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SPECIFICATION 规范

PREMIUM QUALITY 6A1-4V TITANIUM ALLOY BLADES AND VANES

优质 6A1-4V 钛合金叶片和叶片

1.SCOPE

1.1 Scope.This specification covers requirements for Premium Quality 6A1-4V titanium alloy blades and vanes.

1.1 范围。本规范包括优质 6A1-4V 钛合金叶片和叶片的要求。

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

1.1.1 分类。本规范包含以下类别。除非另有规定，此处的要求适用于所有类别。

CLASS A: Double Vacuum Arc Remelt (VAR) A 类：双真空电弧重熔（VAR）

CLASS B: CANCELLED-Use CLASS A 取消 - 使用 CLASS A.

CLASS C: Triple VAR 三重 VAR

CLASS D:Hearth Melt Plus VAR 炉缸熔融加 VAR

CLASS E: Double VAR-Fan and Large Compressor Blades 双 VAR 风扇和大型压缩机叶片

CLASS F: Triple VAR-Fan and Large Compressor Blades 三重 VAR 风扇和大型压缩机叶片

CLASS G: Hearth Melt Plus VAR-Fan and Large Compressor Blades 炉缸熔融加 VAR-Fan 和大型压缩机叶片

CLASS H: Small Hearth Melt Plus VAR 小炉膛熔体加 VAR

CLASS I: Small Hearth Melt Plus VAR-Fan and Large Compressor Blades 小炉缸熔体加 VAR 风扇和大型压缩机叶片

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|--------------------------------------|---|------------------------------------|
| PREPARED NW Betcher 准备 NW Betcher | REVIEWED Evendale/Lynn 评 论 Evendale / Lynn | APPROVED EVENDALE 批准 的 EVENDALE |
| APPROVED GE Best 批准的 GE Best | DISTRIBUTION 10A 分发 10A | LYNN |

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1.2 Definitions.The terminology used herein is in accordance with AS 1814.For purposes of this specification,the following definitions shallapply:

1.2 定义。此处使用的术语符合 AS 1814.为了本说明书的目的，以下定义为 shallapply:

Alpha Case-A continuous hard white oxygen rich alpha-phase surface Layer.

Alpha Case-A 连续硬白色富氧 α 相表面层

Bar-Converted material having a circular or rectangular cross section area of less than or equal to 16.0 square inches(103.2 cm).

条形转换材料，其圆形或矩形横截面积小于或等于 16.0 平方英寸（103.2 厘米）。

Beta Transus-The minimum metal temperature that alpha-beta processed material can be heated to transform it completely to the beta phase. Beta Transus-可以加热 α - β 处理材料的最低金属温度，使其完全转变为 β 相。

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.

能力 - “应能够”或“能力测试”一词表示产品所要求的特性或性质，但不需要对每批产品进行测试。但是，如果此类测试由买方进行，则材料不符合

Crack-A separation,rupture or fissure altering the continuity of the surface,usually narrow or tight and characterized by sharp edges or abrupt changes in direction with depth to width

ratio of 4 to 1 or greater.

裂缝 - 分离, 破裂或裂缝改变表面的连续性, 通常是狭窄或紧密的, 其特征不在于锋利的边缘或方向的突然变化, 深宽比为 4 比 1 或更大。

Established Procedure-A procedure that is subject to Purchaser approval and is contained in a controlled document.It includes limits,controls,and applicable standards.

已建立的程序-A 程序受买方批准并包含在受控文件中。它包括限制, 控制和适用标准。

Forging Run-A run of parts at final forging operations that was processed utilizing the same setup and forging techniques.

锻造运行 - 在最终锻造操作中使用相同的设置和锻造技术处理的零件。

Hand Operation-An operation where the part or tool is held by an operator.

手动操作 - 操作员握住零件或工具的操作。

Heat-The ingot and ingot product produced from the final melt.

手动操作 - 操作员握住零件或工具的操作。

Heat Treat Lot-All parts heat treat processed within a single or multistep run in the same continuous or batch type furnace with no change in the furnace settings or interruption of power.

热处理批次 - 所有零件热处理在同一连续或间歇式炉中单次或多步运行处理, 炉子设置没有变化或功率中断

Inclusions-Particles of impurities or foreign materials that are present or introduced during any stage of alloy processing.Examples include a Type I Hard Alpha Inclusion formed by high interstitial element content and a high density inclusion(HDI)formed by refractory mmetals such as tungsten or molybdenum.

夹杂物 - 在合金加工的任何阶段存在或引入的杂质或异物的颗粒。实例包括由高间隙元素含量形成的 I 型硬质 α 夹杂物和由难熔性金属形成的高密度夹杂物 (HDI) 如钨或钼。

Intergranular Attack-Preferential attack occurring at grain boundarieswith negligible attack to adjacent grains.

粒间攻击 - 在晶界发生的优先攻击, 对相邻晶粒的攻击可忽略不计。

Lap,Fold,Seam-A dark irregular line caused by the plastic working of metal that may create overlapping surfaces that are not fused together.

由金属塑性加工引起的深色不规则线, 可能会产生未融合在一起的重叠表面。

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Large Compressor Blades-Compressor blades having a plan view airfoil surface area(maximum chord width multiplied by the airfoil span at stacking axis)greater than 30.0 square inches(193.5 cm²).

