



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

Subject: Developing Data for Major
Repairs of Turbine Engine Parts

Date: 4/30/10

AC No: 33-9

Initiated by: ANE-110

1. Purpose.

a. This advisory circular (AC) provides information and guidance on developing the technical data needed for major repairs of critical and complex turbine engine parts. This guidance will help persons developing major repair data meet the requirements of Title 14 of the Code of Federal Regulations (14 CFR) part 43 to restore the engine to at least equal to its original or properly altered condition. This does not mean that a repaired part must be returned to a factory-new condition. However, the engine on which the repaired part is installed must remain airworthy and in compliance with the applicable regulations. For repairs of turbine engines and parts, the applicable requirements are Airworthiness Standards: Aircraft Engines (14 CFR part 33) and Fuel Venting and Exhaust Emissions Requirements for Turbine Engine Powered Airplanes (14 CFR part 34).

b. Additionally, this AC provides guidance to assist persons developing major repairs with developing a continued operational safety plan. It also helps them evaluate engine parts recovered from accidents and incidents prior to making a repair.

2. Applicability.

a. This AC provides guidance to all persons developing the technical data to substantiate major repairs for critical or complex turbine engine parts, including type certificate (TC) and supplemental type certificate (STC) holders.

b. This guidance is neither mandatory nor regulatory in nature and does not constitute a regulation. It describes acceptable means, but not the only means, for demonstrating compliance with the applicable regulations. The FAA (“we”) will consider other methods of demonstrating compliance that a person developing repair data may elect to present. Terms such as “should,” “shall,” “may,” and “must” are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance in this document is used. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the applicable regulations. On the other hand, if we become aware of circumstances that convince us that following this AC would not result in

compliance with the applicable regulations, we will not be bound by the terms of this AC, and we may require additional substantiation as the basis for finding compliance.

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

3. Related References. Please check the FAA's website at http://www.faa.gov/regulations_policies/ for the latest revision of the following documents.

a. AC 20-62D, Eligibility, Quality, and Identification of Aeronautical Replacement Parts; May 24, 1996.

b. AC 33.75-1A, Guidance Material for 14 CFR 33.75, Safety Analysis; September 26, 2007.

c. AC 39-8, Continued Airworthiness Assessments of Powerplant and Auxiliary Power Unit Installations of Transport Category Airplanes; September 8, 2003.

d. AC 43-18, Fabrication of Aircraft Parts by Maintenance Personnel; March 24, 2006.

e. AC 120-77, Maintenance and Alteration Data; October 7, 2002.

f. Order 8110.37D, Designated Engineering Representative (DER) Handbook; August 10, 2006.

g. Order 8110.4C, Type Certification; August 14, 2008.

h. Order 8110.54, Instructions for Continued Airworthiness Responsibilities, Requirements, and Contents; July 1, 2005.

i. Order 8120.2F, Production Approval and Certificate Management Procedures; January 30, 2009.

j. FAA Order 8120.11, Disposition of Scrap or Salvageable Aircraft Parts and Materials; February 12, 1996.

4. Background.

a. The designs of many critical and complex turbine engine parts, hereafter referred to as "parts," require the use of advanced design and test methodologies, comprehensive materials data, and refined manufacturing techniques to achieve high levels of safety, reliability and performance. A person developing a repair for a critical or complex part should have a thorough understanding of the part's design characteristics, operational environments, operating requirements, and failure modes and effects. This knowledge is useful for determining if a repair to a part is major and for developing the appropriate technical data for FAA approval.

b. Our previous evaluations of major repair data packages for critical and complex parts have indicated that the data were not always adequate to support substantiation of the repair. Data developed for major repairs of critical or complex parts may typically include rigorous analyses and tests to show the engine on which the repaired part is installed will be at least equal to its original or properly altered condition. An original or properly altered condition is an airworthy condition that existed before the need for the proposed repair. An airworthy condition means the aircraft conforms to its type certificate and is in a condition for safe operation.

c. This AC uses part categorization as an aid for persons to determine whether a part being repaired is a critical or complex part. In addition, this AC recommends certain information be included in major repair data packages to improve consistency and completeness. In Appendix 2 of this AC, we also provide templates for repairs related to various engine part families to assist repair developers in identifying the technical elements and regulatory requirements when developing and substantiating similar repairs, if determined major.

5. Part Categorization. This AC categorizes parts based on their most severe potential failure effect using various methods for assessing malfunctions and failure modes. To assess malfunctions and failure modes, repair developers may use the failure modes and effects assessment described in Appendix 1 of this AC or other acceptable analytic techniques. Refer to AC 33.75-1A for examples of other acceptable techniques.

a. Part Categories. The categories used in this AC are consistent with categories found in Order 8120.2 and AC 39-8, and used in AC 43-18. The part categories are:

(1) Category 1. A product, i.e. engine, or part(s) thereof, whose failure could prevent continued safe flight and landing; resulting consequences could reduce safety margins, degrade performance, or cause loss of capability to conduct certain flight operations. A Category 1 part, for the purpose of this AC and Orders 8110.37 and 8110.4, is a critical part.

(2) Category 2. An engine or part(s) thereof whose failure would not prevent continued safe flight and landing; resulting consequences may reduce the capability of the aircraft or the ability of the crew to cope with adverse operating conditions or subsequent failures. For the purpose of this AC and Order 8110.4, a Category 2 part is typically a complex part that may affect a critical part.

(3) Category 3. An engine or part(s) thereof whose failure would have no effect on continued safe flight and landing of the aircraft. The only consequence would be partial or complete loss of engine thrust or power (and associated engine services). For single engine applications, consider changing part categorization to Category 1 or 2 if complete loss of thrust could prevent continued safe flight and landing or reduce the ability of the crew to cope with adverse operating conditions or subsequent failures.

b. Tables of Potential Failure Effects. The following tables provide some potential failure effects for Categories 1 and 2. We also listed a few examples of parts whose malfunction or failure could result in one or more of the listed potential failure effects.

Table 1. Category 1 Engine Parts

Potential Failure Effects	Part Examples
(1) Non-containment of high-energy debris.	Life-limited parts
(2) Concentration of toxic products in the engine bleed air intended for the cabin, and sufficient to incapacitate crew or passengers.	Main engine mounts, with no redundant load carrying features High pressure vessels (for example, casings subject to compressor discharge pressure and combustor pressure)
(3) Significant thrust in the opposite direction to that commanded by the pilot.	Containment structures Fan blades
(4) Uncontrolled fire.	Fuel system shut-off
(5) Failure of the engine mount system leading to inadvertent engine separation.	Primary structures (for example, structures that provide support and rigidity of the main engine backbone and for attachment of engine to airframe)
(6) Release of the propeller by the engine, if applicable.	Thrust reverser control component if thrust reverser control component is part of the engine type certificate.
(7) Complete inability to shut the engine down.	

Table 2. Category 2 Engine Parts

Potential Failure Effects	Part Examples
(1) Controlled fires (that is, those brought under control by shutting down the engine or by onboard extinguishing systems).	Rotating parts that are not life-limited (for example, compressor and turbine airfoils)
(2) Case burn-through where it can be shown there is no propagation to hazardous engine effects.	Accessory gearbox and internal components
(3) Release of low-energy parts where it can be shown there is no propagation to hazardous engine effects.	Engine bearings
(4) Vibration levels that result in crew discomfort.	Spinners
(5) Concentration of toxic products in the engine bleed air for the cabin sufficient to degrade crew performance.	Main engine mounts with redundant load carrying features
(6) Thrust in the opposite direction to that commanded by the pilot, below the level defined as hazardous.	Static gas path parts (for example, vanes and seals)
(7) Loss of integrity of the load path of the engine supporting system without actual engine separation.	Control system actuators
(8) Loss of integrity of the load path of the engine supporting system without actual engine separation.	Combustion liners
(8) Generation of thrust greater than maximum rated thrust.	Fuel nozzles
(9) Significant uncontrollable thrust oscillation.	
(10) Loss of protection such as loss of overspeed protection or loss of containment case capability.	
(11) Effect or influence on a Category 1 part.	

6. Developing Data for Major Repairs. To improve the quality and adequacy of data for major repairs of critical (Category 1) and complex (Category 2) parts, we recommend persons developing the major repair data include the following information in their repair data packages:

- a. A description of:
 - (1) The part to be repaired, including the part number.
 - (2) The repair, including any associated limitations. For example:
 - The extent of the damage the repair covers.
 - How many times, if limited, the repair can be repeated on a single part.
- b. The part categorization, if categorization is used.
- c. The applicable sections of the regulatory requirements from the certification basis for the engine(s) that the repaired part is eligible for installation on.
- d. An applicability assessment of any related service difficulty reports and airworthiness directives (ADs) to the part.
- e. The complete step-by-step “how to” instructions for accomplishing the repair. This should include drawings and specifications, new materials and fabrication details, if any.
- f. Technical data. The regulations require that when performing a major repair, the work be done in accordance with technical data approved by the Administrator. Technical data also includes substantiation data to show compliance to applicable regulatory requirements.

(1) Category 1 parts. We recommend that persons developing data in support of a major repair of a Category 1 part meet with the project aircraft certification office (PACO) to develop a substantiation plan before submitting a data package. The plan should outline the pertinent technical and regulatory requirements and testing, as needed to develop the data and substantiate the repair. In addition, the plan should identify process controls, inspections or tests, or both, required in the step-by-step procedures to mitigate the risks of improperly completing the repair.

Note: For major repairs of Category 1 parts, Order 8110.37, Designated Engineering Representative (DER) Handbook, requires DERs notify the PACO prior to approval of the data. Order 8110.4, Type Certification, requires PACO engineers notify the accountable directorate of a major repair of a Category 1 part and coordinate data approval with the certificate management ACO.

(2) Category 2 parts. We recommend persons developing data in support of a major repair of a Category 2 part use the templates in Appendix 2 of this AC or develop a new template, if applicable.

(a) Together with industry we developed the sample templates in Appendix 2 for typical repairs that were previously determined major. These templates may be used as aids to identify technical elements and regulatory requirements to be considered when developing your data and substantiating your repair for similar repairs to Category 2 parts, if determined major. These templates are not all inclusive; rather, they are for a limited number of typical Category 2 parts.

(b) Persons using these templates should discuss any questions with the PACO. If a template is not available for a proposed major repair, consider developing a new template. Using a format consistent with the templates provided will help ensure that your template identifies the applicable technical considerations and regulatory requirements. You should review the new template with the PACO early in the project to determine if any additional data will be needed.

g. An assessment of the applicability of the Instructions for Continued Airworthiness (ICAs). If ICAs are affected or needed, supplemental ICAs must be provided. Refer to FAA Order 8110.54, Instruction for Continued Airworthiness Responsibilities, Requirements, and Contents, for further information.

7. Developing a Continued Operational Safety (COS) Plan.

a. COS Management Plan. Repair approval holders and persons making a major repair must perform their work in accordance with approved technical data and applicable performance regulations. If service experience or FAA oversight audits show the repair data was inadequate, in error, or the work was performed improperly, the FAA will evaluate the safety impact and take appropriate action. That action may be to issue an AD, Special Airworthiness Information Bulletin (SAIB), or other appropriate document. In such a case, the repair approval holder or the person who performed the work, or both, may be requested to develop a corrective action program or a design change to restore safety to an acceptable level. Therefore, the FAA recommends that repair approval holders who develop data for major repairs and persons who use that data to perform maintenance develop a COS management plan.

b. Part Identification. To facilitate part tracking as part of a COS management plan, we recommend that persons proposing a repair provide supplementary part identification procedures.

(1) Any original part markings, such as the part number and serial number, should be maintained. Supplementary identification should be permanent and legible. It should include a name, trademark, or other symbol of the person performing the repair. Supplementary identification combined with adequate maintenance records ensures that if a problem occurs the affected parts can be identified, tracked, and, if necessary, removed from service.

(2) Parts subject to an airworthiness limitation should retain their original markings in accordance with § 45.14. When adding supplementary identification to the part, repair developers must ensure that their repair identification does not adversely impact the part. For example, do not apply repair identification on contact surfaces or near radii of parts because

these are typically areas of high stress concentrations. When impractical, i.e., the part is too small or applying the repair identification would compromise part integrity, we recommend entering part identification information in the part's maintenance records.

c. Maintaining Records. Federal Aviation Regulations have specific minimum time requirements for the retention of certain maintenance records. Experience has shown that the maintenance records and the availability of repair data can be extremely valuable for accident investigation and corrective action development. Therefore, we recommend that the data approval holder and persons performing the major repairs, for example, repair stations, owner/operators, or air carriers, keep records that include at least the following:

- (1) A record keeping plan to:
 - (a) Identify where repaired parts are in service or who the customer owners/operators of the parts are.
 - (b) Retain records of the work performed during the repair.
 - (c) Retain the technical data for the parts.
- (2) Documentation of the quality control of the repair.
- (3) A means to monitor the performance of repaired parts in service.
- (4) A means to identify and isolate parts that do not conform to approved data or are unairworthy.
- (5) The capability to analyze failed parts and identify root causes of failures in order to develop and implement corrective action(s) when needed.

