Advisory Circular

Subject: PROPOSED DRAFT – Turbine Engine Repairs and Alterations – Approval of Technical and Substantiation Data

Date: XX/XX/XX

AC No: DRAFT

Initiated by: ANE-110

1. PURPOSE.

a. This advisory circular (AC) provides information and guidance on developing the technical and substantiation data for turbine engine repairs and alterations to demonstrate compliance with the applicable airworthiness standards of Title 14 of the Code of Federal Regulations parts 33 and 34 (14 CFR parts 33 and 34). This includes guidance to identify, and develop substantiation and control procedures for critical processes.

b. This AC provides guidance about how to categorize turbine engine parts and ensure appropriate Federal Aviation Administration (FAA) coordination for category 1 and category 2 type parts.

c. Also, this AC provides information on part marking of turbine engine parts during repair and alteration, as well as repair of parts recovered from accidents and incidents.

2. APPLICABILITY.

a. The guidance provided in this AC is directed to engine type certificate (TC) holders, repair stations, operators, designees, and other applicants seeking FAA approval for proposed major repairs and major alterations of turbine engine parts.

b. This document is neither mandatory nor regulatory in nature. It does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. Terms such as "should," "shall," "may," and "must" are used only in the sense of ensuring applicability of this particular method of compliance. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations and should be followed. An applicant may also elect to follow an alternative method, provided the FAA Engine and Propeller Directorate (E&PD) finds the alternative method to be an acceptable means of complying with the applicable regulations. On the other hand, if the FAA becomes aware of circumstances that convince us that following this AC would not result in compliance with the regulations, we are not bound by this AC and may require additional substantiation to find compliance.

c. This document does not change, create any additional, authorize changes in, or permit deviations from, existing regulatory requirements.

d. This AC does not change the regulations assigning the aircraft owner or operator the responsibility to ensure that all parts have been properly repaired or altered when maintenance is performed, including outsourced maintenance. The aircraft owner or operator must also ensure

that the installation of repaired and altered parts complies with the owners' or operators' maintenance manuals.

3. DEFINITIONS. For the purpose of this AC, the following definitions apply:

a. Category 1 Part: System safety critical turbine engine part whose failure could result in a hazardous engine effect.

b. Category 2 Part: Reliability key turbine engine part whose failure could adversely affect engine operation but would not likely result in a hazardous engine effect.

c. Category 3 Part: General reliability turbine engine part whose failure would have no measurable affect on engine operation. In general, if a part is not a category 1 or category 2 part, it is a category 3 part.

d. Critical process: A process or process sequence that could affect the design intent of the part (for example the material structure, physical, mechanical, chemical or electrical properties), may not be suitable for evaluation by non-destructive inspection techniques, or is necessary to maintain the continued airworthiness of the part.

e. Failure Modes and Effects Analysis (FMEA): A procedure that is used to evaluate the effects on the engine system of each possible element or component failure.

f. Life-assessed: A term applied to a category 1 or category 2 turbine engine part that is evaluated for its fatigue life as part of its type design, does not have a safe life-limit or a mandatory inspection requirement, and is not listed in the Airworthiness Limitation Section of

the Instructions for Continued Airworthiness (ICA).

g. System effects: The affect that a part may have on the engine, either directly or indirectly. Direct effect is based on physical contact with adjacent part. Indirect effect does not require physical contact between components, but does affect primary flow, loads, secondary flows (such as, air, fuel and oil), mechanical stability, operability, etc.

4. BACKGROUND.

a. During the past decade, the FAA reviewed the impact repairs, alterations, and supplemental type certificates had on the various products we certify. Some of those initiatives and outcomes are found in the following related studies.

(1) As part of the review, the FAA chartered a Safety Analysis Team (SAT) to find significant safety threats to aviation. The SAT was to provide information to another group, the Aircraft Certification Management Team, to aid them in formulating industry and business initiatives to reach a “zero-accidents” goal.

(2) The SAT reported in 1997 (SAT Report No. SAT 01), that the leading cause of transport category aircraft accidents and serious incidents that originated in the basic engine, was from the failure of high energy rotating structures (engine rotors). The majority of these engine rotor failures (for example, disk, shaft, and spacers) were due to improper maintenance, including inadequate repair designs, some of which lacked process controls, from both TC holder and non-TC holder repairs.

(3) Following the SAT, in 2001, the FAA chartered the Commercial Airplane Certification

Process Study (CPS). The study was to identify opportunities for process improvements involving aircraft certification, operation, and maintenance, as well as make safety advances to an already safe aviation system.