大型压缩机叶片 - 压缩机叶片具有平面图翼型表面积 (最大弦宽乘以堆积轴上的翼型跨度) 大于 30.0 平方英寸 (193.5cm²)。

Macroetch-Chemical treatment of a metal surface to accentuate structural details and anomalies for visual observation.

Macroetch-化学处理金属表面, 以突出结构细节和异常视觉观察。

Metal Temperature-The actual temperature of the material,including temperature variation

from sources such as furnace tolerance,etc.For example,if a metal temperature range of 1725F to 1825'F (941'C to 996'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 $125^{\circ}\text{F} (+ 14^{\circ}\text{C})$ from set temperature,the furnace control temperature shall be set to achieve a nominal metal temperature in the range of 1750F to 1800'F(954C to 982C)to assure that the metal temperature does not exceed the specified limits.If a $1300^{\circ}\text{F} + 25^{\circ}\text{F} (704^{\circ}\text{C} \pm 14^{\circ}\text{C})$ metal temperature is specified,and the furnace tolerance is $+ 15^{\circ}\text{F} (+ 8^{\circ}\text{C})$ then the furnace control temperature shall be set to achieve a nominal metal temperature of 1290" F to 1310'F (699'C to 710'C).

金属温度 - 材料的实际温度，包括炉子公差等来源的温度变化。例如，如果金属温度范围为 1725F 至 1825'F (941'C 至 996'C) 被指定为 热处理工艺要求和热处理应在炉温为设定温度为 $125^{\circ}\text{F} (+ 14^{\circ}\text{C})$ 的炉内进行，炉温控制温度应设定为标称金属温度范围为 1750F 至 1800'F(954C 至 982C)，以确保金属温度不超过规定的极限。如果指定 $1300^{\circ}\text{F} + 25^{\circ}\text{F} (704^{\circ}\text{C} \pm 14^{\circ}\text{C})$ 金属温度，炉子公差为+ 然后将炉子控制温度设定为 $15^{\circ}\text{F} (+ 8^{\circ}\text{C})$ ，以达到标称金属温度 1290" F 至 1310'F (699'C 至 710'C)。

Premium Quality-Material produced under special process and quality control requirements and used primarily for critical rotating and orbiting parts.

优质 - 在特殊工艺和质量控制要求下生产的材料，主要用于关键的旋转和轨道部件。

Purchaser-The procuring activity of GE Aircraft Engines(GEAE)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.

买方 - GE 航空发动机 (GEAE) 的采购活动，其中包含了援引本规范的采购文件。当美国政府采购活动 (或此类活动的指定人) 引用本规范时，买方应指具体情况下的此类活动或指定人员。

Segregation-Volumes in the alloy product containing an abnormal content of alloying elements.These segregated volumes appear as zones of abnormal quantities of either the alpha or beta phases of titanium. Alpha-rich segregation is called Type II segregation.Beta-rich segregation is called a beta fleck.

偏析 - 含有合金元素异常含量的合金产品中的体积。这些偏析体积表现为钛的 α 或 β 相异常量的区域。富含 α 的分离被称为 II 型分离。富含 β 离子的分离称为 β 斑点。

Supplier-Source other than GE Aircraft Engines(GEAE)who provides material,parts or services,for incorporation into GEAE products.

供应商 - GE 飞机发动机 (GEAE) 以外的其他来源，提供材料，零件或服务，以便纳入 GEAE 产品。

Type I Hard Alpha Inclusion-An interstitially stabilized alpha-rich region of higher hardness and lower ductility than the surrounding normal matrix.It arises from a high local concentration of one or more of the elements nitrogen,oxygen or carbon.

I 型硬质 α 包含物 - 一种间隙稳定的富含 α 的区域，其硬度高，延展性低于周围的正常基质。它来自一种或多种元素氮，氧或碳的高局部浓度。

1.3 Regulated Materials.The requirements of P2TFI,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 which are referenced

in sub-tier documents.

1.3 受管制的材料。应符合 P2TF1, CL-A 的要求。本规范中引用下面所示的材料和本规范发布之日的 P2TF1, CL-A。以下列表不包括子层文档中引用的所有材料。

There are no referenced materials.

没有参考资料。

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2.APPLICABLE DOCUMENTS 适用文件

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.