8. Repair of Engine Parts Recovered from Accidents or Incidents.

a. We recommend persons repairing parts recovered from accidents or incidents inspect these parts for hidden damage prior to beginning a repair. Repair stations are required to perform this inspection per regulation, refer to § 145.211(c). This pre-repair inspection will ensure the part does not have hidden damage or has not been overstressed or overheated, which is not always obvious from visual or dimensional inspection.

b. The ICAs may be insufficient for this pre-repair inspection. Therefore, developing special instructions for evaluating repairability of such parts may be appropriate. We suggest repair developers review the part's maintenance and operational records for relevant service information and verify the history and origin of the parts when making that determination. Parts that are determined to be unsuitable for repair should not be repaired and should be returned to the owner with the appropriate entry in the part maintenance record. Refer to AC 20-62 and Order 8120.11 for further information on the airworthiness and eligibility of such parts. Parts

otherwise eligible for repair which do not exhibit evidence of irreparable damage may be repaired.

A handwritten signature in black ink, appearing to read "Francis A. Favara". The signature is written in a cursive style with some loops and flourishes.

Francis A. Favara
Manager, Engine and Propeller Directorate
Aircraft Certification Service

APPENDIX 1. FAILURE MODES AND EFFECTS ASSESSMENT

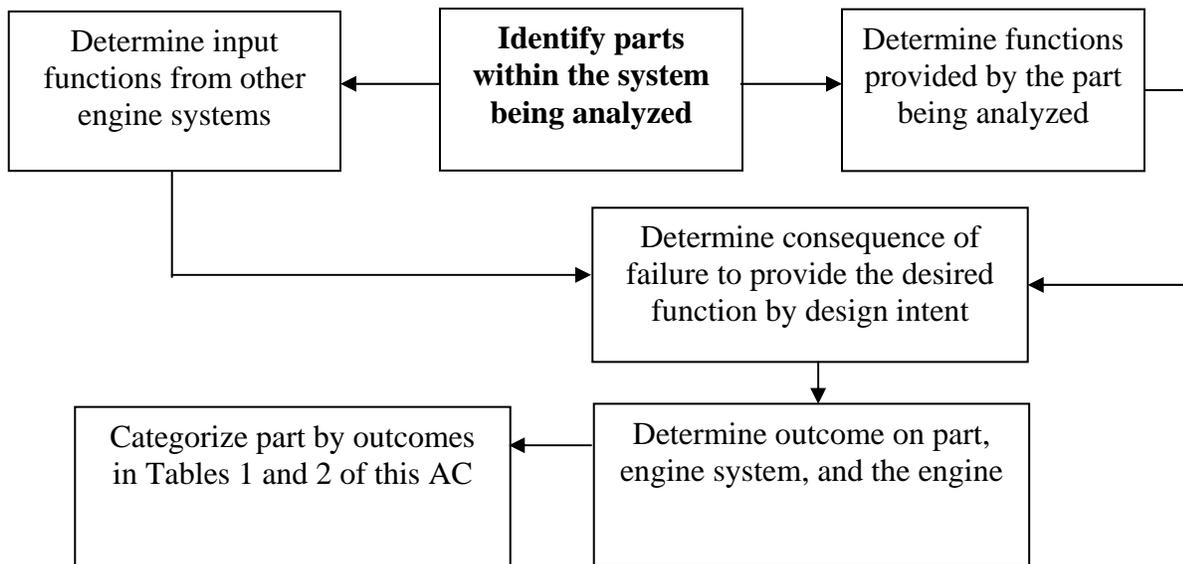
1. A failure modes and effects assessment is a qualitative process, independent of failure rates and probabilities, by which each failure mode of a part in the engine system is analyzed. Some top-level functions typically considered in an engine failure modes and effects assessment are:

- Maintaining structural integrity, including allowed overspeed and overtemperature exceedances;
- Providing thrust or power;
- Operating in inclement weather;
- Providing customer bleed, power extraction, or both; and
- Meeting fuel consumption, exhaust gas temperature, vibration, emission or noise limits.

2. Each system and subsystem of the engine is broken down into its basic functions using a functional block diagram consistent with the Air Transport Association policy for identification and definition of systems.

3. The functional block diagram defines each system and subsystem, and all their functions, in the turbine engine. The experienced safety engineer performing the analysis determines the part-to-part and part-to-system influences in both directions (input and output). The process flow is shown in figure A1.1 below:

Figure A1.1. Process Flow Diagram



4. The part categorization process is built around the fundamental understanding of the part function and its potential effects on physically or functionally mating parts or both. The fundamental premise in the categorization process, and in the physical operation and function of the turbine engine, is system interactions.

a. System interactions are influences a part, or a set of parts, can have on the turbine engine, propulsion system, or aircraft through form, fit, or function, where

(1) Form is the shape, size, dimensions, and other physical measurable parameters that uniquely characterize a part.

(2) Fit is the ability of a part to interface or interconnect, physically and functionally, at the common boundaries with another part or system of the engine.

(3) Function is the action(s) the part is designed to perform in the engine.

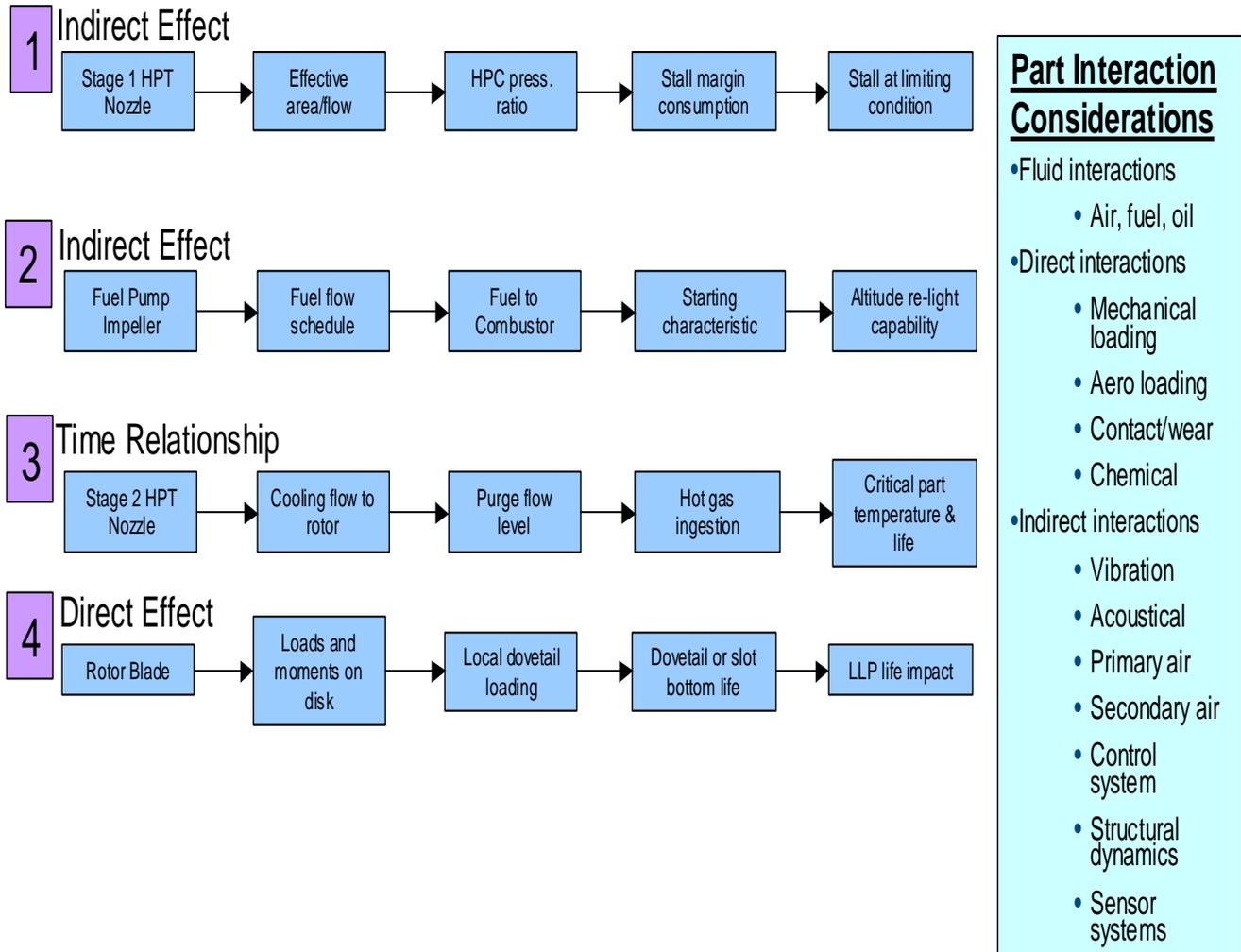
b. These influences may extend beyond the component being classified, may be direct or indirect, and may develop immediately or over time. Characteristics of these influences include:

(1) Direct influences, which are form and fit. These influences are based on physical contact or interface clearances between adjacent parts.

(2) Indirect influences, which are functional in nature. These influences are not based on physical contact, but may be aerodynamic, thermal, or vibratory.

5. The interactions where the consequence of failure is the furthest from the cause are the most difficult to identify. Many fundamental relationships in part interactions and subsequent system effects exist. Figure A1.2 below provides four examples.

Figure A1.2. Part Interaction Considerations



APPENDIX 2. SAMPLE TEMPLATES

1. Purpose. This appendix includes templates for major repairs related to 17 engine part families, listed in Table A2-1 below. The FAA selected them based on typical repairs for complex turbine engine parts submitted as major. These templates will aid repair developers in identifying the technical elements and regulatory requirements they should consider when developing and substantiating similar major repairs. Persons developing data must ensure that any additional technical criteria or regulatory requirements are met for their specific proposed major repair.

2. Template Instructions. Each template shows both shaded and un-shaded (clear) cells corresponding to the sample repair and its specific engineering, technical and regulatory considerations. Those cells that are generally applicable are un-shaded. However, the repair developer must decide if the cells need to be completed or not. The templates identify the current part 33 regulations, Amendments 1-20 inclusive, applicable to turbine engines as an example. When reviewing the associated regulatory considerations, the repair developer should determine applicability and identify the corresponding methods of compliance to be used to provide the supporting data.

a. The certification basis of the engine(s) on which the repaired part is eligible for installation identifies the regulatory requirements that should be reviewed for applicability. Applicable regulations are those regulations that must be evaluated to determine that the engine remains in compliance and airworthy with respect to the repair work performed. For critical and complex parts, the repair developer should determine which of the original compliance findings to those applicable regulations could be affected by their proposed major repair. To do this, you must understand how the part to be repaired functions in the engine operating environment, and the associated regulatory requirements. Repair developers substantiate their repair to these requirements, using acceptable methods, to show that the condition of the engine on which the repaired part is installed will be at least equal to its original or properly altered condition.

b. Acceptable methods are identified as follows:

- (1) D - Documentation (for example, Instructions for Continued Airworthiness).
- (2) A - Analysis of relevant data.
- (3) I - Inspection (for example, metallurgical examination, hardness testing, Non-destructive testing inspection).
- (4) R - Rig testing.
- (5) C - Component testing.
- (6) E - Engine testing.

(7) S - Similarity to previously FAA approved data. Repair developers will need to show that the previously approved data is applicable to the new proposed repair, and to the product type design if different than the type design for which the data was previously approved.

3. Sample Templates. If a template is not available for a particular major repair, the repair developer can create or modify another as necessary.

Table A2-1. Sample Templates.

