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General Electric Company
Cincinnati, OH 45215

Supersedes B50TF343-S1

SPECIFICATION

NICKEL-CHROMIUM-MOLYBDENUM-TUNGSTEN CONTROLLED EXPANSION ALLOY FORGINGS AND RINGS

1. SCOPE

1.1 Scope. This specification presents requirements for nickel-chromium-molybdenum-tungsten alloy forgings and rings with controlled expansion properties known as Haynes 244.

1.1.1 Classification. This specification contains the following class(es). Unless otherwise specified, the requirements herein apply to all classes.

CLASS A: Solution Heat Treated
CLASS B: Solution Heat Treated and Aged

1.2 Definitions. For purposes of this specification, the following definitions shall apply:

PREPARED John Warren 10/16/2015	REVIEWED	APPROVED ☒ EVENDALE
APPROVED Robert Zimmerman 10/16/2015	DISTRIBUTION 10A	☒ LYNN

Capability - The words "shall be capable of" or "capability test" indicate characteristics or properties required in the product but for which testing of each lot is not required. However, if such testing is performed by the Purchaser, material not conforming to the requirements shall be subject to rejection.

Inflection Temperature - That point along a curve of expansion versus temperature line, where the direction of curvature changes abruptly.

Lot - A specific amount of material produced at one time using the same process and same conditions of manufacture.

Metal Temperature - The actual temperature of the material, regardless of temperature variation from sources such as furnace tolerance, etc. For example, if a metal temperature range of 1700 to 1800 °F (927 to 982 °C) is specified as part of the heat treatment process requirements and the heat treatment is to be performed in a furnace with a furnace tolerance of ± 25 °F (± 14 °C) from set temperature, the furnace set temperature must be set in the range of 1725 to 1775 °F (941 to 968 °C) to assure that the metal temperature does not exceed the specified limits.

Purchaser - The procuring activity of GE Aviation that issued the procurement document invoking this specification. When this specification is invoked by a U. S. Government purchasing activity (or such activity's designee) the Purchaser shall mean such activity or designee as the case may be.

Supplier – Source, other than GE Aviation, who provides material, parts or services, for incorporation into GE Aviation products.

1.3 EHS Regulated Materials. The requirements of P2TF1 CL-A shall be complied with. The material(s) shown below were referenced in this specification and P2TF1 CL-A, as of the date of this specification issue. The list below does not include all materials that are referenced in sub-tier documents.

(a) Chromium and Compounds

(b) Nickel and Compounds

2. APPLICABLE DOCUMENTS

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

AEROSPACE MATERIAL SPECIFICATIONS

AMS 2269	Chemical Check analysis Limits - Wrought Nickel Alloys and Cobalt Alloys

AMERICAN SOCIETY FOR TESTING AND MATERIALS

ASTM E 8	Test Methods for Tension Testing of Metallic Materials
ASTM E 10	Test Method for Brinell Hardness of Metallic Materials
ASTM E 18	Test Methods for Rockwell Hardness Of Metallic Materials
ASTM E 21	Test Methods for Elevated Temperature Tension Tests of Metallic Materials
ASTM E 103	Standard Practice for Rapid Indentation Hardness Testing of Metallic Materials
ASTM E 139	Test Method for Conducting Creep, Creep-Rupture and Stress-Rupture of Metallic Materials
ASTM E 140	Hardness Conversion Tables for Metals
ASTM E 228	Test Method for Linear Thermal Expansion of Solid Materials with a Push-Rod Dilatometer

GE AVIATION SPECIFICATIONS

E50TF133	Metallographic Evaluation Of Grain Size In Wrought Nickel And Heat Resistant Alloys
P2TF1	Regulated Materials, Environmental, Health and Safety

2.2 Order of Precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

*3.1 Deleted

3.2 Chemical Composition, Weight Percent. Material supplied to this specification shall have the following composition:

Molybdenum-------	22.00-23.00	Manganese ----------	0.80 Max.
Chromium --------	7.50-8.50	Aluminum ----------	0.50 Max.
Tungsten---------	5.40-6.70	Carbon ----------	0.03 Max.
Iron ----------	2.00 Max.	Nickel ----------	Remainder

3.2.1 Analysis. The analysis made by the Supplier to determine the percentages of elements required by this specification shall conform to the requirements of 3.2 and shall be reported in the certificate of test herein specified.