2.1 文件问题。以下文件构成本说明书的一部分，除非另有说明，否则最新版本适用。

AEROSPACE MATERIAL SPECIFICATIONS

AMS 2249

Chemical Check Analysis Limits Titanium and Titanium Alloys

化学检查分析限制钛和钛合金

AMS 2642

Structural Examination of Titanium Alloys,EtchAnodize Inspection

钛合金的结构检验，蚀刻阳极氧化检测

AMS 2750

Pyrometry

AEROSPACE STANDARDS 航空标准

Terminology for Titanium Microstructures

钛微结构术语

AS 1814

AMERICAN SOCIETY FOR TESTING AND MATERIALS 美国测试与材料学会

ASTM E8 Tension Testing of Metallic Materials 金属材料的拉伸试验

GE AIRCRAFT ENGINES SPECIFICATIONS GE 飞机发动机规格

ESOTF148

Axial Strain Control Low Cycle Fatigue Testing of Metal Test Bars

轴向应变控制金属试棒低周疲劳试验

PITF28

Premium Quality Multiple VAR Titanium Base Alloys

优质多 VAR 钛基合金

P1TF73

Premium Quality Hearth Melt Plus VAR Titanium Base Alloys

优质 Hearth Melt Plus VAR 钛基合金

P1TF79

Metallic Test Specimen Preparation,Low Stress

金属试样制备，低应力

P1TF103

Premium Quality Small Hearth Melt Plus VAR Titanium Base Alloys

优质小炉膛熔体加 VAR 钛基合金

P2TF1

Regulated Materials

受管制材料

P3TF2

Fluorescent Penetrant Inspection

荧光渗透检测

P3TF5

Radiographic Inspection

射线检查

P3TF19

Examination of Wrought Titanium Alloys for Alpha Case

阿尔法表壳锻造钛合金的检验

P3TF25

Structural Examination of Titanium Alloys, Etch Anodize Inspection Procedure

钛合金的结构检验, 蚀刻阳极氧化检验程序

P3TF34

Ultrasonic Inspection of Metallic Bar Stock Using Pulse Echo Immersion Techniques

脉冲回波浸没技术对金属棒料的超声检测

P4TF3

Cleaning of Titanium

钛的清洁

P10TF1

Vacuum Heat Treating and Brazing

真空热处理和钎焊

P11TF3

Shot Peening of Metal Parts

P29TF40

Acceptability Limits for Fluorescent Penetrant Inspection of Compressor Blades and Vanes

压缩机叶片和叶片的荧光渗透检测的可接受性限制

GE AIRCRAFT ENGINES PHOTOGRAPHS

320817

Titanium Microstructure at 100X, Level 10 and Level 20

钛微结构在 100X, 10 级和 20 级

320818

Titanium Microstructure at 100X, Level 30 and Level 40

钛微结构在 100X, 30 级和 40 级

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320819

Titanium Microstructure at 100X,Level 50 and Level 60

钛微结构在 100X, 50 级和 60 级

320820

Titanium Microstructure at 100x,Level 70 and Level 80

钛微结构在 100x, 70 级和 80 级

S20181

Acceptable Shear Banding

可接受的剪切带

S20182

Limit of Acceptable Shear Banding

可接受的剪切带的限制

3.REQUIREMENTS3.要求

3.1 Bar And Forged Parts. 棒和锻造零件。

CLASSES A AND E:Parts shall be produced from 6A1-4V titanium alloy bar.Bar shall be double VAR processed and converted using procedures and acceptance criteria in accordance with P1TF28,CL-A.Ultrasonic inspection of finished bar shall be performed in accordance with P3TF34,CL-A,CL-B or CL-D.Acceptance testing may be performed on one end of each bar utilizing an Established Procedure approved by the Purchaser.Bar shall be finished by alpha-beta processing and machined or centerless ground.Substitution of CLASS C Or CLASS D Or CLASS H For CLASS A and CLASS F Or CLASS G Or CLASS I for CLASS E is permitted.
A 级和 E 级: 零件应由 6A1-4V 钛合金棒生产。棒应采用双 VAR 处理, 并按照 P1TF28, CL-A 的程序和验收标准进行转换。成品棒的超声波检验应按照 P3TF34, CL-A, CL-B 或 CL-D。可以使用买方批准的既定程序在每个杆的一端进行验收测试。杆应通过 α - β 处理和机加工或无心地面完成。CLASS C 或 CLASS D 或 CLASS H 对于 CLASS A 和 CLASS F 或 CLASS G 或 CLASS I for CLASS E 是允许的。

CLASSES C AND F:Parts shall be produced from 6A1-4V titanium alloy bar.Bar shall be triple VAR processed and converted using procedures and acceptance criteria in accordance with P1TF28,CL-B.Ultrasonic inspection Of finished bar shall be performed in accordance with P3TF34,CL-A,CL-B or CL-D.Acceptance testing may be performed on one end of each bar utilizing an Established Procedure.Bar shall be finished by alpha-beta processing and machined or centerless ground.Substitution of CLASS D for CLASS C and CLASS G for CLASS F is permitted.

C 和 F 类: 零件应采用 6A1-4V 钛合金棒材生产。棒材应采用三重 VAR 加工, 并按照 P1TF28, CL-B 的程序和验收标准进行转换。超声波检验成品棒材应按照 P3TF34, CL-A, CL-B 或 CL-D。可以使用已建立的程序在每个柱的一端进行接受测试。杆应通过 α - β 处理和加工或无心接地完成。CLASS D 的替换为 CLASS 允许使用 CLASS F 的 C 和 CLASS G。

CLASSES D AND G:Parts shall be produced from 6A1-4V titanium alloy bar. Bar shall be hearthmelt plus VAR processed and converted using procedures and acceptance criteria in accordance with P1TF73,CL-A.Ultrasonic inspection of finished bar shall be performed in

accordance with P3TF34,CL-A,CL-B Or CL-D.Acceptance testing may be performed on one end of each bar utilizing an Established Procedure.Bar shall be finished by alpha-beta processing and machined or centerless ground.