Template Number	Title	Page
1	Bearing Compartment and Carbon Seal Parts Family	15
2	High Pressure Turbine (HPT) Blade Part Family	25
3	Low Pressure Compressor (LPC) – High Pressure Compressor (HPC) Blade Part Family	36
4	Blades – Low Pressure Turbine (LPT)	46
5	Combustor Part Family	55
6	Externals Part Family (Tubes, Manifolds, Ducts, Brackets)	66
7	Fuel Nozzle Part Family	75
8	Gearbox Housing Assembly Part Family (Shafts, Gears, Housings)	84
9	Low Pressure Compressor (LPC) – High Pressure Compressor (HPC) Stator Part Family – Vane Sector (And Full Ring) Type Stators	94
10	Low Pressure Compressor (LPC) – High Presser Compressor (HPC) Stator Part Family – Fixed Vane Type Stators	103
11	Major Engine Cases	112
12	Major Rotating (Non-Life Limited) Part Family (Excluding Turbine Shaft Coupling Part Family)	121
13	High Pressure Compressor (HPC)/High Pressure Turbine (HPT)/Low Pressure Turbine (LPT) Airseals (Non-Rotating) And Shrouds (Stationary) Part Family	130
14	Static Structure Part Family (ducts, bearing housings, etc.)	138
15	Low Pressure Compressor (LPC) – High Pressure Compressor (HPC) Stator Part Family – Variable Vane Type Stators	148
16	HPT Vane Part Family	157
17	Low Pressure Turbine (LPT) Vane Part Family	166

Template 1**REPAIR SUBSTANTIATION CHECKLIST - BEARING COMPARTMENT AND
CARBON SEAL PART FAMILIES**

Categories of Bearing Compartment & Carbon Seal Part Family Repair. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Restoration of Protective Coating <ul style="list-style-type: none"> This repair includes touch-up coating
2.	Weld or Braze Repair <ul style="list-style-type: none"> This repair excludes detail part replacement
3.	Weld or Braze Repair <ul style="list-style-type: none"> This repair includes detail part replacement
4.	Assembly and/or Disassembly <ul style="list-style-type: none"> This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted.
5.	Blend Repair
6.	Dimensional Restoration by Coating or Plating
7.	Bushing/Helicoil Repair
8.	Straightening, Re-twist, or Reforming Repair <ul style="list-style-type: none"> This repair includes straightening of bent knife edges
9.	Surface Treatment Repair <ul style="list-style-type: none"> This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)
10.	Machining Repair <ul style="list-style-type: none"> This repair includes lapping, skim cut, non-conventional machining.
11.	Restoration of Adhesives, Bonding Agents, Potting Compound

When the cell under a category of repair is not shaded, the items listed under that requirement should be reviewed for applicability, based on the repair design, and only the items pertinent to this category of repair should be selected and addressed appropriately. Items not selected need not be addressed.

An FAA-approved configuration means a new part (produced under a PC, TSO, or PMA) or a previously approved repaired part.

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 											

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 											

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness.</p> <p>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size, and volume fraction, etc.)</p> <p>b. Porosity (weldment)</p> <p>c. Diffusion Zone (brazing)</p> <p>d. Heat Affected Zone (welding)</p>											

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface Contamination) l. Hydrogen Embrittlement (Plating) m. Compatibility With Base Material/Other Coatings 											
5.	<p>Select surface treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 											

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (Kt) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 											

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.											
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight											
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> • Surface finish/texture • Shotpeen Intensity/Coverage • Bearing bore dimensions and location characteristics • Pressure Strength Test • Flow Capacity test • Dimensions, including heat distortion effects 1) Roundness 2) Flatness 3) Parallelism 4) Concentricity 5) True Position Tolerances 6) Edge Distance Requirements 7) Finish Dimensions Requirements											
10.	Significant Operations Identified for Validation that would include parameter variability limits.											

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
11.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specs • Quality Requirements • Critical Process Validation needs 											
Applicable 14 CFR Part 33 Requirements												
Subpart A – General												
12.	33.4 Instructions for Continuous Airworthiness (ICA's)											
13.	33.5 Instruction manual for installing and operating the engine											
14.	33.7 Engine ratings and operating limitations											
15.	33.8 Selection of engine power and thrust ratings											
Subpart B – Design and Construction; General												
16.	33.14 Start-stop cyclic stress (low cycle fatigue)											
17.	33.15 Materials											
18.	33.17 Fire prevention											
19.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)											

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	
20.	33.21 Engine cooling												
21.	33.23 Engine mounting attachments and structure												
22.	33.25 Accessory attachments												
23.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors												
24.	33.28 Electrical and electronic control systems												
25.	33.29 Instrument connection												
	Repair Process Capability Technical Substantiation Requirements												
	Subpart E – Design and Construction; Turbine Aircraft Engines												
26.	33.62 Stress analysis												
27.	33.63 Vibration												
28.	33.65 Surge and stall characteristics (Note 2)												
29.	33.66 Bleed air system												
30.	33.67 Fuel system												
31.	33.68 Induction system icing (operability aspects) (Note 2)												
32.	33.69 Ignitions system												
33.	33.71 Lubrication system												
34.	33.72 Hydraulic actuating systems												
35.	33.73 Power or thrust response												
36.	33.74 Continued rotation												

Req No.	Airworthiness Standards to be Substantiated	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	11
	Subpart E – Design and Construction; Turbine Aircraft Engines (continued)											
37.	33.75 Safety analysis											
38.	33.76 Bird ingestion (operability aspects of ingestion)											
39.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)											
40.	33.78 Rain and hail ingestion											
41.	33.79 Fuel burning thrust augmentor											
	Subpart F – Block Tests; Turbine Aircraft Engines											
42.	33.83 Vibration test											
43.	33.85 Calibration tests											
44.	33.87 Endurance test											
45.	33.88 Engine overtemperature test											
46.	33.89 Operation test (Note 2)											
47.	33.90 Initial maintenance inspection											
48.	33.91 Engine component tests (HCF/LCF bench testing)											
49.	33.92 Rotor locking tests											
50.	33.93 Teardown inspection											
51.	33.94 Blade containment and rotor unbalance tests (weight changes)											
52.	33.95 Engine-propeller system tests											
53.	33.96 Engine tests in auxiliary power unit (APU) mode											
54.	33.97 Thrust reversers											
55.	33.99 General conduct of block tests											
	Part 33 -Appendix A – Instructions for Continued Airworthiness											
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail											
	Part 34 – Exhaust Emissions											

Template 2**REPAIR SUBSTANTIATION CHECKLIST – HIGH PRESSURE TURBINE (HPT)
BLADE PART FAMILY**

Categories of HPT Blade Part Family Repair. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Overcoat Repair (without stripping)
2.	Strip and Re-coat Repair <ul style="list-style-type: none"> • This repair removes and replaces all types of coatings.
3.	Weld or Braze Repair (excludes detail parts replacement) <ul style="list-style-type: none"> • Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair <ul style="list-style-type: none"> • Includes detail parts replacement
5.	Surface Treatment Repair Including shot-peen, glass bead peen, and vibratory tumble (e.g.; restoration of surface finish/texture).
6.	Blend Repair
7.	Blade Internal Cavity Cleaning Repair
8.	Sulfidation or Corrosion Repair
9.	Assembly and/or Disassembly. This repair removes and replaces details parts without the use of permanent attachment techniques (i.e., welding or brazing), but assembly is either bolted or riveted.

		CATEGORIES OF REPAIR								
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O3 chemical attack, etc. 									
2.	Select all mechanical, metallurgical, and physical properties of the part affected by the repair design , and assess their impact on the part's airworthiness:									

		CATEGORIES OF REPAIR								
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9
	<p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young’s Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 									

		CATEGORIES OF REPAIR								
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 									

		CATEGORIES OF REPAIR								
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface Contamination) l. Hydrogen Embrittlement (Plating) m. Compatibility With Base Material/Other Coatings 									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 									
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 									

		CATEGORIES OF REPAIR								
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.									
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Critical Measurable Characteristics									
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen Intensity/Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions Requirements g. Airfoil Profile <ul style="list-style-type: none"> • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist/Lean/Bow h. Tip Length i. Airfoil wall thickness 									
10.	Part Weight: <ul style="list-style-type: none"> a. Mass b. Moment 									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
11.	Platform width & (angel wing) Cross Notch/Cross Shroud geometry										
12.	Cooling (Total flow, flow split, back flow margin, hole exit geometry/angle/location, cross-over hole size, metering plate)										
	Repair Process Capability Technical Substantiation Requirements										
13.	Verification Plan with Significant Operations Identified for Repair Source Qualification										
14.	Process Demonstration (including variability requirements)										
15.	Part Demonstration/Inspection										
16.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 										
	Applicable 14 CFR Part 33 Requirements										
	Subpart A – General										
17.	33.4 Instructions for Continuous Airworthiness (ICA's)										
	Repair Process Capability Technical Substantiation Requirements										
18.	33.5 Instruction manual for installing and operating the engine										
19.	33.7 Engine ratings and operating limitations										
20.	33.8 Selection of engine power and thrust ratings										
	Subpart B – Design and Construction; General										
21.	33.14 Start-stop cyclic stress (low cycle fatigue)										

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
22.	33.15 Materials									
23.	33.17 Fire prevention									
24.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)									
25.	33.21 Engine cooling									
26.	33.23 Engine mounting attachments and structure									
27.	33.25 Accessory attachments									
28.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
29.	33.28 Electrical and electronic control systems									
30.	33.29 Instrument connection									
	Subpart E – Design and Construction; Turbine Aircraft Engines									
31.	33.62 Stress analysis									
32.	33.63 Vibration									
33.	33.65 Surge and stall characteristics (Note 2)									
34.	33.66 Bleed air system									
35.	33.67 Fuel system									
36.	33.68 Induction system icing (operability aspects) (Note 2)									
37.	33.69 Ignitions system									
38.	33.71 Lubrication system									
39.	33.72 Hydraulic actuating systems									
40.	33.73 Power or thrust response									
41.	33.74 Continued rotation									
42.	33.75 Safety analysis									
43.	33.76 Bird ingestion (operability aspects of ingestion)									
44.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)									
45.	33.78 Rain and hail ingestion									
46.	33.79 Fuel burning thrust augmentor									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Subpart F – Block Tests; Turbine Aircraft Engines									
47.	33.83 Vibration test									
48.	33.85 Calibration tests									
49.	33.87 Endurance test									
50.	33.88 Engine overtemperature test									
51.	33.89 Operation test (Note 2)									
52.	33.90 Initial maintenance inspection									
53.	33.91 Engine component tests (HCF/LCF bench testing)									
54.	33.92 Rotor locking tests									
55.	33.93 Teardown inspection									
56.	33.94 Blade containment and rotor unbalance tests (weight changes)									
57.	33.95 Engine-propeller system tests									
58.	33.96 Engine tests in auxiliary power unit (APU) mode									
59.	33.97 Thrust reversers									
60.	33.99 General conduct of block tests									
	Part 33 -Appendix A – Instructions for Continued Airworthiness									
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail									
	Part 34 – Exhaust Emissions									

Template 3**REPAIR SUBSTANTIATION CHECKLIST – LOW PRESSURE COMPRESSOR (LPC)
– HIGH PRESSURE COMPRESSOR (HPC) BLADE PART FAMILY**

Categories of LPC/HPC Blade Part Family Repair. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Strip and Re-coat Repair <ul style="list-style-type: none"> • This repair removes and replaces any and all types of coatings
2.	Weld or Braze Repair (excludes detail parts replacement) <ul style="list-style-type: none"> • This repair includes restoration of airfoil tip and chord length
3.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair includes detail parts replacement
4.	Assembly or Disassembly <ul style="list-style-type: none"> • This repair removes and replaces detail parts without the use of permanent attachment techniques (i.e., welding or brazing) but assembly is either bolted or riveted.
5.	Blend Repair
6.	Remove and Restore Anti-gallant Coating
7.	Dimensional Restoration by Coating or Plating
8.	Straightening, Re-twist or Re-forming Repair <ul style="list-style-type: none"> • This repair includes dent repair
9.	Surface Treatment Repair <ul style="list-style-type: none"> • This repair includes shot-peen, glass bead peen, vibratory tumble (e.g., restoration of surface finish/texture)

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 									

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p style="text-align: center;"><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p style="text-align: center;"><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p style="text-align: center;"><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (interface contamination) l. Hydrogen Embrittlement (plating) m. Compatibility with Base Material/Other Coatings 										
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 										

Req No.	Repair Properties & Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 									
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>									

Req No.	Repair Properties & Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
8.	Select all that may be potentially affected by the repair design and evaluate system effect(s): Stress a. Heat Transfer b. Secondary Airflow c. Aerodynamics									
Critical Measurable Characteristics										
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity/Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements g. Airfoil Profile <ul style="list-style-type: none"> • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist/Lean/Bow h. Tip Length i. Airfoil wall thickness									

Req No.	Repair Properties & Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Critical Measurable Characteristics									
10.	Dovetail functional fit test									
11.	Part weight test: a. Mass Weight b. Moment Weight									
	Repair Process Capability Technical Substantiation Requirements									
12.	Technical Plan with Significant Operations Identified									
13.	Process Demonstration (including variability requirements)									
14.	Part Demonstration/Inspection									
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									
	Applicable 14 CFR Part 33 Requirements									
	Subpart A – General									
16.	33.4 Instructions for Continuous Airworthiness (ICA's)									
17.	33.5 Instruction manual for installing and operating the engine									
18.	33.7 Engine ratings and operating limitations									
19.	33.8 Selection of engine power and thrust ratings									
	Subpart B – Design and Construction; General									
20.	33.14 Start-stop cyclic stress (low cycle fatigue)									
21.	33.15 Materials									
22.	33.17 Fire prevention									
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)									
24.	33.21 Engine cooling									
25.	33.23 Engine mounting attachments and structure									
26.	33.25 Accessory attachments									