(4) In March 2002, the CPS provided a number of findings and observations. Their results can be reviewed at http://www.aia-aerospace.org/search/search.cfm. Their recommendations extend to all FAA Directorates, and include long-term recommendations that the Directorates develop guidance on repairs and alterations for their products, to accomplish the following:

- Ensure the continued airworthiness of repaired and altered products.
- Provide clear and objective certification substantiation requirements, for example, development of templates.
- Aid in international repair acceptance reciprocity.

b. Our recent review of numerous Designated Engineering Representative (DER) approved turbine engine repair designs, in accordance with the FAA Order 8100.8, Designee Management, indicated a significant increase in the number of repairs and alterations to category 1 and category 2 turbine engine parts that are not in the TC holder's ICAs and are not otherwise supported by the engine TC holders. Technical data for these repairs and alterations often require complex engineering analyses, testing, and critical processes validation. Repairs and alterations for category 1 and category 2 turbine engine parts require the highest level of evaluation and substantiation to justify the repair or alteration as minor or support approval for major. Yet records supporting these repairs and alterations were notably lacking in documentation.

c. We also found that repair designs for certain turbine engine parts lacked coordination with the appropriate Project Aircraft Certification Office (PACO), or subsequent coordination with the Certificate Management ACO (CMACO), as required by FAA Orders 8110.37, Designated Engineering Representative (DER) Guidance Handbook, and 8110.4, Type Certification. We also learned of several cases where DER approved repair designs changed the original part number as part of the repair process.

d. This AC responds to the above indicated need for guidance to:

(1) Ensure proper FAA coordination.

(2) Develop technical data, as defined in paragraph 10 of this AC, to adequately define the repair or alteration design. This should include critical process data, when required, as discussed in paragraph 24 of this AC.

(3) Develop substantiation data, as defined in paragraph 11 of this AC, for compliance to parts 33 and 34. This includes the substantiation of critical processes when required as discussed in paragraph 24 of this AC.

(4) Properly mark repaired parts.

e. We expect this guidance will help ensure that engine reliability and safety are maintained through the development of adequate technical and substantiation data that shows compliance with the regulations.

6. DISCUSSION.

a. As industry has grown and technology has advanced, engine designs have become more

complex and part design margins have decreased. As the maintenance industry undertakes the repair and alteration of category 1 and category 2 turbine engine parts, diligence must be exercised. With this in mind, and a history that identified problems and recognized failures of these type engine parts from maintenance activities, this AC is intended to support the common goals of both the FAA and industry to maintain and improve aviation safety. Therefore, this AC will:

(1) Identify part categories for support of the continued safe operation of turbine engines.

(2) Provide guidance on developing the technical data for turbine engine repairs, alterations, and ICA, and using the same or similar practices compared to those used at original certification or post-certification.

(3) Be consistent with other guidance, such as

- AC 33-75, Guidance Material for Safety Analysis
- AC 43-18, Fabrication of Aircraft Parts by Maintenance Personnel
- AC 120-77, Maintenance and Alteration Data

7. REPAIRS AND ALTERATIONS THAT AFFECT ENGINE EMISSIONS. Some repairs and alterations affect engine emissions. DERs should coordinate with the PACO if a repair or alteration may affect compliance with the requirements for engine exhaust emission of part 34.

8. REPAIRS AND ALTERATIONS THAT AFFECT ENGINE NOISE. Repairs and alterations that affect the engine noise characteristics may affect an aircraft's airworthiness. Most of the components affecting engine noise are located in the inlet and exhaust area. DERs

should consult with the PACO when not certain if the repair or alteration may affect the engine noise. The PACO should also coordinate with the appropriate aircraft ACO if a repair or alteration will impact part 36 aircraft noise compliance.

9. DATA FOR REPAIRS AND ALTERATIONS – GENERAL.

a. The following regulations require persons that perform major repairs and major alterations, use technical data that is approved by the Administrator:

- 14 CFR part 43, §§ 43.7(d) and 43.17(e)(2)
- 14 CFR part 65, § 65.95(a)(1)
- 14 CFR part 121, § 121.379(b)
- 14 CFR part 135, § 135.437(b)
- 14 CFR part 145, §§ 145.201(c)(1) and 145.201(c)(2)

b. Major repairs and major alterations of category 1 and 2 turbine engine parts must be adequately substantiated to show compliance with the requirements of parts 33 and 34 and must be evaluated for the use of critical processes (see paragraph 24 of this AC).

c. Justification to conclude if a repair or alteration of a category 1 or category 2 part is minor may also include data that shows it is not a major repair or major alteration. Although no requirement exists for minor repairs or minor alterations to have approved data, the FAA recommends that adequate and acceptable technical data be available to support the continued

operational safety of the engine with the installed category 1 or category 2 repaired or altered part.

d. Data related to major engine repairs and major engine alterations is the sum of "technical data, substantiating data," and "methods, techniques, and practices." These terms are discussed in more detail below.