3.2.2 Remelt Ingots. When a heat of material consists of remelted ingots not produced from alloy originally melted in a single furnace charge, the individual melts shall be produced from the same controlled lots of raw material, and the total weight of such a composite heat shall not exceed 25,500 pounds (9,331 kg).

3.2.2.1 Individual Melt Variation Limits. The weight percent chemical variation limit between individual melts shall be within the limits listed in 3.2.

3.3 Manufacturing. Material shall be produced by one of the following melting processes:

(a) Vacuum induction melting followed by vacuum consumable electrode remelting.

(b) Vacuum induction melting followed by consumable electrode remelting by the electroslag process, under a protective flux blanket.

3.4 Billets. Material supplied to this specification shall be uniform in quality and in condition, clean, sound, free from foreign materials and segregation, and from internal and external defects detrimental to fabrication or performance of the parts.

3.5 Heat Treatment. All heat treat times refer to time at temperature for the heaviest section. All heat treat temperatures refer to metal temperature ± 25 °F (± 14 °C). Material shall be supplied in one of the following heat treat conditions as specified on the purchase order:

CLASS A: Solution at a selected metal temperature in the range of 2000 to 2100 °F (1093 to 1149 °C), including metal temperature variation, for 1 hour + 12/-0 minutes. Cool at a rate equal to forced air cool or faster.

CLASS B: CLASS A plus age at a metal temperature of 1400 °F (760 °C) for 16 hours + 60/-0 minutes, cool to 1200 °F (649 °C), hold at 1200 °F (649 °C) for 32 hours + 60/-0 minutes and air cool.

3.6 Mechanical Properties. Specimens from material to CLASS A after aging in accordance with CLASS B shall meet the mechanical property requirements for CLASS B material.

3.6.1 Tensile. Material to CLASS B and material to CLASS A after heat treatment to CLASS B shall meet the minimum properties in Table I.

Table I – Tensile Properties

Properties	Room Temperature	1200 °F (650 °C)
Tensile Strength, ksi (mPa)	180 (1241)	130 (896)
0.2% Yield Strength, ksi (mPa)	110 (758)	80 (552)
Elongation, %	17	13
Reduction in Area, %	18	16

3.6.2 Stress Rupture. When specified on the drawing, test specimens machined from material to CLASS B and test specimens machined from material to CLASS A, after heat treatment to CLASS B, shall meet the following minimum stress rupture requirements:

Temperature ---------- 1400 °F (760 °C)
Stress ---------- 44,000 psi (303 mPa)
Life ---------- 30 hours
Elongation, in 2 inches or 4D ----- 3 percent

3.6.2.1 Alternate Method. Stress rupture testing may be performed at stress levels higher than that specified provided all other test conditions are maintained. The specified life and elongation measurements shall apply and the stress shall remain constant while the test is in progress. Specific stress used shall be reported in the certificate of test.

3.6.2.2 Incremental Loading. When approved by the Purchaser, the 1400 °F (760 °C) stress rupture tests may be performed using incremental loading. In such cases a stress of 44,000 psi (303 mPa) shall be used until rupture or to 30 hours, whichever occurs first. After the minimum time occurs, and at intervals of 8 to 16 hours thereafter, the stress shall be increased in increments of 5000 psi (34 mPa). The specified elongation measurements shall apply.

3.7 Hardness. CLASS B and CLASS A after heat treatment to CLASS B shall have a minimum hardness of 38 Rockwell C or equivalent in accordance with ASTM E 140. Hardness shall not be cause for rejection if material from the same lot with the same hardness meets the tensile property requirements of this specification.

3.8 Grain Size. When examined at 100X magnification in a plane parallel to the direction of working, the microstructure of forgings and rings shall exhibit an average grain size of ASTM No. 3 or finer. Grains as large as (ALA) ASTM No. 1 are permissible provided they are surrounded by finer grains.

3.9 Thermal Expansion. The mean coefficient of linear thermal expansion at 1000 °F (538 °C) using 70 °F (21 °C) as a reference temperature shall be 6.4 to 6.8 x 10^{-6} inches/inch per °F (11.5 to 12.2 x 10^{-6} mm/mm per °C).