Req No.	Repair Properties & Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
28.	33.28 Electrical and electronic control systems									
29.	33.29 Instrument connection									
	Subpart E – Design and Construction; Turbine Aircraft Engines									
30.	33.62 Stress analysis									
31.	33.63 Vibration									
32.	33.65 Surge and stall characteristics (Note 2)									
33.	33.66 Bleed air system									
34.	33.67 Fuel system									
35.	33.68 Induction system icing (operability aspects) (Note 2)									
36.	33.69 Ignitions system									
37.	33.71 Lubrication system									
38.	33.72 Hydraulic actuating systems									
39.	33.73 Power or thrust response									
40.	33.74 Continued rotation									
41.	33.75 Safety analysis									
42.	33.76 Bird ingestion (operability aspects of ingestion)									
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)									
44.	33.78 Rain and hail ingestion									
45.	33.79 Fuel burning thrust augmentor									
	Subpart F – Block Tests; Turbine Aircraft Engines									
46.	33.83 Vibration test									
47.	33.85 Calibration tests									
48.	33.87 Endurance test									
49.	33.88 Engine overtemperature test									
50.	33.89 Operation test (Note 2)									
51.	33.90 Initial maintenance inspection									
52.	33.91 Engine component tests (HCF/LCF bench testing)									
53.	33.92 Rotor locking tests									
54.	33.93 Teardown inspection									

Req No.	Repair Properties & Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
55.	33.94 Blade containment and rotor unbalance tests (Weight changes)										
56.	33.95 Engine-propeller system tests										
57.	33.96 Engine tests in auxiliary power unit (APU) mode										
58.	33.97 Thrust reversers										
59.	33.99 General conduct of block tests										
	Part 33 -Appendix A – Instructions for Continued Airworthiness										
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail										
	Part 34 – Exhaust Emissions										

Template 4**REPAIR SUBSTANTIATION CHECKLIST - LOW PRESSURE TURBINE (LPT)
BLADE PART FAMILIES**

Categories of LPT Blade Part Family Repair. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Strip and Re-coat Repair <ul style="list-style-type: none"> • This repair removes and replaces any and all types of coatings
2.	Overcoat Repair (without stripping)
3.	Weld or Braze Repair (excludes detail part replacement) <ul style="list-style-type: none"> • Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair <ul style="list-style-type: none"> • Includes detail part replacement
5.	Sulfidation or Corrosion Repair
6.	Blend Repair
7.	Straightening, Re-twist, or Reforming Repair
8.	Surface Treatment Repair <ul style="list-style-type: none"> • This repair includes shot peen, glass bead peen, vibratory tumble (e.g., restoration of surface finish/texture)

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p style="text-align: center;"><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p style="text-align: center;"><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p style="text-align: center;"><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 									
4.	<p>Coating Material Properties, Characteristics & Processes:</p> <ul style="list-style-type: none"> a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free p. (Plating) q. Compatibility With Base Material 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 								
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 								
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>								

Req No.	Repair Properties & Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
8.	<p>Select all that may be potentially affected by the repair design, and evaluate system effect(s):</p> <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 								
Critical Measurable Characteristics									
9.	<p>Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s):</p> <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen Intensity/Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements g. Airfoils Profile <ul style="list-style-type: none"> • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist/Lean/Bow h. Tip Length i. Airfoil wall thickness j. Throat Area 								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Critical Measurable Characteristics									
10.	Part Weight: a. Moment b. Mass									
11.	Platform width & (angel wing) Cross Notch/Cross Shroud geometry									
	MPE Repair Process Capability Technical Substantiation Requirements									
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
13.	Process Demonstration (including variability requirements)									
14.	Part Demonstration/Inspection									
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements									
	Applicable 14 CFR Part 33 Requirements									
	Subpart A – General									
16.	33.4 Instructions for Continuous Airworthiness (ICA's)									
17.	33.5 Instruction manual for installing and operating the engine									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Subpart A – General								
18.	33.7 Engine ratings and operating limitations								
19.	33.8 Selection of engine power and thrust ratings								
	Subpart B – Design and Construction; General								
20.	33.14 Start-stop cyclic stress (low cycle fatigue)								
21.	33.15 Materials								
22.	33.17 Fire prevention								
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)								
24.	33.21 Engine cooling								
25.	33.23 Engine mounting attachments and structure								
26.	33.25 Accessory attachments								
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors								
28.	33.28 Electrical and electronic control systems								
29.	33.29 Instrument connection								
	Subpart E – Design and Construction; Turbine Aircraft Engines								
30.	33.62 Stress analysis								
31.	33.63 Vibration								
32.	33.65 Surge and stall characteristics (Note 2)								
33.	33.66 Bleed air system								
34.	33.67 Fuel system								
35.	33.68 Induction system icing (operability aspects) (Note 2)								
36.	33.69 Ignitions system								
37.	33.71 Lubrication system								
38.	33.72 Hydraulic actuating systems								
39.	33.73 Power or thrust response								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Subpart E – Design and Construction; Turbine Aircraft Engines (continued)								
40.	33.74 Continued rotation								
41.	33.75 Safety analysis								
42.	33.76 Bird ingestion (operability aspects of ingestion)								
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)								
44.	33.78 Rain and hail ingestion								
45.	33.79 Fuel burning thrust augmentor								
	Subpart F – Block Tests; Turbine Aircraft Engines								
46.	33.83 Vibration test								
47.	33.85 Calibration tests								
48.	33.87 Endurance test								
49.	33.88 Engine overtemperature test								
50.	33.89 Operation test (Note 2)								
51.	33.90 Initial maintenance inspection								
52.	33.91 Engine component tests (HCF/LCF bench testing)								
53.	33.92 Rotor locking tests								
54.	33.93 Teardown inspection								
55.	33.94 Blade containment and rotor unbalance tests (weight changes)								
56.	33.95 Engine-propeller system tests								
57.	33.96 Engine tests in auxiliary power unit (APU) mode								
58.	33.97 Thrust reversers								
59.	33.99 General conduct of block tests								
	Part 33 -Appendix A – Instructions for Continued Airworthiness								
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail								
	Part 34 – Exhaust Emissions								

Template 5**REPAIR SUBSTANTIATION CHECKLIST - COMBUSTOR PART FAMILY**

Categories of Combustor Part Family Repairs. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Strip & Recoat Repair <ul style="list-style-type: none"> • This repair removes and replaces any and all types of coatings.
2.	Blend Repair
3.	Straightening, Re-twist, or Reforming Repair <ul style="list-style-type: none"> • This repair includes straightening of bent flanges
4.	Weld/Braze Repair <ul style="list-style-type: none"> • Excludes Detail Part Replacement
5.	Weld/Braze Repair <ul style="list-style-type: none"> • Includes Detail Part Replacement
6.	Assembly and/or Disassembly <ul style="list-style-type: none"> • This repair removes and replaces detail parts without use of permanent attachment technique, (i.e. weld or braze); assembly is either bolted or riveted.
7.	Bushing/Helicoil Repair
8.	Dimensional Restoration by Coating or Plating.

		CATEGORIES OF REPAIR							
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 								

		CATEGORIES OF REPAIR							
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 								
	<p>Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements</p>								
4.	<p>Coating & Plating Material Properties Characteristics & Processes:</p> <ul style="list-style-type: none"> a. Deposit material composition b. Thickness, Coverage, and Uniformity c. Microstructure d. Hardness e. Sintering f. Strip process g. Residual stress h. Lubricant properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) n. Environmental Resistance o. Diffusion Zone p. Hydrogen Embrittlement Free Plating q. Compatibility with base material 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
5.	<p>Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s):</p> <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance requirements • Finish dimensions requirements 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 								
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 								
	Critical Measurable Characteristics								
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen Intensity/Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength test e. Flow Capacity test f. Dimensions, including heat distortion effects g. Roundness h. Flatness i. Parallelism j. Concentricity k. True Position Tolerances l. Edge Distance Requirements m. Finish Dimensions Requirements n. Diameter/Locating o. Air Swirler Features p. Mixing Air (dilution) Features q. Datum Location Features r. Air Cooling Hole Diameter s. Flowpath Exit Features t. Sealing Features u. Aft Seal v. Fuel Nozzles w. Igniter interfaces x. Flanges 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
10.	Cooling Feature Characteristics: a. Airflow b. Hole Diameter c. Blocked Hole Quantity/Location d. Cooling Slot Height/Length/Location e. Quantity of Holes/Slots								
11.	Thermal Barrier Coating: a. Thickness b. Coverage c. Type								
Repair Process Capability Technical Substantiation Requirements									
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Repair Process Capability Technical Substantiation Requirements								
13.	Process Demonstration Including: a. Variability Requirements								
14.	Part Demonstration/Inspection								
15.	Manufacturing Requirements for fabrication of repair details or replacement sections to accomplish repair: a. Drawings/Specifications b. Quality Requirements c. Source Substantiation Requirements								
	Applicable 14 CFR Part 33 Requirements								
	Subpart A – General								
16.	33.4 Instructions for Continuous Airworthiness (ICA's)								
17.	33.5 Instruction Manual for Installing and Operating the Engine								
18.	33.7 Engine Ratings and Operating Limitations								
19.	33.8 Selection of Engine Power and Thrust Ratings								
	Subpart B – Design and Construction; General								
20.	33.14 Start-stop cyclic stress (low cycle fatigue)								
21.	33.15 Materials								
22.	33.17 Fire prevention								
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)								
24.	33.21 Engine								
25.	33.23 Engine mounting attachments and structure								
26.	33.25 Accessory attachments								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
27.	33.27 Turbine, compressor, fan, and turbo supercharger rotors								
28.	33.28 Electrical and electronic control systems								
29.	33.29 Instrument connection								
	Subpart E – Design and Construction; Turbine Aircraft Engines								
30.	33.62 Stress analysis								
31.	33.63 Vibration								
32.	33.65 Surge and stall characteristics, (Note 2)								
33.	33.66 Bleed air system								
34.	33.67 Fuel system								
35.	33.68 Induction system icing, (operability aspects) (Note 2)								
36.	33.69 Ignitions system								
37.	33.71 Lubrication system								
38.	33.72 Hydraulic actuating systems								
39.	33.73 Power or thrust response								
40.	33.74 Continued rotation								
41.	33.75 Safety analysis								
42.	33.76 Bird ingestion (operability aspects of ingestion)								
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)								
44.	33.78 Rain and hail ingestion								
45.	33.79 Fuel burning thrust augmentor								
	Subpart F – Block Tests; Turbine Aircraft Engines								
46.	33.83 Vibration test								
47.	33.85 Calibration tests								
48.	33.87 Endurance tests								
49.	33.88 Engine overtemperature test								
50.	33.89 Operation test (Note 2)								
51.	33.90 Initial maintenance inspection								
52.	33.91 Engine component tests (HCF/LCF Bench Testing)								
53.	33.92 Rotor locking tests								
54.	33.93 Teardown inspection								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
55.	33.94 Blade containment and rotor unbalance tests (weight changes)									
56.	33.95 Engine-propeller system tests									
57.	33.96 Engine tests in auxiliary power unit (APU) mode									
58.	33.97 Thrust reversers									
59.	33.99 General conduct of block tests									
	Part 33-Appendix A – Instructions for Continued Airworthiness									
	Part 33-Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail									
	Part 34 – Exhaust Emissions									

Template 6**REPAIR SUBSTANTIATION CHECKLIST - EXTERNALS PART FAMILY
(Tubes, Manifolds, Ducts, Brackets)**

Categories of Externals (Tubes, Manifolds, Ducts, Brackets) Part Family. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Assembly and/or Disassembly <ul style="list-style-type: none"> • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted.
2.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair excludes detail part replacement
3.	Weld or Braze Repair <ul style="list-style-type: none"> • Includes detail part replacement
4.	Blend Repair
5.	Sulfidation or Corrosion Repair
6.	Dimensional Restoration by Coating or Plating
7.	Bushing/Helicoil Repair
8.	Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> • This repair includes dent repair
9.	Repairs to Restore Adhesives, Bonding Agents, Potting Compounds.
10.	Machining Repair <ul style="list-style-type: none"> • This repair includes lapping, skim cut, non-conventional machining

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 										

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 										

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 										
4.	<p>Coating & Plating Material Properties Characteristics & Processes:</p> <ul style="list-style-type: none"> a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material 										
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 										

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 										

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.										
8.	Select all that may be potentially affected by the repair design and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight										
Critical Measurable Characteristics											
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance requirements • Finish dimensions requirements 										
10.	Coating Coverage Definition										
11.	Blend Area Proximity Limits Defined										

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
	Repair Process Capability Technical Substantiation Requirements										
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification										
13.	Process Demonstration (including variability requirements)										
14.	Part Demonstration/Inspection										
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 										
	Applicable 14 CFR Part 33 Requirements										
	Subpart A – General										
16.	33.4 Instructions for Continuous Airworthiness (ICA's)										
17.	33.5 Instruction manual for installing and operating the engine										
18.	33.7 Engine ratings and operating limitations										
19.	33.8 Selection of engine power and thrust ratings										
	Subpart B – Design and Construction; General										
20.	33.14 Start-stop cyclic stress (low cycle fatigue)										
21.	33.15 Materials										
22.	33.17 Fire prevention										
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)										
24.	33.21 Engine cooling										
25.	33.23 Engine mounting attachments and structure										
26.	33.25 Accessory attachments										
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors										