D 和 G 类：零件应由 6A1-4V 钛合金棒制成。根据 P1TF73, CL-A, 使用程序和验收标准对棒材进行加工和转换。应根据 P3TF34, CL-A, CL-B 或 CL-D 进行超声波检验。验收测试可以使用已建立的程序在每个杆的一端进行。杆应通过 α - β 处理和机加工或无心地面完成。

CLASSES H AND I:Parts shall be produced from 6A1-4V titanium alloy bar.Bar shall be small hearth melt plus VAR processed and converted using procedures and acceptance criteria in accordance with PITF103,CL-A. Ultrasonic inspection of finished bar shall be performed in accordance withP3TF34,CL-A,CL-B Or CL-D.Bar shall be finished by alpha-beta processing and machined or centerless ground.Substitution of CLASS C or CLASS D for CLASS H and CLASS F or CLASS G for CLASS I is permitted.

类别 H 和 I：零件应由 6A1-4V 钛合金棒生产。棒应为小型炉膛熔体加 VAR 处理，并按照 PITF103, CL-A 的程序和验收标准进行转换。成品棒的超声波检测应按照 P3TF34, CL-A, CL-B 或 CL-D 进行。棒应通过 α - β 处理和机加工或无心接地完成。对 CLASS H 和 CLASS D 进行替换，用于 CLASS H 和 CLASS I 的 CLASS F 或 CLASS G 是允许的。

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

3.1.1 化学成分，重量百分比。本规范提供的材料应具有以下成分：

Aluminum-----5.50-6.75,Al \leq 0.30%

Vanadium-----3.50-4.50,V \leq 0.30%

Tin,Molybdenum,Copper, 锡，钼，铜

Manganese,and Zirconium, 锰和锆，

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Iron-----0.30 Max. Fe \leq 0.30%

Oxygen-----0.20 Max.O \leq 0.20%

Carbon-----0.05 Max. C \leq 0.05%

Nitrogen-----0.05 Max. N \leq 0.05%

Hydrogen-----0.0125 Max. H \leq 0.0125%

Yttrium-钇-----0.0050 Max.[1] Y \leq 0.0050%

Boron-硼-----0.0014 Max. B \leq 0.0014%

Each-----0.10 Max. 单个 \leq 0.10%

Total-----0.20 Max. 总共 \leq 0.20%

Other Elements, 其它元素，

Each---0.10 Max.[1]

Total---0.20 Max.[1]

Titanium---Remainder [1] 钛---剩余[1]

Note:[1] Determination not required for routine acceptance.

注：[1]常规验收不需要确定。

3.1.1.1 Chemical Analysis.The analysis made by the Supplier to determine the percentages of

elements required by this specification shall conform to the requirements of 3.1.1 and shall be reported in a certificate of test.

3.1.1.1 化学分析。供应商为确定本规范要求的元素百分比而进行的分析应符合 3.1.1 的要求，并应在测试证书中进行编制。

3.1.1.2 Other Elements.The "Other Elements"covered in 3.1.1 may be residual metallic elements from the sponge making process or from the use of recycled material in the melting process.No intentional additions of metallic or non-metallic materials shall be made other than titanium, aluminum,vanadium,iron and oxygen.

3.1.1.2 其他元素 3.1.1 中所述的“其他元素”可以是海绵制造过程中的残余金属元素，也可以是熔化过程中使用再生材料的金属元素。不应有意添加金属或非金属材料。除了钛，铝，钒，铁和氧以外的其他产品。

3.1.2 Beta Transus Temperature.The bar or forging Supplier shall determine the beta transus temperature for each heat of bar material used to produce parts procured to this specification.

3.1.2 Beta Transus 温度。棒材或锻造供应商应确定用于生产本规范采购零件的每种棒材热量的 β 转变温度。

3.1.3 Bar And Part Suppliers.Bars and parts shall be procured only fromSources approved by the Purchaser.

3.1.3 条形和零件供应商。条形和零件只能从买方批准的资源中采购。

3.2 Material Processing.Parts supplied to this specification shall be produced from alpha-beta processed bar.All processing shall be performed in accordance with Established Procedures which shall be controlled as specified herein.

3.2 材料加工。本规范提供的部件应由 α - β 加工棒生产。所有加工均应按照已确定的程序进行，该程序应按本文规定进行控制。

3.2.1 Process Control.Suppliers shall maintain a controlled document with effective controls for each step of the processing sequence. Significant process parameters shall be identified along with their corresponding control points and control limits(within engineering requirement limits).Process parameter measurements shall be made at the control points.Frequency of control point monitoring shall be identified.Procedures for documenting and processing control limit violations also shall be identified.

3.2.1 过程控制。供应商应保持受控文件，对处理顺序的每个步骤都有有效控制。应识别重要的过程参数及其相应的控制点和控制限值（在工程要求 limits 内）。过程参数测量应在控制点进行。应识别控制点监测的频率。记录和处理控制限制违规的程序也应该确定。

3.2.1.1 Process Parameter Control.The controlled document shall be subject to approval by the Purchaser and,once approved,no changes to the significant process parameters shall be made without obtaining written approval from the Purchaser.When any of the significant process parameters exceed the defined control limits,the Supplier shall follow procedures defined in a controlled document.