10. TECHNICAL DATA.

a. Technical data is defined in AC 120-77. Technical data may include the results of either tests or analyses, or both. This data may also include other engineering information, such as data in engineering handbooks, or military and industry specifications.

b. In addition, for repairs and alterations on category 1 and category 2 turbine engine parts, technical data may include critical process substantiation criteria, as discussed in paragraph 24 of this AC.

11. SUBSTANTIATING DATA.

a. Substantiating data is defined in AC 120-77. Substantiation data may include:

(1) Test and analyses results appropriate to the repair or alteration being evaluated.

(2) Operational and service experience data, maintenance and reliability data, as well as other documented information applicable to product airworthiness.

(3) Critical process substantiation data, as discussed in paragraph 24 of this AC.

12. METHODS, TECHNIQUES AND PRACTICES. Methods, techniques, and practices are the step-by-step or "how-to" of performing the repair or alteration. These instructions need adequate detail to ensure consistent repeatability. If critical processes are identified, those processes must be controlled as discussed in paragraph 24 of this AC.

13. DATA PACKAGE FOR MAJOR REPAIRS AND MAJOR ALTERATIONS FOR CATEGORY 1 AND CATEGORY 2 PARTS.

a. To assist in the standardization of data submittals for major repairs and major alterations on safety system critical and reliability key turbine engine parts, the FAA recommends using a data package that includes the following information:

(1) A description of:

(a) The part.

(b) The degradation mode and need for the repair or alteration.

(c) The proposed repair or alteration.

(2) Documentation of the part's service history (for example, service difficulties, Airworthiness Directives (AD), incident and accident investigations, etc.).

(3) A FMEA.

(4) The technical data.

(5) The certification basis of the engine model(s) the repaired or altered part is to be installed on.

(6) The step-by-step procedures to accomplish the repair or alteration.

(7) A substantiation plan to show compliance with applicable airworthiness standards, using the most severe operating environments associated with the engine model(s) the repaired or altered part is to be installed on.

(8) The substantiation data.

(9) Any critical processes, and if used provide:

(a) The substantiation of the process outcomes.

(b) The process controls.

(10) Assess the applicability of existing ICAs or develop unique ICAs.

b. If a DER reviews a major repair or major alteration, the DER should provide a signed FAA Form 8110-3, Statement of Compliance with the Federal Aviation Regulations. Otherwise, a letter should be addressed to the appropriate ACO requesting a review and approval.

14. FAILURE MODES AND EFFECTS ANALYSIS.

a. When applied to parts, the FMEA is based on an understanding of the part's physical and functional integration (system effects) into the engine system. A FMEA should consider single engine applications and the reliability requirements of extended range operations with twin engine airplanes, when applicable.

b. The FAA recommends using a FMEA to aid in determining part categorization, independent of the repair or alteration proposed. This assessment provides at a minimum:

(1) A qualitative assessment of failure modes and effects, which evaluates the part and considers the following:

- The effect of characteristics, processes, or inspections when there is a failure, omission, or non-conformance.
- The effect of operating outside of the intended part application or environment.

(2) Effect of part failure on the next higher assembly and its performance.

(3) Effect on the product and its performance if the next higher assembly fails.

15. PART CATEGORIZATION.

a. The categorization of parts is used to:

(1) Assure that the proper level of FAA oversight is applied to the approval process according to FAA Orders 8110.37 and 8110.4.

(2) Establish the level of documentation and data necessary to show that the part and any affected higher assemblies or systems, or both, comply with the applicable requirements of parts 33 and 34.

b. Three part categories are recommended to cover the full range of potential outcomes resulting from the FMEA. The following table lists the outcomes to determine turbine engine part categorization and includes some resulting examples. The outcomes used to categorize turbine engine parts is more specific than that used in FAA Order 8120.2, Production Approval and Certificate Management Procedures, because this AC applies just to engines.