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR										
		1	2	3	4	5	6	7	8	9	10	
	Subpart B – Design and Construction; General											
28.	33.28 Electrical and electronic control systems											
29.	33.29 Instrument connection											
	Subpart E – Design and Construction; Turbine Aircraft Engines											
30.	33.62 Stress analysis											
31.	33.63 Vibration											
32.	33.65 Surge and stall characteristics											
33.	33.66 Bleed air system											
34.	33.67 Fuel system											
35.	33.68 Induction system icing (operability aspects) (Note 2)											
36.	33.69 Ignitions system											
37.	33.71 Lubrication system											
38.	33.72 Hydraulic actuating systems											
39.	33.73 Power or thrust response											
40.	33.74 Continued rotation											
41.	33.75 Safety analysis											
42.	33.76 Bird ingestion (operability aspects of ingestion)											
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)											
44.	33.78 Rain and hail ingestion											
45.	33.79 Fuel burning thrust augmentor											
	Subpart F – Block Tests; Turbine Aircraft Engines											
46.	33.83 Vibration test											
47.	33.85 Calibration tests											
48.	33.87 Endurance test											
49.	33.88 Engine overtemperature test											

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10		
	Subpart F – Block Tests; Turbine Aircraft Engines												
50.	33.89 Operation test												
51.	33.90 Initial maintenance inspection												
52.	33.91 Engine component tests (HCF/LCF bench testing)												
53.	33.92 Rotor locking tests												
54.	33.93 Teardown inspection												
55.	33.94 Blade containment and rotor unbalance tests (weight changes)												
56.	33.95 Engine-propeller system tests												
57.	33.96 Engine tests in auxiliary power unit (APU) mode												
58.	33.97 Thrust reversers												
59.	33.99 General conduct of block tests												
	Part 33 -Appendix A – Instructions for Continued Airworthiness												
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail												
	Part 34 – Exhaust Emissions												

Template 7

REPAIR SUBSTANTIATION CHECKLIST - FUEL NOZZLE PART FAMILY

Categories of Fuel Nozzle Part Family Repair. Determine which repair description best fits the repair proposal based. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Blend Repair
2.	Thread Restoration and Functional Testing.
3.	Assembly and/or Disassembly <ul style="list-style-type: none"> • Repair removes and replaces detail parts without use of permanent attachment techniques, (i.e. welding or brazing) but assembly is either bolted or riveted.
4.	Machining Repair <ul style="list-style-type: none"> • Includes lapping, skim cut, non-conventional machining.
5.	Weld or Braze Repair <ul style="list-style-type: none"> • Excludes Detail Part Replacement
6.	Weld or Braze Repair <ul style="list-style-type: none"> • Includes Detail Part Replacement
7.	Dimensional Restoration By Coating or Plating

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 							

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:</p> <p>Mechanical Properties:</p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, dwell time) d. Creep e. Tensile Properties (yield, strength, elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p>Metallurgical Properties:</p> <ul style="list-style-type: none"> i. Chemical Composition (alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate <p>Physical Properties:</p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 							

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 								
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface Contamination) l. Hydrogen Embrittlement (plating) m. Compatibility With Base Material/Other Coatings 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 							
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 							
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>							

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
8.	<p>Select all that may be potentially affected by the repair design and evaluate system effect(s):</p> <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 							
Critical Measurable Characteristics								
9.	<p>Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s):</p> <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance requirements • Finish dimensions requirements g. Diameter/locating h. Air swirler features i. Mixing air (dilution) features j. Datum location features k. Air cooling hole diameter l. Flowpath exit features m. Aft seal n. Flanges o. Igniter interfaces 							

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
	Critical Measurable Characteristics							
10.	Material Debit Due To: a. Heat Treat b. Weld, Braze, Coat or Plate Processes c. Machine Process d. Blend e. Hone f. Lap g. Grit Blast h. Strip							
11.	Flow Volume							
12.	Flow Pattern							
13.	Pressure/Leak Test							
	Repair Process Capability Technical Substantiation Requirements							
14.	Verification Plan with Significant Operations Identified for Repair Source Qualification							
15.	Process Demonstration (including variability requirements)							
16.	Part Demonstration/Inspection							
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 							
	Applicable 14 CFR Part 33 Requirements							
	Subpart A – General							
18.	33.4 Instructions for Continuous Airworthiness (ICA's)							
19.	33.5 Instruction manual for installing and operating the engine							
20.	33.7 Engine ratings and operating limitations							
21.	33.8 Selection of engine power and thrust ratings							

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
	Subpart B – Design and Construction; General							
22.	33.14 Start-stop cyclic stress (Low cycle fatigue)							
23.	33.15 Materials							
24.	33.17 Fire prevention							
25.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)							
26.	33.21 Engine cooling							
27.	33.23 Engine mounting attachments and structure							
28.	33.25 Accessory attachments							
29.	33.27 Turbine, compressor, fan, and turbo supercharger rotors							
30.	33.28 Electrical and electronic control systems							
31.	33.29 Instrument connection							
	Subpart E – Design and Construction; Turbine Aircraft Engines							
32.	33.62 Stress analysis							
33.	33.63 Vibration							
34.	33.65 Surge and stall characteristics (Note 2)							
35.	33.66 Bleed air system							
36.	33.67 Fuel system							
37.	33.68 Induction system icing (operability aspects) (Note 2)							
38.	33.69 Ignitions system							
39.	33.71 Lubrication system							
40.	33.72 Hydraulic actuating systems							
41.	33.73 Power or thrust response							
42.	33.74 Continued rotation							
43.	33.75 Safety analysis							
44.	33.76 Bird ingestion (operability aspects of ingestion)							
45.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)							
46.	33.78 Rain and hail ingestion							
47.	33.79 Fuel burning thrust augmentor							

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
	Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements								
	Subpart F – Block Tests; Turbine Aircraft Engines								
48.	33.83 Vibration test								
49.	33.85 Calibration tests								
50.	33.87 Endurance test								
51.	33.88 Engine overtemperature test								
52.	33.89 Operation test (Note 2)								
53.	33.90 Initial maintenance inspection								
54.	33.91 Engine component tests (HCF/LCF bench testing)								
55.	33.92 Rotor locking tests								
56.	33.93 Teardown inspection								
57.	33.94 Blade containment and rotor unbalance tests (weight changes)								
58.	33.95 Engine-propeller system tests								
59.	33.96 Engine tests in auxiliary power unit (APU) mode								
60.	33.97 Thrust reversers								
61.	33.99 General conduct of block tests								
	Part 33 Appendix A – Instructions for Continued Airworthiness								
	Part 33 Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail								
	Part 34 – Exhaust Emissions								

Template 8**REPAIR SUBSTANTIATION CHECKLIST - GEARBOX HOUSING ASSEMBLY
PART FAMILY (SHAFTS, GEARS, HOUSINGS)**

Categories of Gearbox Housing Assembly Part Family (shafts, gears, housings). Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Restoration of Protective Coating <ul style="list-style-type: none"> • Includes Touch Up Coating
2.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair excludes detail part replacement
3.	Weld or Braze Repair <ul style="list-style-type: none"> • Includes detail part replacement
4.	Assembly and/or Disassembly <ul style="list-style-type: none"> • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted.
5.	Sulfidation or Corrosion Repair
6.	Blend Repair
7.	Dimensional Restoration by Coating or Plating
8.	Bushing/Helicoil Repair
9.	Straightening, Re-twist, or Reforming Repair <ul style="list-style-type: none"> • This repair includes straightening of bent knife edges
10.	Surface Treatment Repair <ul style="list-style-type: none"> • This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)
11.	Machining Repair <ul style="list-style-type: none"> • This repair includes lapping, skim cut, non-conventional machining
12.	Restoration of Adhesives, Bonding Agents, Potting Compounds.

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 												

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 												

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 												
4.	<p>Coating & Plating Material Properties Characteristics & Processes:</p> <ul style="list-style-type: none"> a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material 												

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 												
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 												

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.												
8.	Select all that may be potentially affected by the repair design and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight												

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
	Critical Measurable Characteristics												
9.	Bearing Bore: a. Dimension b. Location												
10.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat g. distortion effects • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance requirements • Finish dimensions requirements												

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
	Critical Measurable Characteristics continued												
11	Oil Nozzle Flow Test												
	Repair Process Capability Technical Substantiation Requirements												
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification												
13.	Process Demonstration (including variability requirements)												
14.	Part Demonstration/Inspection												
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 												
	Applicable 14 CFR Part 33 Requirements												
	Subpart A – General												
16.	33.4 Instructions for Continuous Airworthiness (ICA's)												
17.	33.5 Instruction manual for installing and operating the engine												
18.	33.7 Engine ratings and operating limitations												
19.	33.8 Selection of engine power and thrust ratings												

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
	Subpart B – Design and Construction; General												
20.	33.14 Start-stop cyclic stress (low cycle fatigue)												
21.	33.15 Materials												
22.	33.17 Fire prevention												
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)												
24.	33.21 Engine cooling												
25.	33.23 Engine mounting attachments and structure												
26.	33.25 Accessory attachments												
27.	33.27 Turbine, compressor, fan, and turbo supercharger rotors												
28.	33.28 Electrical and electronic control systems												
29.	33.29 Instrument connection												
	Subpart E – Design and Construction; Turbine Aircraft Engines												
30.	33.62 Stress analysis												
31.	33.63 Vibration												
32.	33.65 Surge and stall characteristics (Note 2)												
33.	33.66 Bleed air system												
34.	33.67 Fuel system												
35.	33.68 Induction system icing (operability aspects) (Note 2)												
36.	33.69 Ignitions system												
37.	33.71 Lubrication system												
38.	33.72 Hydraulic actuating systems												
39.	33.73 Power or thrust response												
40.	33.74 Continued rotation												
41.	33.75 Safety analysis												
42.	33.76 Bird ingestion (operability aspects of ingestion)												

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
	Subpart E – Design and Construction; Turbine Aircraft Engines												
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)												
44.	33.78 Rain and hail ingestion												
45.	33.79 Fuel burning thrust augmentor												
	Subpart F – Block Tests; Turbine Aircraft Engines												
46.	33.83 Vibration test												
47.	33.85 Calibration tests												
48.	33.87 Endurance test												
49.	33.88 Engine overtemperature test												
50.	33.89 Operation test (Note 2)												
51.	33.90 Initial maintenance inspection												
52.	33.91 Engine component tests (HCF/LCF bench testing)												
	Subpart F – Block Tests; Turbine Aircraft Engines												
53.	33.92 Rotor locking tests												
54.	33.93 Teardown inspection												
55.	33.94 Blade containment and rotor unbalance tests (weight changes)												
56.	33.95 Engine-propeller system tests												
57.	33.96 Engine tests in auxiliary power unit (APU) mode												
58.	33.97 Thrust reversers												
59.	33.99 General conduct of block tests												
	Part 33 -Appendix A – Instructions for Continued Airworthiness												
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail												
	Part 34 – Exhaust Emissions												

Template 9**REPAIR SUBSTANTIATION CHECKLIST – LOW PRESSURE COMPRESSOR (LPC)
– HIGH PRESSURE COMPRESSOR (HPC) STATOR PART FAMILY – VANE
SECTOR (AND FULL RING) TYPE STATORS**

Categories of LPC-HPC Stator Repair. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Restoration of Protective Coating (Paint, Aluminizing, Oil, etc.) <ul style="list-style-type: none"> • This repair includes touch-up coating
2.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair excludes detail part replacement
3.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair includes detail part replacement
4.	Assembly and/or Disassembly <ul style="list-style-type: none"> • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
5.	Blend Repair
6.	Dimensional Restoration by Coating or Plating
7.	Surface Treatment Repair <ul style="list-style-type: none"> • This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)
8.	Straightening, Re-twist, or Reforming Repair <ul style="list-style-type: none"> • This repair includes straightening of bent flanges
9.	Restoration of Adhesives, Bonding Agents & Potting Compounds

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:</p> <p>Mechanical Properties:</p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, dwell time) d. Creep e. Tensile Properties (yield, strength, elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p>Metallurgical Properties:</p> <ul style="list-style-type: none"> i. Chemical Composition (alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate <p>Physical Properties:</p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 									
4.	<p>Coating & Plating Material Properties Characteristics & Processes:</p> <ul style="list-style-type: none"> a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 									
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 									
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>									