3.2.1.1 过程参数控制。受控文件应经买方批准，一经批准，未经买方书面许可，不得对重要过程参数进行任何变更。当任何重要过程参数超出定义控制限制，供应商应遵循受控文件中规定的程序。

3.2.2 Hogouts.Parts may be machined directly from alpha-beta processed bar if approved by

the Purchaser. If parts are machined from bar, the machining Supplier shall be considered the part Supplier for purposes of this specification.

3.2.2 Hogouts. Parts 可以直接从 alpha-beta 加工杆加工。如果买方批准，如果零件是用棒材加工的，加工供应商应被视为本规范的供应商。

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3.2.3 Forging Process. Unless machined directly from bar, parts shall be forged at a selected temperature using an established procedure. The maximum metal temperature to which the slugs or preforms are exposed shall not exceed the design temperature minus 25°F (14°C) during any operation of the forging process. The material shall be heated to the selected metal temperature and the temperature variation within the material shall not exceed 125°F (114°C). The forging temperature used shall be recorded.

3.2.3 锻造过程。除非直接从底部进行加工，否则应使用已建立的程序在选定的温度下对部件进行加工，使嵌条或预制件暴露的最高金属温度不得超过设计温度减去 25°F (14°C)。在任何操作过程中，材料应加热到选定的金属温度，材料内的温度变化不应超过 125°F (114°C)，应记录锻造温度。

3.2.4 Heat Treatment. All heat treat and processing temperatures refer to metal temperature and all times refer to the minimum time at temperature for the thickest section. Heat treat temperatures shall be maintained within 25°F (14°C) of the metal temperatures specified.

3.2.4 热处理。所有热处理和加工温度均为金属温度和每次参考温度最低时间段的最小时间，保持温度为 ±11 保持在指定金属温度的 259°F (14°C)。

3.2.4.1 Heat Treat Requirements. Before machining, all forged parts and bar for hogouts shall be heat-treated at 1300°F (704°C) for 2.0 hours in accordance with an established procedure.

3.2.4.1 热处理要求。在加工前，所有锻造部件和用于 hogouts 的棒材应在 1300°F (704°C) 下进行热处理，持续时间为 2.0 h 根据已建立的程序。

3.2.4.2 Stress Relieving. Blades and vanes that have been subjected to bonding, forging or other plastic deformation processes at temperatures below 1100°F (593°C) shall be stress relieved. Additional stress relief operations may be performed in accordance with this paragraph. Parts shall be stress relieved at 1020°F (549°C) for 2 hours. Stress relief after peening, coating and thread rolling operations is not permitted.

3.2.4.2 在低于 1100°F (593°C) 的温度下经受粘接、翘曲或其他塑性变形过程的 3 个应力消除，叶片和叶片应有应力消除。附加的应力消除操作可能会根据本段进行处理，部件应力消除应在 1020°F (549°C) 下进行 2 小时。不允许进行后处理，涂层和螺纹滚压操作。

3.2.5 Cleaning. Part and in process cleaning shall be in accordance with PATF3, CL-A, with the following additions: (a) Halogen levels in excess of 50 ppm are permitted for forging lubricants and solutions used to remove forging lubricants, and for ring water used during in-process cleaning unless the ring operation is followed by a thermal process performed at a temperature greater than 500°F (260°C). (b) The presence of entrapped machining coolant compounds having a halogen content in excess of 50 ppm is permitted during the removal of an encapsulation material provided the removal process is performed at a

metal temperature not to exceed 675°F(357°C).

3.2.5 清洗。部件和处理中的清洗按照 PATF3, CL-A 进行, 并添加以下内容: (a) 外加剂中的卤素含量为 50 ppm, 允许用于锻造润滑剂和用于去除清洁润滑剂的溶液, 以及 Loringe 除非在大于 500 °F (260°C) 的温度下进行热处理, 然后进行热处理, 否则在加工过程中需要加水。(b) 存在卤素含量超过 50 ppm 1s 的机械加工冷却剂化合物 在去除封装材料的过程中允许进行去除过程, 金属温度不超过 675 °F (357 °C)。

3.2.6 Peening_ Requirements, All parts supplied to this specification shall be peened or otherwise surface enhanced after all thermal treatments, metal removal in the designated peen area, initial fluorescent penetrant inspection and before coating.

3.2.6 喷丸要求, 本规范提供的所有部件应在所有热处理, 指定喷丸中的金属去除, 初始荧光渗透检查和涂装前进行喷丸处理或其他改进。

3.2.6.1 Airfoil Peening. Compressor blade and vane airfoils shall be glass bead peened in areas specified on the drawing to an intensity of 0.006 to 0.012 inch (0.152 to 0.305 mm) N using Number 5 bead in accordance with P11TF3, CL-A, Fan blade airfoils shall be peened as specified on the drawing, Care must be taken on small, thin airfoil to not damage the edges when using the upper limit of the intensity range, Hand dressing of edges of finished parts to remove raised metal resulting from handling damage is permitted without re-peening provided the operation is part of an Established Procedure.