Table 1: Examples

Category	Potential Outcome	Examples
Category 1: System Safety Critical – The failure of which could result in a hazardous engine effect.	(1) Unconfined or inextinguishable engine fire. (2) Uncontained engine failure. (3) Mount failure. (4) Inability to shut down. (5) Emission of toxic cabin bleed air. (6) Inadvertent thrust reverser deployment in takeoff or flight when the thrust reverser system is part of the engine type design.	- Life-limited or life-assessed part (for example, pressurized cases and engine mounts with no redundant load carrying feature) - Containment Structures - Fan Blades - Fuel system shut-off or related component - Primary Structures (for example, structures that provide support and rigidity of the main engine backbone and for attachment of engine to airframe) - Thrust reverser control component if thrust reverser is part of the engine type certificate

Category	Potential Outcome	Examples
Category 2: Reliability Key Parts – The failure of which could adversely affect engine operation but would not likely result in a hazardous engine effect.	(1) Loss of thrust control (for example, the inability to modulate power or thrust from idle to 90% of maximum rated thrust or power). (2) In flight shut down. (3) Surge or stall, or both, including automatic relights of combustor flameouts. (4) Inability to restart the engine in flight. (5) Engine fire contained within the fire zone and is readily extinguished by using aircraft means.	- Combustor liner or can - Compressor vane - Stationary seal in the gas path - Thrust reverser part in the gas path - Rotating parts that are not life-limited or life-assessed (for example, compressor and turbine airfoils) - Accessory gearbox and internal components
Category 3: General Reliability	The failure of which would have no measurable affect on engine operation. In general, if a part is not a category 1 or 2 part, it is a category 3 part.	

16. CATEGORY 1 AND 2 PARTS – GENERAL.

a. Turbine engine parts that applicants classify as safety system critical or reliability key require coordination with the PACO and the CMACO according to FAA Orders 8110.37 and 8110.4. The following items from the data package, at a minimum, should be coordinated:

(1) A description of:

(a) The part.

(b) The degradation mode and need for the repair or alteration.

(c) The proposed repair or alteration.

(2) Part service history.

(3) The FMEA.

(4) Operating environment.

(5) Certification Basis.

(6) Substantiation plan.

b. Why a category 1 or category 2 turbine engine part proposed repair or alteration is minor may require showing that the proposed repair or alteration has no appreciable effect on weight, balance, structural strength, performance, flight characteristics, or other qualities affecting the airworthiness of the engine the repaired or altered part is to be installed on.

c. The applicant should analyze the adverse effects certain processes in repairs or alterations to these category turbine engine parts will have on how the part functions, as discussed in paragraph 24 of this AC.

17. CATEGORY 1 - CRITICAL SAFETY SYSTEM PARTS – Rotating Turbine Engine Life-limited Parts (RTE-LLPs). The information from Policy Statement ANE-2006-33.3-4, published July 27, 2006, will be adopted into this section upon final issuance of this AC.

18. CATEGORY 1 - CRITICAL SAFETY SYSTEM PARTS OTHER THAN RTE-LLPs.

a. In addition to coordination with the CMACO, the FAA expects notification of major repairs and major alterations of safety system critical turbine engine parts to the E&PD Standards Staff using the Standardized Certification Project Notification Form (see Order 8110.4).

b. For category 1 parts, coordination with the CMACO of the substantiation plan includes its development.

19. CATEGORY 2 – RELIABILITY KEY PARTS.

a. The FAA has identified a number of typical repairs and alterations on reliability key part families, and we worked with industry to develop sample "repair" templates, which are included as appendix 1 of this AC. For each part family repair, the templates identify the requirements that need to be evaluated to develop the substantiation plan and show compliance with parts 33 and 34 of the Federal Aviation Regulations. The templates identify the engineering and technical considerations associated with the particular repair types. The templates also assist in assessing and developing quality controls for features on parts or components, or fabrication details that are necessary to the repair or alteration. The templates are a guide. It is the applicant's responsibility to review the repair, and the guidance, and to assess the adequacy and applicability of the guidance. For reliability key parts, the applicant or DER should review these templates and discuss any questions with the PACO. If no template is available, DERs should use similar procedures to identify the applicable requirements and necessary substantiation data, and coordinate with their PACO for guidance.

b. For major repairs or alterations where templates are used and a DER is involved in the review and approval, an 8110-3 form should be signed and accompany the data package. Otherwise, a letter should be addressed to the appropriate ACO requesting review and approval.

20. CATEGORY 3 – RELIABILITY GENERAL PARTS. Repairs and alterations of general reliability parts may be substantiated based on previously approved data, or any other data acceptable to the FAA. Examples of acceptable data are:

a. Manufacturers' technical information, not approved by the FAA.

b. Military specifications.

c. Previously accomplished FAA field approvals for same parts, and similar installations on comparable makes and models.