Req. No.	Repair Design Requirements to be Identified and Substantiated, Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Critical Measurable Characteristics									
8.	Select all that may be potentially affected by the repair design and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight									
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity/Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances <ul style="list-style-type: none"> • Edge Distance • Requirements • Finish Dimensions Requirements g. Airfoil Profile h. Leading & Trailing Edge Contours i. Concave & Convex Contours j. Thickness k. Chord & Tip Length l. Twist/Lean/Bow									
	Critical Measurable Characteristics									
10.	Outer Band Rail Functional Fit									
11.	Inner Band Arc Length									
12.	Outer Band to Inner Band Dim Relationship									
13.	Assembled Honeycomb Inner Radius									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Repair Process Capability Technical Substantiation Requirements									
14.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
15.	Process Demonstration (including variability requirements)									
16.	Part Demonstration/Inspection									
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									
	Applicable 14 CFR Part 33 Requirements									
	Subpart A – General									
18.	33.4 Instructions for Continuous Airworthiness (ICA's)									
19.	33.5 Instruction manual for installing and operating the engine									
20.	33.7 Engine ratings and operating limitations									
21.	33.8 Selection of engine power and thrust ratings									
	Subpart B – Design and Construction; General									
22.	33.14 Start-stop cyclic stress (low cycle fatigue)									
23.	33.15 Materials									
24.	33.17 Fire prevention									
25.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)									
26.	33.21 Engine cooling									
27.	33.23 Engine mounting attachments and structure									
28.	33.25 Accessory attachments									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Repair Process Capability Technical Substantiation Requirements									
	Subpart B – Design and Construction; General									
29.	33.27 Turbine, compressor, fan, and turbosupercharger									
30.	33.28 Electrical and electronic control systems									
31.	33.29 Instrument connection									
	Subpart E – Design and Construction; Turbine Aircraft Engines									
32.	33.62 Stress analysis									
33.	33.63 Vibration									
34.	33.65 Surge and stall characteristics (Note 2)									
35.	33.66 Bleed air system									
36.	33.67 Fuel system									
37.	33.68 Induction system icing (operability aspects) (Note 2)									
38.	33.69 Ignitions system									
39.	33.71 Lubrication system									
40.	33.72 Hydraulic actuating systems									
41.	33.73 Power or thrust response									
42.	33.74 Continued rotation									
43.	33.75 Safety analysis									
44.	33.76 Bird ingestion (operability aspects of ingestion)									
45.	33.77 Foreign object ingestion (operability aspects of ingestion)									
46.	33.78 Rain and hail ingestion									
47.	33.79 Fuel burning thrust augmentor									
	Subpart F – Block Tests; Turbine Aircraft Engines									
48.	33.83 Vibration test									
55.	33.85 Calibration tests									
49.	33.87 Endurance test									
50.	33.88 Engine overtemperature test									
51.	33.89 Operation test (Note 2)									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
52.	33.90 Initial maintenance inspection									
53.	33.91 Engine component tests (HCF/LCF bench testing)									
54.	33.92 Rotor locking tests									
55.	33.93 Teardown inspection									
56.	33.94 Blade containment and rotor unbalance tests (weight changes)									
57.	33.95 Engine-propeller system tests									
58.	33.96 Engine tests in auxiliary power unit (APU) mode									
59.	33.97 Thrust reversers									
60.	33.99 General conduct of block tests									
	Part 33 -Appendix A – Instructions for Continued Airworthiness									
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail									
	Part 34 – Exhaust Emissions									

Template 10

**REPAIR SUBSTANTIATION CHECKLIST –LOW PRESSURE COMPRESSOR (LPC)
– HIGH PRESSER COMPRESSOR (HPC) STATOR PART FAMILY – FIXED VANE
TYPE STATORS (CANTILEVERED AT O.D.)**

Categories of LPC-HPC Stator Repair. Determine which repair description best fits the repair proposal based. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Dimensional Restoration by Coating or Plating
2.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair excludes detail part replacement
3.	Blend Repair
4.	Surface Treatment Repair <ul style="list-style-type: none"> • This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 				

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 				

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 				
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (interface contamination) l. Hydrogen Embrittlement (plating) m. Compatibility with Base Material/Other Coatings 				

Req No.	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 				
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 				

Req No.	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.				
8.	Select all that may be potentially affected by the repair design and evaluate system effect(s): <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 				
Critical Measurable Characteristics					
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects: <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance requirements • Finish dimensions requirements Airfoil Profile <ul style="list-style-type: none"> • Leading & Trailing Edge Contours • Concave & Convex Contours • Thickness • Chord & Tip Length Twist/Lean/Bow 				

		CATEGORIES OF REPAIR			
		1	2	3	4
	Repair Properties & Requirement to be Identified and Substantiated.				
	Critical Measurable Characteristics				
10.	Outer Band Rail Functional Fit				
11.	Inner Band Arc Length				
12.	Outer Band to Inner Band Dim Relationship				
13.	Assembled Honeycomb Inner Radius				
	Repair Process Capability Technical Substantiation Requirements				
14.	Technical Plan with Significant Operations Identified				
15.	Process Demonstration (including variability requirements)				
16.	Part Demonstration/Inspection				
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:				
	<ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 				

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
	Applicable 14 CFR Part 33 Requirements				
	Subpart A – General				
18.	33.4 Instructions for Continuous Airworthiness (ICA's)				
19.	33.5 Instruction manual for installing and operating the engine				
20.	33.7 Engine ratings and operating limitations				
21.	33.8 Selection of engine power and thrust ratings				
	Subpart B – Design and Construction; General				
22.	33.14 Start-stop cyclic stress (low cycle fatigue)				
23.	33.15 Materials				
24.	33.17 Fire prevention				
25.	33.19 Durability(Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)				
26.	33.21 Engine cooling				
27.	33.23 Engine mounting attachments and structure				
28.	33.25 Accessory attachments				
29.	33.27 Turbine, compressor, fan, and turbosupercharger rotors				
30.	33.28 Electrical and electronic control systems				
31.	33.29 Instrument connection				
	Subpart E – Design and Construction; Turbine Aircraft Engines				
32.	33.62 Stress analysis				
33.	33.63 Vibration				
34.	33.65 Surge and stall characteristics (Note 2)				
35.	33.66 Bleed air system				
36.	33.67 Fuel system				
37.	33.68 Induction system icing (operability aspects) (Note 2)				
38.	33.69 Ignitions system				
39.	33.71 Lubrication system				
40.	33.72 Hydraulic actuating systems				
41.	33.73 Power or thrust response				

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
	Subpart E – Design and Construction; Turbine Aircraft Engines (continued)				
42.	33.74 Continued rotation				
43.	33.75 Safety analysis				
44.	33.76 Bird ingestion (operability aspects of ingestion)				
45.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)				
46.	33.78 Rain and hail ingestion				
47.	33.79 Fuel burning thrust augmentor				
	Subpart F – Block Tests; Turbine Aircraft Engines				
48.	33.83 Vibration tests				
49.	33.85 Calibration tests				
50.	33.87 Endurance tests				
51.	33.88 Engine overtemperature test				
52.	33.89 Operation test (Note 2)				
53.	33.90 Initial maintenance inspection				
54.	33.91 Engine component tests (HCF/LCF bench testing)				
55.	33.92 Rotor locking tests				
56.	33.93 Teardown inspection				
57.	33.94 Blade containment and rotor unbalance tests (Weight changes)				
58.	33.95 Engine-propeller system tests				
59.	33.96 Engine tests in auxiliary power unit (APU) mode				
60.	33.97 Thrust reversers				
61.	33.99 General conduct of block tests				
	Part 33 -Appendix A – Instructions for Continued Airworthiness				
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail				
	Part 34 – Exhaust Emissions				

Template 11

REPAIR SUBSTANTIATION CHECKLIST -- MAJOR ENGINE CASES

Categories of Major Cases Part Family. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair includes detail part replacement
2.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair excludes detail part replacement
3.	Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> • This repair includes dent repair
4.	Dimensional Restoration by Coating or Plating
5.	Restoration of Adhesives, Bonding Agents, Potting Compound.
6.	Bushing or Helicoil Repair
7.	Restoration of Protective Coating <ul style="list-style-type: none"> • Includes touch-up coating
8.	Assembly and/or Disassembly <ul style="list-style-type: none"> • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without the use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted.
9.	Remove and Restore Anti-gallant
10.	Blend Repair

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 										

Req. No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
2.	Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:										
	<p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 										

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
3.	Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.										
4	Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface Contamination) l. Hydrogen Embrittlement (plating) m. Compatibility With Base Material/Other Coatings										
5.	Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing										

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 										

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.										
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s):										
	Critical Measurable Characteristics										
9.	Hole dimensions and location characteristics										
10.	Flange & Case Wall thickness & configuration										
11.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance requirements • Finish dimensions requirements 										
	Repair Process Capability Technical Substantiation Requirements										
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification										
13.	Process Demonstration (including variability requirements)										

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
14.	Part Demonstration/Inspection										
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:										
	<ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 										
	Applicable 14 CFR Part 33 Requirements										
	Subpart A – General										
16.	33.4 Instructions for Continuous Airworthiness (ICA's)										

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIRS										
			1	2	3	4	5	6	7	8	9	10
17.	33.5 Instruction manual for installing and operating the engine											
18.	33.7 Engine ratings and operating limitations											
19.	33.8 Selection of engine power and thrust ratings											
	Subpart B – Design and Construction; General											
20.	33.14 Start-stop cyclic stress (low cycle fatigue)											
21.	33.15 Materials											
22.	33.17 Fire prevention											
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)											
24.	33.21 Engine cooling											
25.	33.23 Engine mounting attachments and structure											
26.	33.25 Accessory attachments											
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors											
28.	33.28 Electrical and electronic control systems											
29.	33.29 Instrument connection											
	Subpart E – Design and Construction; Turbine Aircraft Engines											
30.	33.62 Stress analysis											
31.	33.63 Vibration											
32.	33.65 Surge and stall characteristics (Note 2)											
33.	33.66 Bleed air system											
34.	33.67 Fuel system											
35.	33.68 Induction system icing (operability aspects) (Note 2)											
36.	33.69 Ignitions system											
37.	33.71 Lubrication system											
38.	33.72 Hydraulic actuating systems											
39.	33.73 Power or thrust response											
40.	33.74 Continued rotation											

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
	Subpart F – Block Tests; Turbine Aircraft Engines										
41.	33.75 Safety analysis										
42.	33.76 Bird ingestion (operability aspects of ingestion)										
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)										
44.	33.78 Rain and hail ingestion										
45	33.79 Fuel burning thrust augmentor										
	Subpart F – Block Tests; Turbine Aircraft Engines										
46.	33.83 Vibration test										
47.	33.85 Calibration tests										
48.	33.87 Endurance test										
49.	33.88 Engine overtemperature test										
50.	33.89 Operation test (Note 2)										
51.	33.90 Initial maintenance inspection										
52.	33.91 Engine component tests (HCF/LCF bench testing)										
53.	33.92 Rotor locking tests										
54.	33.93 Teardown inspection										
55.	33.94 Blade containment and rotor unbalance tests (weight changes)										
56.	33.95 Engine-propeller system tests										
57.	33.96 Engine tests in auxiliary power unit (APU) mode										
58.	33.97 Thrust reversers										
59.	33.99 General conduct of block tests										
	Part 33 -Appendix A – Instructions for Continued Airworthiness										
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail										
	Part 34 – Exhaust Emissions										

Template 12**REPAIR SUBSTANTIATION CHECKLIST - MAJOR ROTATING (NON-LIFE LIMITED) PART FAMILY (EXCLUDING TURBINE SHAFT COUPLING PART FAMILY)**

Categories of Major Rotating (Non-Life Limited) Part Repairs. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Restoration of Protective Coating (Paint, Aluminizing, Oil, etc.) • Includes touch-up coating
2.	Weld or Braze Repair • This repair excludes detail part replacement
3.	Assembly and/or Disassembly • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
4.	Blend Repair
5.	Remove and Restore Anti-gallant
6.	Dimensional Restoration by Coating or Plating
7.	Bushing/Helicoil Repair
8.	Honing Repair
9.	Machining Repair • This repair includes lapping, skim cut, non-conventional machining