3.2.6.1 翼型喷丸。压缩机叶片和叶片翼型应采用图中规定的玻璃喷砂强度为 0.006 至 0.012 inch (0.152 至 0.305 mm) N, 使用 5 号珠粒, 符合 P11TF3, CL-A, 风扇叶片翼型应按图纸上的规定进行喷丸处理。必须注意小而薄的翼型, 以免损坏强度范围的上部 1 的边缘, 手工修整 finished 部件的边缘, 以去除由此产生的凸起金属。如果操作是 Established Procedure 的一部分, 则允许处理损坏而不重复。

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3.2.6.2 Dovetail Peening. Blade dovetails and vane roots shall be steel shot peened in areas specified on the drawing to an intensity of 0.004 to 0.008 inches (0.102 to 0.203 mm) A using an S110 or S170 shot size in accordance with P11TF3, CL-A.

3.2.6.2 鸠尾榫喷丸。在图纸规定的区域内, 应使用 S110 或 S170 的尺寸按照 P11TF3, CL-A 强度为 0.004 至 0.008 英寸 (0.102 至 0.203 毫米) A 的楔形燕尾槽和叶片根部进行喷丸处理。一个。

3.2.6.3 Small Part Peening. When specified on the drawing, blades and vanes with very thin airfoils which may be susceptible to peening-induced distortion may be tumbled using a Purchaser approved process to achieve desired surface enhancement.

3.2.6.3 小部件喷丸。如图所示, 叶片和叶片的翼型很薄, 可能易受喷丸引起的变形, 可以使用买方认可的工艺翻滚, 以达到理想的表面强度。

3.3 Acceptance Criteria 3.3 验收标准

3.3.1 Acceptability Limits. Forgings and parts supplied to this specification shall be uniform in quality and free from imperfections such as cracks, voids, pits, laps, segregation and inclusions detrimental to the performance of the finished parts.

3.3.1 可接受性限制。本规范提供的配件和零件质量应均匀, 并且没有缺陷, 如裂缝, 空隙, 凹坑, 圈, 偏析和夹杂物, 不利于成品的性能。

3.3.1.1 Inclusions. One or more inclusion in any forging or part may subject the entire heat to disqualification.

3.3.1.1 夹杂物。任何锻件或部件中的一个或多个夹杂物可能使整个加热失效。

3.3.2 Macroetch Inspection. CLASSES E, F, G AND I ONLY: After completion of all processing operations except peening or tumbling, coating and airfoil tip machining, parts shall be macroetched in accordance with AMS 2642 and then inspected to acceptance limits in accordance with P3TF25, CL-A.

3.3.2 Macroetch Inspection. CLASSES E, F, G 和 I 仅在完成除喷丸或翻滚, 涂层和翼型尖端加工之外的所有加工操作后, 应按照 AMS 2642 对零件进行宏观加工, 然后按照 AMS 2642 检查接受限值 使用 P3TF25, CL-A。

3.3.3 Radiographic Inspection. Forgings and parts shall be capable of being free from radiographic indications interpreted as cracks, voids or inclusions. Radiographic indications having a maximum dimension of less than 0.015 inch (0.38 mm) are considered non-interpretable.

3.3.3 射线照相检查。原件和部件应能够避免射线照相指示被解释为裂缝, 空隙或夹杂物。最大尺寸小于 0.015 英寸 (0.38 毫米) 的射线照相指示被认为是不可解释的。

*3.3.4 Mechanical Properties. Tests for mechanical properties shall be performed on each heat of material from each bar size used to produce forgings. Specimens shall be cut longitudinally from the bar and heat-treated in accordance with the requirements of this specification. Parts and forgings shall be capable of meeting the mechanical properties requirements of this specification.

3.3.4 机械性能。每种用于生产锻件的棒材的每种材料的热量都应进行机械性能试验。试样应从棒材纵向切割, 并按照本规范的要求进行热处理。部件和锻件应采用 能够满足本规范的机械性能要求。

*3.3.4.1 Tensile. Bar shall meet the tensile requirements of Table I.

3.3.4.1 拉伸。棒应满足表一的拉伸要求。

Forgings and parts shall be capable of meeting the tensile requirements of Table I.

锻件和零件应能满足表一的拉伸要求。

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Table I - Tensile Properties

表 I - 拉伸性能

| Property 属性 | Requirement at Room Temperature 室温要求 |
|--|--------------------------------------|
| Tensile Strength, Minimum, psi (MPa) 抗拉强度, 最小, psi (MPa) | 130.000(896) |
| 0.2% Yield Strength, Minimum, psi (MPa) 0.2% 屈服强度, 最小, psi (MPa) | 120.000(827) |
| Elongation (% in 4D) Percent Minimum 伸长率 (4D%) 最小百分比 | 10 |
| Reduction of Area, Percent Minimum 减少面积, 最小百分比 | 25 |

3.3.4.2 低循环台面。E 类、F 类、G 类和 I 类: 当 drawing 低循环疲劳测试中指定时, 应按照 E50TF148, CL-A 执行。

3.3.5 金相检查。叶片翼型部分的颗粒流动。

或叶片应在纵向（展向）方向。叶片或叶片中的任何剪切带不得超过 EAE 照片 S20181 和 S20182 所示的可接受极限。锻件及零件的显微组织不得超过 GEAE photo 320819 的 60 级。连续的【大于 0.2 英寸（0.51 毫米）】晶界的组织是不可接受的。

3.3.6 荧光渗透检测（FPI）。

3.3.6.1 荧光渗透检查腐蚀。

3.3.7 成品部件氢限。成品部件的氢含量不得超过 0.0125%。

3.3.8 粒间攻击和案例检查。成品部件不应显示颗粒攻击（IGA）或阿尔法病例

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3.3.9 Surface Requirements. There shall be no visual evidence of oxidized discoloration on finished parts. Pickling, descaling or other surface polishing to remove discoloration is permitted if part of an Established Procedure.