3.9.1 Inflection Temperature. The inflection temperature of each heat of material shall be within the range of 1150 to 1250 °F (621 to 677 °C).

3.10 Tolerances. Tolerances shall conform to AMS 2262 as applicable.

3.11 Certificate of Test. The Material Supplier shall retain a certificate of test for each shipment of parts supplied to this specification. The Material Supplier shall certify all chemical and mechanical tests specified herein. The certificate of test shall include the numerical results (or conformance certification when numerical results are not applicable) of all required tests and inspections performed by the Material Supplier. The results shall be in accordance with the requirements herein. The Material Supplier shall certify capability for all tests and inspections designated by a capability requirement herein, and a statement of the capability shall be included in the certificate of test. The certificate of test shall also include the following information:

(a) Purchase order number

(b) Supplier name

(c) Heat number

(d) Heat treat lot number for each forging

(e) Forging lot number for each forging

(f) Testing and machining source for tensile and thermal expansion specimens

(g) Thermal expansion characteristics

(h) Inflection temperature

(i) This GE specification number, class, and issue number.

3.12 Material Identification Record. A material identification record shall be submitted by the Machining Supplier to the Purchaser and shall include the following information:

(a) Forging Supplier's certificate of test

(b) Heat treat Supplier name

(c) Machining Supplier's laboratory release report number

(d) Inspection reports when requested

(e) This GE specification number, class, and issue number.

4. QUALITY ASSURANCE PROVISIONS

4.1 Chemical Analysis. Chemical analyses shall be performed in accordance with ASTM standards or methods approved by the Purchaser.

4.1.1 Limits. Chemical check analysis limits shall be in accordance with AMS 2269.

4.2 Mechanical Properties Testing

4.2.1 Test Methods. All testing shall be performed in accordance with ASTM standards or methods as approved by the Purchaser. The Supplier shall inform the Purchaser of the test procedures used.

4.2.2 Periodic Testing. Forgings with integral test rings shall be cut up and periodically tested to the requirements of this specification. The frequency of testing and the number and types of tests shall be as approved by the Purchaser. The location of test specimens shall be as indicated on the specific part number drawing.

4.2.3 Tensile. Tensile tests shall be performed in accordance with the applicable requirements of ASTM E 8 or ASTM E 21.

4.2.3.1 Referee Procedure. For referee tensile tests, a strain rate of 0.005 inch per inch (0.005 mm per mm) per minute through the 0.2 percent yield strength shall be used.

4.2.4 Stress Rupture. Stress rupture tests shall be performed in accordance with the applicable requirements of ASTM E 139. Tests shall be continued to rupture.

4.2.4.1 Test Specimens. Test specimens shall be smooth bar specimens.

4.2.4.2 Referee Procedure. For referee tests smooth rupture specimens shall conform to the dimensions and proportions of a standard 0.252 inch (6.40 mm) diameter test bar in accordance with ASTM E 8 or ASTM E 139, except that a gage diameter as small as 0.200 inch (5.08 mm) with other dimensions proportional, may be used in order to maintain a thread diameter to gage diameter ratio of 2.5, minimum.

4.3 Hardness. Hardness shall be determined in accordance with ASTM E 10, ASTM E 18 or ASTM E 103, as applicable.

4.4 Grain Size. Grain size shall be determined in accordance with E50TF133, CL-A.

4.5 Thermal Expansion And Inflection Temperature. Thermal expansion shall be determined in accordance with the applicable requirements of ASTM E 228. Inflection temperature is determined by establishing the intersection of the tangent of the upper and lower portions of the dilatometric expansion curve.

5. PACKAGING

5.1 Packing. All parts shall be packed to prevent damage, loss or contamination during shipment, and shall be separated by size and heat numbers.

5.2 Marking. Each shipment shall be legibly marked with the purchase order number, Supplier's name, sizes, heat numbers, drawing number, and this GE specification number, class and issue number.

6. NOTES

6.1 Purpose. This section contains information of a general nature, which may be helpful, but is not mandatory. It does not contain any requirements.

*6.2 Deleted

REVISION HISTORY

B50TF343-S1	Initial Issue	10-16-2015
-S2	CID 548386	05-31-2016

*Denotes Latest Revision