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, dwell time) d. Creep e. Tensile Properties (yield, strength, elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 									
4.	<p>Coating & Plating Material Properties Characteristics & Processes:</p> <ul style="list-style-type: none"> a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (interface contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (plating) p. Compatibility with Base Material 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 									
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 									
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
8.	<p>Select all that may be potentially affected by the repair design, and evaluate system effect(s):</p> <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 									
Critical Measurable Characteristics										
9.	<p>Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s):</p> <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat g. Distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements 									
10.	Coating Coverage Definition									
11.	Blend Area Proximity Limits Defined									
12.	No Grit Blast/Coating in Fillet Radii									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Repair Process Capability Technical Substantiation Requirements									
13.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
14.	Process Demonstration (including variability requirements)									
15.	Part Demonstration/Inspection									
16.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									
	Applicable 14 CFR Part 33 Requirements									
	Subpart A – General									
17.	33.4 Instructions for Continuous Airworthiness (ICA's)									
18.	33.5 Instruction manual for installing and operating the engine									
19.	33.7 Engine ratings and operating limitations									
20.	33.8 Selection of engine power and thrust ratings									
	Subpart B – Design and Construction; General									
21.	33.14 Start-stop cyclic stress (low cycle fatigue)									
22.	33.15 Materials									
23.	33.17 Fire prevention									
24.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)									
25.	33.21 Engine cooling									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Subpart B – Design and Construction; General									
26.	33.23 Engine mounting attachments and structure									
27.	33.25 Accessory attachments									
28.	33.27 Turbine, compressor, fan, and turbo-supercharger									
29.	33.28 Electrical and electronic control systems									
30.	33.29 Instrument connection									
	Subpart E – Design and Construction; Turbine Aircraft Engines									
31.	33.62 Stress analysis									
32.	33.63 Vibration									
33.	33.65 Surge and stall characteristics (Note 2)									
34.	33.66 Bleed air system									
35.	33.67 Fuel system									
36.	33.68 Induction system icing (operability aspects) (Note 2)									
37.	33.69 Ignitions system									
38.	33.71 Lubrication system									
39.	33.72 Hydraulic actuating systems									
40.	33.73 Power or thrust response									
41.	33.74 Continued rotation									
42.	33.75 Safety analysis									
43.	33.76 Bird ingestion (operability aspects of ingestion)									
44.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)									
45.	33.78 Rain and hail ingestion									
46.	33.79 Fuel burning thrust augmentor									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Subpart F – Block Tests; Turbine Aircraft Engines									
47.	33.83 Vibration test									
48.	33.85 Calibration tests									
49.	33.87 Endurance test									
50.	33.88 Engine overtemperature test									
51.	33.89 Operation test (Note 2)									
52.	33.90 Initial maintenance inspection									
53.	33.91 Engine component tests (HCF/LCF bench testing)									
54.	33.92 Rotor locking tests									
55.	33.93 Teardown inspection									
56.	33.94 Blade containment and rotor unbalance tests (weight changes)									
57.	33.95 Engine-propeller system tests									
58.	33.96 Engine tests in auxiliary power unit (APU) mode									
59.	33.97 Thrust reversers									
60.	33.99 General conduct of block tests									
	Part 33 -Appendix A – Instructions for Continued Airworthiness									
	Part 33 -Appendix B -- Certification Standard Atmospheric Concentrations of Rain and Hail									
	Part 34 – Exhaust Emissions									

Template 13**REPAIR SUBSTANTIATION CHECKLIST – HIGH PRESSURE COMPRESSOR (HPC)/HIGH PRESSURE TURBINE (HPT)/LOW PRESSURE TURBINE (LPT) AIRSEALS (NON-ROTATING) AND SHROUDS (STATIONARY) PART FAMILY**

Categories of HPC/HPT/LPT Airseals (non-rotating) and Shrouds (stationary) Part Family Repair. Determine which repair description best fit the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Assembly and/or Disassembly <ul style="list-style-type: none"> • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
2.	Blend Repair
3.	Strip and Re-coat Repair <ul style="list-style-type: none"> • This repair removes and replaces any and all types of coatings
4.	Dimensional Restoration by Coating or Plating
5.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair excludes detail part replacement
6.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair includes part detail replacement
7.	Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> • This repair includes dent repair
8.	Machining Repair <ul style="list-style-type: none"> • This repair includes lapping, skim cut, non-conventional machining

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, dwell time) d. Creep e. Tensile Properties (yield, strength, elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze, should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 								
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (interface contamination) l. Hydrogen Embrittlement (plating) m. Compatibility with Base Material/Other Coatings 								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 								
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_I) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 								
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>								
8.	<p>Select all that may be potentially affected by the repair design and evaluate system effect(s):</p> <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Critical Measurable Characteristics									
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> 1) Roundness 2) Flatness 3) Parallelism 4) Concentricity 5) True Position Tolerances 6) Edge Distance 7) Requirements 8) Finish Dimensions Requirements 									
	Critical Measurable Characteristics									
10.	Coating Coverage Definition: <ul style="list-style-type: none"> a. No Grit Blast b. No coating in Filet Radii 									
11.	Blend Area Proximity Limits Defined									
	Repair Process Capability Technical Substantiation Requirements									
12.	Technical Plan with Significant Operations Identified									
13.	Process Demonstration (including variability requirements)									
14.	Part Demonstration/Inspection									
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Applicable 14 CFR Part 33 Requirements								
	Subpart A – General								
16.	33.4 Instructions for Continuous Airworthiness (ICA's)								
17.	33.5 Instruction manual for installing and operating the engine								
18.	33.7 Engine ratings and operating limitations								
19.	33.8 Selection of engine power and thrust ratings								
	Applicable 14 CFR Part 33 Requirements								
	Subpart B – Design and Construction; General								
20.	33.14 Start-stop cyclic stress (low cycle fatigue)								
21.	33.15 Materials								
22.	33.17 Fire prevention								
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)								
24.	33.21 Engine cooling								
25.	33.23 Engine mounting attachments and structure								
26.	33.25 Accessory attachments								
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors								
28.	33.28 Electrical and electronic control systems								
29.	33.29 Instrument connection								
	Subpart E – Design and Construction; Turbine Aircraft Engines								
30.	33.62 Stress analysis								
31.	33.63 Vibration								
32.	33.65 Surge and stall characteristics (Note 2)								
33.	33.66 Bleed air system								
34.	33.67 Fuel system								
35.	33.68 Induction system icing (operability aspects) (Note 2)								
36.	33.69 Ignitions system								
37.	33.71 Lubrication system								
38.	33.72 Hydraulic actuating systems								
39.	33.73 Power or thrust response								
40.	33.74 Continued rotation								
41.	33.75 Safety analysis								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Subpart E – Design and Construction; Turbine Aircraft Engines								
42.	33.76 Bird ingestion (operability aspects of ingestion)								
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)								
44.	33.78 Rain and hail ingestion								
45.	33.79 Fuel burning thrust augmentor								
	Subpart F – Block Tests; Turbine Aircraft Engines								
46.	33.83 Vibration tests								
47.	33.85 Calibration tests								
48.	33.87 Endurance tests								
49.	33.88 Engine overtemperature test								
50.	33.89 Operation test (Note 2)								
51.	33.90 Initial maintenance inspection								
52.	33.91 Engine component tests (HCF/LCF bench testing)								
53.	33.92 Rotor locking tests								
54.	33.93 Teardown inspection								
55.	33.94 Blade containment and rotor unbalance tests (Weight changes)								
56.	33.95 Engine-propeller system tests								
57.	33.96 Engine tests in auxiliary power unit (APU) mode								
58.	33.97 Thrust reversers								
59.	33.99 General conduct of block tests								
	Part 33 -Appendix A – Instructions for Continued Airworthiness								
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail								
	Part 34 – Exhaust Emissions								

Template 14

**REPAIR SUBSTANTIATION CHECKLIST - STATIC STRUCTURE PART FAMILY
(Ducts, Bearing Housings, Etc.)**

Categories of Static Structure Parts Family Repairs. Determine which repair description best fits the repair proposal based. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Blend Repair
2.	Weld/Braze Repairs <ul style="list-style-type: none"> • Excludes Detail Part Replacement
3.	Weld/Braze Repairs <ul style="list-style-type: none"> • Includes Detail Part Replacement
4.	Assembly and/or Disassembly <ul style="list-style-type: none"> • This repair removes and replaces detail parts without the use of permanent attachment. Techniques, i.e., welded or brazed, assembly is either bolted or riveted.
5.	Dimensional Restoration Coating or Plating
6.	Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> • This repair includes dent repair.

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 						

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (yield, strength, elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate <p><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 						

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
			1	2	3	4	5	6
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 							

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (interface contamination) l. Hydrogen Embrittlement (Plating) m. Compatibility with Base Material/Other Coatings 						
	Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements						
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 						

Req No	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_i) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 						
7.	<p>Cleaning Properties, Characteristics & Material Property Debits:</p> <ul style="list-style-type: none"> a. Chemical (solutions, etc.) b. Grit Blast (,pressure media etc.) c. Power Flush (pressure, solution time, temp, etc.) d. Ultrasonic (solution frequency, time, etc.) e. Furnace (time, temp, atmosphere, etc.) 						

Req No	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
8.	Select all that may be potentially affected by the repair design and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight						
Critical Measurable Characteristics							
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity/Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position • Tolerances • Edge Distance • Requirements • Finish Dimensions • Requirements 						
10.	Parent material thickness reduction assessment						
11.	Dimensional & Tolerance Reverse engineered parts						
Repair Process Capability Technical Substantiation Requirements							
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification						

Req No	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR						
			1	2	3	4	5	6
13.	Process Demonstration: • Including variability requirements							
14.	Part Demonstration/Inspection							
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements							
	Applicable 14 CFR Part 33 Requirements							
	Subpart A – General							
16.	33.4 Instructions for Continuous Airworthiness (ICA's)							
17.	33.5 Instruction manual for installing and operating the engine							
18.	33.7 Engine ratings and operating limitations							
19.	33.8 Selection of engine power and thrust ratings							
	Subpart B – Design and Construction; General							
20.	33.14 Start-stop cyclic stress (low cycle fatigue) (weight and CG location changes effects on disks)							
21.	33.15 Materials							
22.	33.17 Fire prevention							
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)							
24.	33.21 Engine cooling							
25.	33.23 Engine mounting attachments and structure							
26.	33.25 Accessory attachments							
27.	33.27 Turbine, compressor, fan, and turbo supercharger rotors							

Req No	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR						
			1	2	3	4	5	6
	Subpart B – Design and Construction; General; continued							
28.	33.28 Electrical and electronic control systems							
29.	33.29 Instrument Control							
	Subpart E – Design and Construction; Turbine Aircraft Engines							
30.	33.62 Stress analysis							
31.	33.63 Vibration							
32.	33.65 Surge and stall characteristics (Note 2)							
33.	33.66 Bleed air system							
34.	33.67 Fuel system							

Req No	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
	Subpart E – Design and Construction; Turbine Aircraft Engines						
35.	33.68 Induction system icing						
36.	33.69 Ignitions system						
37.	33.71 Lubrication system						
38.	33.72 Hydraulic actuating systems						
39.	33.73 Power or thrust response						
40.	33.74 Continued rotation						
41.	33.75 Safety analysis						
42.	33.76 Bird ingestion (operability aspects of ingestion)						
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)						
44.	33.78 Rain and hail ingestion						
45.	33.79 Fuel burning thrust augmentor						
	Subpart F – Block Tests; Turbine Aircraft Engines						
46.	33.83 Vibration test						
47.	33.85 Calibration tests						
48.	33.87 Endurance test(see Note 2)						
49.	33.88 Engine overtemperature test						
50.	33.89 Operation test (operability aspects)						
51.	33.90 Initial maintenance inspection						
52.	33.91 Engine component tests (HCF/LCF bench testing)						
53.	33.92 Rotor locking tests						
54.	33.93 Teardown inspection						
55.	33.94 Blade containment and rotor unbalance tests (weight changes)						
56.	33.95 Engine-propeller system tests						
57.	33.96 Engine tests in auxiliary power unit (APU) mode						
58.	33.97 Thrust reversers						
59.	33.99 General conduct of block tests						
	Part 33 — Appendix A – Instructions for Continued Airworthiness	DER					
	Part 33— Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail						
	Part 34 – Exhaust Emissions						

Template 15

**REPAIR SUBSTANTIATION CHECKLIST – LOW PRESSURE COMPRESSOR (LPC)
– HIGH PRESSURE COMPRESSOR (HPC) STATOR PART FAMILY – VARIABLE
VANE TYPE STATORS**

Categories of LPC-HPC Stator Repair. Determine which repair description best fits the repair proposal based. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Weld or Braze Repair <ul style="list-style-type: none"> • This repair excludes detail part replacement
2.	Blend Repair
3.	Dimensional Restoration by Coating or Plating
4.	Surface Treatment Repair <ul style="list-style-type: none"> • This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High-cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 				

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p style="text-align: center;"><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p style="text-align: center;"><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p style="text-align: center;"><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 				

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 				
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (interface contamination) l. Hydrogen Embrittlement (plating) m. Compatibility with Base Material/Other Coatings 				
5.	<p>Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 				

Req No.	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 				

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.				
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 				
Critical Measurable Characteristics					
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • roundness • flatness • parallelism • concentricity • true position tolerances • edge distance • requirements • finish dimensions requirements g. Airfoil profile <ul style="list-style-type: none"> • leading & trailing edge contours • concave & convex contours • thickness • chord & tip length • twist/lean/bow 				
Critical Measurable Characteristics					
10.	Spindle (Trunnion) Diameter				
11.	Outer Spindle (Trunnion) to Lever Seating Flat				
12.	Outer Spindle (Trunnion) to Inner Spindle (Trunnion)				
13.	Outer Spindle (Trunnion) to Inner Spindle (Trunnion) Concentricity				