3.3.9 表面要求。成品部件上不得有氧化物变色的视觉证据。如果是既定程序的一部分，则允许进行剔除，除垢或其他表面抛光以消除变色。

3.4 Testing Suppliers. Inspections, testing and test specimen machinings specified herein shall be performed only by Suppliers approved by the Purchaser.

3.4 测试供应商。此处指定的检验，测试和试样加工应仅由买方批准的供应商进行。

3.6 Material Traceability And Accountability. Bar shall be traceable in accordance with P1TF28, CL-A or CL-B, or P1TF73, CL-A, or P1TF103, CL-A.

3.6 材料可追溯性和责任性。BAR 应根据 P1TF28, CL-A 或 CL-B 或 P1TF73, CL-A 或 P1TF103, CL-A 进行追踪。

3.6.1 Forging Traceability. The forging Supplier shall maintain a system to permit traceability of forgings to the forging run, melt source heat number and heat treat lot number. Each serialized or lot numbered part produced from bar shall be traceable to the ingot.

3.6.1 锻造可追溯性。锻造供应商应保持一个系统，允许锻件可追溯到锻造运行，冶炼源热数和热处理批号。每个由棒生产的系列或批号零件应可追溯到铸锭。

3.6.2 Forging Accountability. The forging Supplier shall certify all chemical and mechanical tests specified herein. The forging Supplier shall maintain a system documenting disposition of all procured bar.

3.6.2 锻造责任。锻造供应商应对此处规定的所有化学和机械试验进行认证。锻造供应商应保持一个记录所有采购钢筋处理的系统。

3.6.3 Machining Traceability. The machining Supplier shall be responsible for maintaining the traceability of forgings or bar to the heat number and heat treat lot number.

3.6.3 加工可追溯性。加工供应商应负责维护锻件或棒材的热量和热处理批号的可追溯性。

3.6.4 Machining Accountability. The machining Supplier shall document the results of all required tests and inspections that are not performed by the forging Supplier.

3.6.4 加工责任。加工供应商应记录锻造供应商未执行的所有必要测试和检查的结果。

4. QUALITY ASSURANCE PROVISIONS

4. 质量保证条款

4.1 Test Procedures. All testing shall be performed in accordance with ASTM standards or methods approved by the Purchaser. The Supplier shall inform the Purchaser of the test procedures used. Once these procedures are established, they shall not be changed without approval of the Purchaser.

4.1 测试程序。所有测试均应按照买方批准的 ASTM 标准或方法进行。供应商应告知买方所使用的测试程序。一旦建立这些程序，未经买方批准，不得更改。

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

4.2 化学分析。化学分析应按照 ASTM 标准或买方批准的方法进行。

4.2.1 Chemical Check Analysis Limits. Chemical check analysis limits shall be in accordance with the chemical composition requirements herein and the limits of AMS 2249.

4.2.1 化学检查分析限值。化学检查分析限值应符合本文化学成分要求和 AMS 2249 的限值。

4.3 Beta Transus Temperature. Beta transus temperature shall be determined in accordance with the following:

4.3 β 转变温度应根据以下方法确定：

CLASSES A and E: P1TF28, CL-A 类别 A 和 E: P1TF28, CL-A

CLASSES C and F: P1TF28, CL-B

CLASSES D and G: P1TF73, CL-A

CLASSES H and I: P1TF103, CL-A

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4.4 Furnace Control. Furnace surveys and calibration of temperature controllers and recorders for forging preheat furnaces shall be in accordance with Established Procedures. Furnace surveys and calibration of temperature controllers and recorders for heat treatment furnaces shall be in accordance with AMS 2750 or P10TF1, CL-A.

4.4 炉膛控制。锻造预热炉的温度控制器和记录仪的炉膛检验和校准应符合已建立的程序。热处理炉的温度控制器和记录仪的炉膛检验和校准应符合 AMS 2750 或 P10TF1, CL-A。

4.5 Radiographic Inspection. Radiographic inspection of bar forgings and parts shall be performed in accordance with P3TE5, CL-A.

4.5 射线检查。棒锻件和部件的射线检查应按照 P3TE5, CL-A 进行。

4.6 Mechanical Properties 机械性能

4.6.1 Tensile. Tensile specimens shall be prepared and tested in accordance with ASTM E 8.

4.6.1 拉伸。拉伸试样应按 ASTM E 8 制备和试验。

4.6.2 Low Cycle Fatigue. Strain control low cycle fatigue test specimens shall be prepared in accordance with P1TF79, CL-A using a Purchaser approved specimen configuration and tested in accordance with E50TF148, CL-A. Switching from strain control to load control in accordance with E50TF148, CL-A is permitted.