21. REPAIR OF ENGINE PARTS RECOVERED FROM ACCIDENTS OR INCIDENTS.

a. Parts exposed to accidents or incidents must be evaluated for continued service eligibility using the instructions specific to the recovery of such hardware. Typically ICAs address the return to service of parts that are operated under normal conditions for overhaul. Parts not acceptable under these ICAs may be returned to service based on information provided by the TC holder or other data approved by the FAA. The service eligibility of such hardware will be dependent upon the circumstances of the accident, the impact on the engine hardware, and on the part condition. Engine parts subjected to extreme stress, sudden stoppage, heat, major failure or an accident, should be identified by some type of documentation that indicates the environment the part was recovered from.

b. Repairs and alterations of eligible parts should follow the guidance in this AC, including

this additional requirement for proof of service eligibility.

22. INSTRUCTIONS FOR CONTINUED AIRWORTHINESS. Repairs or alterations may affect the ICAs. The applicant should show that the product's ICA is still valid with the repaired or altered part installed. Otherwise the applicant should make available supplemental ICA.

23. CONTINUED OPERATIONAL SAFETY (COS).

a. Applicants who repair or alter turbine engine parts outside the TC holders ICAs become responsible to technically support any and all portions of the repaired or altered part. This includes its next higher assembly and the engine the repaired part is installed on, based on system affects.

c. To support COS for category 1 and category 2 turbine engine parts, a repair provider should have the following as a minimum:

(1) Detailed records of all aspects of the repair cycle.

(2) A record-keeping plan for the parts repaired.

(3) A means to review repair design performance by monitoring service experience.

(4) A means to isolate possible discrepant part populations.

(5) The capability to identify causes of failures of the repaired or altered part,

and to the next higher assembly and the engine, as well as implement risk based corrective actions.

24. CRITICAL PROCESS SUBSTANTIATION.

a. Repairs and alterations of parts in category 1 and category 2 may involve certain critical processes that must be carefully controlled to ensure the part is returned to its original or properly altered condition. Such processes may be critical to the airworthiness of these type parts and must be identified and substantiated.

b. Repair applicants must determine if repair processes used in repairs and alterations for category 1 and category 2 parts are critical. Parts that require source substantiation by the engine TC holder when new or repaired often include critical processes. Another way to determine if a process is critical is through the FMEA. Some examples of critical processes are machining, welding, casting, forging, melting, coating, and heat treatment.

c. Since the repaired or altered part's design intent is dependent upon these types of critical processes, and the outcomes of some of these are not always possible to evaluate by non-destructive inspection techniques, control of those processes is essential. Some examples of parameters that must be carefully controlled are feeds, speeds, force, time, flow rates, and temperature.

d. Approval of repair and alteration data of category 1 and category 2 parts that include

critical processes, should be limited to the repair facility that demonstrated compliance to the critical process substantiation criteria.

25. PART MARKING.

a. Each part is assigned a part number by the design approval holder, i.e., TC, STC, PMA or TSO holder, and is traceable to a drawing for the type-certificated engine, which is identified in the type certificate data sheet in accordance with § 21.31. This limits the authority to change the original part number in a repair outside of the engine design approval holder's ICA. Sections 45.14 and 45.15 associate the privilege of part marking to "a person who produces." Thus, the design approval holder can change the part number, as design changes or repair designs are processed and approved by the FAA. Such changes can be directed by service bulletins or other ICA from the design approval holder.

b. Section 43.13(b) requires that the condition of the aircraft engine after repair, will be at least equal to its original or properly altered condition. An original condition and a properly altered condition are two distinct conditions of parts that meet the certification requirements of an existing type design or a supplemental type design. Restoration of a part through a repair to either an original or properly altered condition necessitates that the part after repair maintains the identity it had before the repair, so that the repaired part's engine certification basis is maintained. The regulations make no explicit allowance for maintenance providers to change the design approval holder's part number when a repair is not done in accordance with design approval holder's ICA. Common practice has allowed for supplemental part marking in addition to the original part number, such as suffixes, trademarks, etc., that are useful for identifying the

maintenance provider.

c. When the OEM's repair design necessitates temporary removal of the part number or serial number, or the numbers are not legible due to wear, the original part number or serial number, or both, can be restored in accordance with established procedures or standard practices. This process maintains the originality of the part, particularly when the part is critical or life-limited.

END