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR			
		1	2	3	4
	Repair Process Capability Technical Substantiation Requirements				
14.	Technical Plan with Significant Operations Identified				
15.	Process Demonstration (including variability requirements)				
16.	Part Demonstration/Inspection				
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 				
	Applicable 14 CFR Part 33 Requirements				
	Subpart A – General				
18.	33.4 Instructions for Continuous Airworthiness (ICA's)				
19.	33.5 Instruction manual for installing and operating the engine				
20.	33.7 Engine ratings and operating limitations				
21.	33.8 Selection of engine power and thrust ratings				
	Subpart B – Design and Construction; General				
22.	33.14 Start-stop cyclic stress (low cycle fatigue)				
23.	33.15 Materials				
24.	33.17 Fire prevention				
25.	33.19 Durability(Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)				
26.	33.21 Engine cooling				
27.	33.23 Engine mounting attachments and structure				
28.	33.25 Accessory attachments				
29.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors				
30.	33.28 Electrical and electronic control systems				
31.	33.29 Instrument connection				
	Subpart E – Design and Construction; Turbine Aircraft Engines				
32.	33.62 Stress Analysis				
33.	33.63 Vibration				

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
	Subpart E – Design and Construction; Turbine Aircraft Engines				
34.	33.65 Surge and stall characteristics (Note 2)				
35.	33.66 Bleed air system				
36.	33.67 Fuel system				
37.	33.68 Induction system icing (operability aspects) (Note 2)				
38.	33.69 Ignitions system				
39.	33.71 Lubrication system				
40.	33.72 Hydraulic actuating systems				
41.	33.73 Power or thrust response				
42.	33.74 Continued rotation				
43.	33.75 Safety analysis				
44.	33.76 Bird ingestion (operability aspects of ingestion)				
45.	33.77 Foreign object ingestion (operability aspects of ingestion)				
46.	33.78 Rain and hail ingestion				
47.	33.79 Fuel burning thrust augmentor				
	Subpart F – Block Tests; Turbine Aircraft Engines				
48.	33.83 Vibration test				
49.	33.85 Calibration tests				
50.	33.87 Endurance test				
51.	33.88 Engine overtemperature test				
52.	33.89 Operation test (Note 2)				
53.	33.90 Initial maintenance inspection				
54.	33.91 Engine component tests (HCF/LCF bench testing)				

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR			
		1	2	3	4
	Subpart F – Block Tests; Turbine Aircraft Engines				
55.	33.92 Rotor locking tests				
56.	33.93 Teardown inspection				
57.	33.94 Blade containment and rotor unbalance tests (weight changes)				
58.	33.95 Engine-propeller system tests				
59.	33.96 Engine tests in auxiliary power unit (APU) mode				
60.	33.97 Thrust reversers				
61.	33.99 General conduct of block tests				
	Part33 -Appendix A – Instructions for Continued Airworthiness				
	Part 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail				
	Part 34 – Exhaust Emissions				

Template 16**REPAIR SUBSTANTIATION CHECKLIST - HPT VANE PART FAMILY**

Categories of HPT Vane Repair. Determine which repair description best fits the repair proposal. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Strip and Re-coat Repair <ul style="list-style-type: none"> • This repair removes and replaces any and all types of coatings.
2.	Weld or Braze Repair (excludes detail parts replacement) <ul style="list-style-type: none"> • Includes restoration of airfoil tip and chord length
3.	Weld or Braze Repair <ul style="list-style-type: none"> • Includes detail parts replacement
4.	Assembly and/or disassembly <ul style="list-style-type: none"> • This repair removes and replaces details parts without the use of permanent attachment techniques (i.e., welding or brazing) but assembly is either bolted or riveted.
5.	Blend Repair
6.	Dimensional Restoration by Coating or Plating
7.	Straightening, Re-twist or Reforming Repair

		CATEGORIES OF REPAIR							
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.		1	2	3	4	5	6	7
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 								

		CATEGORIES OF REPAIR						
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p style="text-align: center;"><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p style="text-align: center;"><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate <p style="text-align: center;"><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 							

		CATEGORIES OF REPAIR							
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.		1	2	3	4	5	6	7
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 								
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (interface contamination) l. Hydrogen Embrittlement (plating) m. Compatibility with Base Material/Other Coatings 								

		CATEGORIES OF REPAIR						
Req No,	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 							

Req No.	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 							
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>							
8.	<p>Select all that may be potentially affected by the repair design, and evaluate system effect(s):</p> <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 							

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
	Critical Measurable Characteristics							
9.	Dimension of sealing features (leakage, secondary circuits)							
10.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen intensity/coverage c. Bearing bore dimensions and location characteristics d. Pressure strength test e. Flow capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance • Requirements • Finish dimensions • Requirements g. Airfoils Profile <ul style="list-style-type: none"> • Leading & trailing edge contour • Concave & convex contours • Thickness • Chord & airfoil length • Twist/lean/bow h. Tip length i. Airfoil wall thickness j. Throat area 							
11.	Cooling (Total flow, flow split, back flow margin, hole exit geometry, allowable plugged holes)							
	Repair Process Capability Technical Substantiation Requirements							
12.	Technical Plan with Significant Operations Identified							
13.	Process Demonstration (including variability requirements)							

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
	Repair Process Capability Technical Substantiation Requirements							
14.	Part Demonstration/Inspection							
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 							
	Applicable 14 CFR Part 33 Requirements							
	Subpart A – General							
16.	33.4 Instructions for Continuous Airworthiness (ICA's)							
17.	33.5 Instruction manual for installing and operating the engine							
18.	33.7 Engine ratings and operating limitations							
19.	33.8 Selection of engine power and thrust ratings							
	Subpart B – Design and Construction; General							
20.	33.14 Start-stop cyclic stress (low cycle fatigue)							
21.	33.15 Materials							
22.	33.17 Fire prevention							
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)							
24.	33.21 Engine cooling							
25.	33.23 Engine mounting attachments and structure							
26.	33.25 Accessory attachments							
	Subpart B – Design and Construction; General							
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors							
28.	33.28 Electrical and electronic control systems							
29.	33.29 Instrument connection							
	Subpart E – Design and construction; Turbine aircraft Engines							
30.	33.62 Stress Analysis							
31.	33.63 Vibration							

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
32.	33.65 Surge and stall characteristics (Note 2)								
33.	33.66 Bleed air system								
34.	33.67 Fuel system								
35.	33.68 Induction system icing (operability aspects) (Note 2)								
36.	33.69 Ignitions system								
37.	33.71 Lubrication system								
38.	33.72 Hydraulic actuating systems								
39.	33.73 Power or thrust response								
40.	33.74 Continued rotation								
41.	33.75 Safety analysis								
42.	33.76 Bird ingestion (operability aspects of ingestion)								
43.	33.77 Foreign object ingestion (operability aspects of ingestion)								
44.	33.78 Rain and hail ingestion								
45.	33.79 Fuel burning thrust augmentor								
	Subpart F – Block Tests; Turbine Aircraft Engines								
46.	33.83 Vibration test								
47.	33.85 Calibration tests								
48.	33.87 Endurance test								
49.	33.88 Engine overtemperature test								
50.	33.89 Operation test (Note 2)								
51.	33.90 Initial maintenance inspection								
52.	33.91 Engine component tests (HCF/LCF bench testing)								
53.	33.92 Rotor locking tests								
54.	33.93 Teardown inspection								
55.	33.94 Blade containment and rotor unbalance tests (weight changes)								
56.	33.95 Engine-propeller system tests								
57.	33.96 Engine tests in auxiliary power unit (APU) mode								
58.	33.97 Thrust reversers								
59.	33.99 General conduct of block tests								
	Part 33 -Appendix A – Instructions for Continued Airworthiness								
	Part 33 -Appendix B – Certification Standard Atmospheric Concentrations of Rain and Hail								
	Part 34 – Exhaust Emissions								

Template 17**REPAIR SUBSTANTIATION CHECKLIST - LOW PRESSURE TURBINE (LPT) VANE
PART FAMILY**

Categories of LPT Vane Part Family Repair. Determine which repair description best fit the repair proposal based. If no repair description is appropriate, contact the FAA Advisor for guidance.

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Strip and Re-coat Repair <ul style="list-style-type: none"> • This repair removes and replaces any and all types of coatings
2.	Overcoat Repair (without stripping)
3.	Weld or Braze Repair (excludes detail part replacement) <ul style="list-style-type: none"> • Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair <ul style="list-style-type: none"> • Includes detail part replacement
5.	Disassembly and/or Assembly <ul style="list-style-type: none"> • This repair removes and replaces detail parts without the use of permanent attachment (i.e.; welding or brazing) but assembly is either bolted or riveted.
6.	Blend Repair
7.	Dimensional Restoration Repair (by coating of plating)
8.	Straightening, Re-twist, or Reforming Repair

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-mechanical fatigue b. Oxidation c. Corrosion d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients) e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation f. High cycle fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc. 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
2.	<p>Select all mechanical, metallurgical, and physical properties of the part affected by the repair design, and assess their impact on the part's airworthiness:</p> <p style="padding-left: 40px;"><u>Mechanical Properties:</u></p> <ul style="list-style-type: none"> a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies <p style="padding-left: 40px;"><u>Metallurgical Properties:</u></p> <ul style="list-style-type: none"> i. Chemical Composition (alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate <p style="padding-left: 40px;"><u>Physical Properties:</u></p> <ul style="list-style-type: none"> p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 								

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	
3.	<p>Select all Material Properties/Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy as a result of welds or braze should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 									

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
4.	<p>Select all Coating Properties/Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements/Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface Contamination) l. Hydrogen Embrittlement (plating) m. Compatibility with Base Material/Other Coatings 								
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 								

Req No.	Repair Properties & Requirement to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
6.	<p>Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"> a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (chemical, power flash, ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 								
7.	<p>Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>								
8.	<p>Select all that may be potentially affected by the repair design and evaluate system effect(s):</p> <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Critical Measurable Characteristics									
9.	Cooling (Total flow, flow split, back flow margin, hole exit geometry/angle/location, cross over hole size, metering plate)									
10.	Dimension of sealing features (leakage, secondary circuits)									
11.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen Intensity/Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position • Tolerances • Edge Distance • Requirements • Finish Dimensions • Requirements g. Airfoils Profile <ul style="list-style-type: none"> • Leading and Trailing Edge Contour • Concave and convex contours • Thickness • Chord and Airfoil Length • Twist/Lean/Bow h. Tip Length i. Airfoil wall thickness j. Throat Area 									
	Repair Process Capability Technical Substantiation Requirements									
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
13.	Process Demonstration (including variability requirements)									
14.	Part Demonstration/Inspection									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Repair Process Capability Technical Substantiation Requirements								
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 								
	Applicable 14 CFR Part 33 Requirements								
	Subpart A – General								
16.	33.4 Instructions for Continuous Airworthiness (ICA's)								
17.	33.5 Instruction manual for installing and operating the engine								
18.	33.7 Engine ratings and operating limitations								
19.	33.8 Selection of engine power and thrust ratings								
	Subpart B – Design and Construction; General								
20.	33.14 Start-stop cyclic stress (low cycle fatigue)								
21.	33.15 Materials								
22.	33.17 Fire prevention								
23.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)								
24.	33.21 Engine cooling								
25.	33.23 Engine mounting attachments and structure								
26.	33.25 Accessory attachments								

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Subpart B – Design and Construction; General									
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
28.	33.28 Electrical and electronic control systems									
29.	33.29 Instrument connection									
	Subpart E – Design and construction; Turbine Aircraft Engines									
30.	33.62 Stress analysis									
31.	33.63 Vibration									
32.	33.65 Surge and stall characteristics (Note 2)									
33.	33.66 Bleed air systems									
34.	33.67 Fuel system									
35.	33.68 Induction system icing (operability aspects) (Note 2)									
36.	33.69 Ignitions system									
37.	33.71 Lubrication system									
38.	33.72 Hydraulic actuating systems									
39.	33.73 Power or thrust response									
40.	33.74 Continued rotation									
41.	33.75 Safety analysis									
42.	33.76 Bird ingestion (operability aspects of ingestion)									
43.	33.77 Foreign object ingestion—ice (operability aspects of ingestion)									
44.	33.78 Rain and hail ingestion									
45.	33.79 Fuel burning thrust augmentor									

Req No.	Repair Properties and Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Subpart F – Block Tests; Turbine Aircraft Engines								
46.	33.83 Vibration test								
47.	33.85 Calibration tests								
48.	33.87 Endurance test								
49.	33.88 Engine overtemperature test								
50.	33.89 Operation test (Note 2)								
51.	33.90 Initial maintenance inspection								
52.	33.91 Engine component tests (HCF/LCF bench testing)								
53.	33.92 Rotor locking tests								
54.	33.93 Teardown inspection								
55.	33.94 Blade containment and rotor unbalance tests (weight changes)								
56.	33.95 Engine-propeller system tests								
57.	33.96 Engine tests in auxiliary power unit (APU) mode								
58.	33.97 Thrust reversers								
59.	33.99 General conduct of block tests								
	Part 33 - Appendix A – Instructions for Continued Airworthiness								
	Part 33 - Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail								
	Part 34 – Exhaust Emissions								