Vendor shall furnish reports giving complete processing details of final supply to determine conformance to the technical requirement of the schedule. The schedules shall be included as enclosure to the type test record along with copy of application of approval.
  - 1. Chemical analysis Ladle Mill TC

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- 2. Heat No. details
- 3. Heat treatment batch No. and cycle graphs
- 4. Mechanical test reports
- 5. Metallography (Macro etch, Inclusion rating, Grain size)
- 6. Ultrasonic test report / MPI / Cleanliness Test
- 7. Dimensional & visual inspection report
- 8. Certificates and report review
- 9. Any other customer requirement

#### 16.0 RE-SAMPLING AND RE-TESTING

If any of the test specimen first selected FAIL to pass the mechanical tests, two further specimens from the same batch shall be selected for re-testing.

- 16.1 If the test specimens from both these additional specimens pass, the batch represented by the specimens shall be considered as PASS. If the test specimen from either of these additional specimens FAIL, the failure of any shall be the cause of rejection of the batch. Re-testing shall be done with the knowledge of the Airworthiness agency/QA agency.
- 16.2 During ultrasonic inspection of stocks at suitable stage of manufacture if unacceptable defects found, the area containing each indication shall be removed and re-examined if adequate analysis can be made from observation of ultrasonic indications to identify cause of indication, no further investigation would be necessary. If the nature of extent of the indication cannot be adequate analyzed by examination, the removed portion shall be further sectioned to complete the analysis.
- 16.3 The product faces adjacent to indication shall be etched and examined. If ultrasonic indications are determined to be isolated and caused by or associated with segregation, voids or inclusion the remainder of the affected slab may be used. However, if etched of the adjacent cut faces of the stock reveals additional evidence of segregation, voids or inclusions, further cutting, etching and examination shall be conducted until it is assured that the defective area has been removed.

#### 17.0 IDENTIFICATION (AS PER AMS 2806)

- 1. P.O No.
- 2. Material specification No. including Revision Letter
- 3. Heat No.
- 4. Bar No.
- 5. Nominal Size
- 6. Heat treatment Batch No. and Date
- 7. HT condition

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8. Vendors name and insignia/symbol

#### 18.0 <u>PACKING</u>

20.1 The product shall be prepared for shipment in accordance with commercial practice to avoid any physical damage during shipment and storage as per ASTM A700 / as applicable.

#### 19.0 REJECTIONS

21.1 Material not conforming to this test schedule or to the unauthorized modifications will be subject to rejection.

#### 20.0 <u>Notes</u>

- 20.1. All data logs for 3 development batches to be kept till approval stage and further as per IMTAR21 SubpartC3.
- 20.2. All Process & Testing documents to be submitted thereafter.
- 20.3. Process control document has to be finalized tentatively before the first development batch and send it to RCMA / CEMILAC for coordination. It should be finalized and control copied after development of 3 batches.
- 20.4. Process and Testing have to be informed to RCMA / CEMILAC and DGAQA in advance to plan the coordination for all three development batches. Physical or online witness will be intimated by TAA based on their resources and work load.
- 20.5. After production of the first batch is completed, process compliance test and test reports are duly signed by DGAQA which are then forwarded to RCMA/ CEMILAC for clearance and after clearance the material is then dispatched to customer.
- 20.6. A subsequent batch of two or more must be produced, tested in accordance with the test schedule, and all the results duly signed by DGAQA, along with performance feedback, must be submitted to RCMA / CEMILAC to obtain LoA.
- 20.7 It does not cover any long cycle testing such as notch tensile, fatigue, creep, stress rupture, corrosion, wear, erosion and any physical/thermal/electrical properties. When the OEM/designer/customer selects this material bar for any aircraft/aero engine applications, it is the OEM/designer/customer responsibility to ensure the part specific properties (any additional coupon level and part level) requirements in the machined part. Failing which, OEM/designer/customer is only accountable for the airworthiness lapse.

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