4.6.2 低周疲劳。应变控制低周疲劳试验样品应按照 P1TF79, CL-A 使用买方批准的试样配置进行制备，并按照 E50TF148, CL-A 进行试验。根据 E50TF148, 从应变控制切换到

负载控制，允许使用 CL-A。

4.7 Metallographic Inspection. Microstructure shall be evaluated at 100X magnification on samples prepared using standard titanium alloy polishing and etching procedures. Microstructure acceptability shall be determined by comparison to GEAE photos 320817, 320818, 320819 and 320820. Shear banding acceptability shall be determined by comparison to GEAE photos S20181 and S20182.

4.7 金相检验。微观结构应在 100X 放大倍数下对使用标准钛合金抛光和抛光程序制备的样品进行评估。微观结构的可接受性应通过与 GEAE 照片 320817, 320818, 320819 和 320820 的比较来确定。剪切带的可接受性应通过与 GEAE 照片的比较来确定。S20181 和 S20182。

4.8 Fluorescent Penetrant Inspection. Fluorescent penetrant inspection shall be performed in accordance with P3TF2, CL-H.

4.8 荧光渗透检查。荧光渗透检查应按照 P3TF2, CL-H 进行。

4.9 Hydrogen Limits Of Finished Part. Chemical analyses for hydrogen content shall be performed in accordance with ASTM standards, or methods approved by the Purchaser, on specimens cut from finished parts or on specimens representative of finished parts. Representative specimens shall have the same nominal composition as the parts they represent and shall be processed along with parts through all chemical and thermal processes.

4.9 成品的氢气限制。氢气含量的化学分析应按照 ASTM 标准或买方批准的方法，从成品部件或代表成品部件的样品上切割的样品进行。代表性样品应具有相同的标称成分作为它们所代表的零件，应通过所有化学和热处理与零件一起加工。

4.10 Intergranular Attack And Alpha Case Inspections. Examination for IGA shall be performed at between 400 to 500X magnification on representative specimens mounted with the surface to be polished at a nominal angle of 90 degrees to the original specimen surface and prepared using a standard titanium alloy polishing procedure. Examination for alpha case shall be performed in accordance with P3TF19, CL-A.

4.10 晶间腐蚀和 Alpha 情况检查 IGA 的检查应在 400 至 500 倍放大率下进行，代表性样品安装在待抛光表面上，与原始试样表面成 90 度的标称角度，并使用标准钛合金抛光程序制备。α 案件的审查应按照 P3TF19, CL-A 进行。

4.11 Macroetch Inspection. Macroetch inspection of forgings and parts shall be performed in accordance with P3TF25, CL-A.

4.11 宏观检查。锻件和零件的宏观检查应按照 P3TF25, CL-A 进行。

4.12 Shot Peening. All peening of airfoils, dovetails and vane roots shall be performed in accordance with P11TF3, CL-A or CL-C.

4.12 喷丸处理。机翼，燕尾和叶片根部的所有喷丸均应按照 P11TF3, CL-A 或 CL-C 进行。

5. PACKAGING 5, 包装

5.1 Packing. All material shall be packed to prevent damage, loss or contamination during handling, shipping or storage.

5.1 包装。所有材料均应包装，以防止在处理，运输或储存过程中损坏，丢失或污染。

5.2 Marking.Each shipment shall be legibly marked with the purchase order number,Supplier's name,quantity,batch or lot number and this GEAE specification number,class and issue number.

5.2 标记。每个货件应清楚地标明采购订单编号，供应商名称，数量，批次或批号以及此 GEAE 规格编号，类别和编号。

5.2.1 GEAE Manufactured Parts.Packages of parts manufactured by GEAE shall be marked and shipped in accordance with the procedures set forth in the GEAE Shipping and Receiving system.

5.2.1 GEAE 制造零件.GEAE 制造的零件包装应按照 GEAE 装运和收货系统规定的程序进行标记和装运。

6.NOTES

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

* 6.1 目的。本节包含一般性信息，可能会有所帮助，但不是强制性的。它不包含任何要求。

*6.2 Classification Of Characteristics.This is furnished as an index to those paragraphs that have been classified:

* 6.2 特征分类。这是作为索引提供的，已经分类的段落：

Critical:None

Major:None

Minor:All paragraphs

*6.3 Data For Ordering(DFO)Sheet.DFO-C50TF22 list approved sources.

* 6.3 订购数据（DFO）表.DFO-C50TF22 列出批准的来源。

*6.4 Bar Orders,When this specification is used to supply bar for subsequent processing into parts,paragraphs which are specific to parts shall not apply.Hydrogen level requirements for bar orders shall be as specified on the Purchase Order.

* 6.4 条形订单，当本规范用于供后续加工成零件的条形时，不适用于零件的段落。条形订单的氢含量要求应按采购订单的规定。

REVISION HISTORY

修订记录

080FF221

INIFIALIBBOE

Amend1

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Amend 1

Mrend2

CID 11496

02-21-91

Amend 3

CID 076991

04-19-91

-89

CID 077402

10-26-92

CID 070309

05-08-56

CID 078121

02-07-57

CID 078589

10-14-97

CID 078759

02-09-99

CID 078995

02-14-00

-815

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-816

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Denotes latest change

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