

U.S. Department of Transportation Federal Aviation Administration

Advisory Circular

Subject: Developing Data for Major Repairs of Turbine Engine Parts

Date: 4/30/10 Initiated by: ANE-110 AC No: 33-9

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. <u>Part Categories</u>. 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. <u>Tables of Potential Failure Effects</u>. 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.

Potential Failure Effects	Part Examples
(1) Non-containment of high- energy debris.	Life-limited parts
(2) Concentration of toxic	Main engine mounts, with no redundant load carrying features
products in the engine bleed air intended for the cabin, and sufficient to incapacitate crew or passengers.	High pressure vessels (for example, casings subject to compressor discharge pressure and combustor pressure)
(3) Significant thrust in the	Containment structures
opposite direction to that commanded by the pilot.	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
(7) Complete inability to shut the engine down.	type certificate.

Table 1. Category 1 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 Spinners
 (4) Vibration levels that result in crew discomfort. (5) Concentration of toxic products in the engine bleed air for the cabin sufficient to degrade crew 	Main engine mounts with redundant load carrying features
performance.(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) Control system actuators
(7) 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.	

Table 2. Category 2 Engine Parts

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) <u>Category 1 parts</u>. 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) <u>Category 2 parts.</u> 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. <u>COS Management Plan</u>. 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. <u>Part Identification</u>. 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. <u>Maintaining Records</u>. 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.

John A. White cor

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:

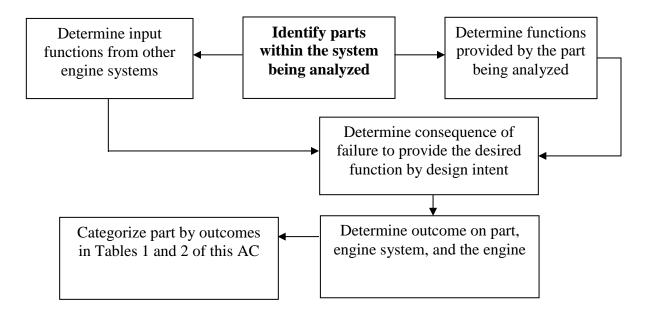


Figure A1.1. Process Flow Diagram

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.

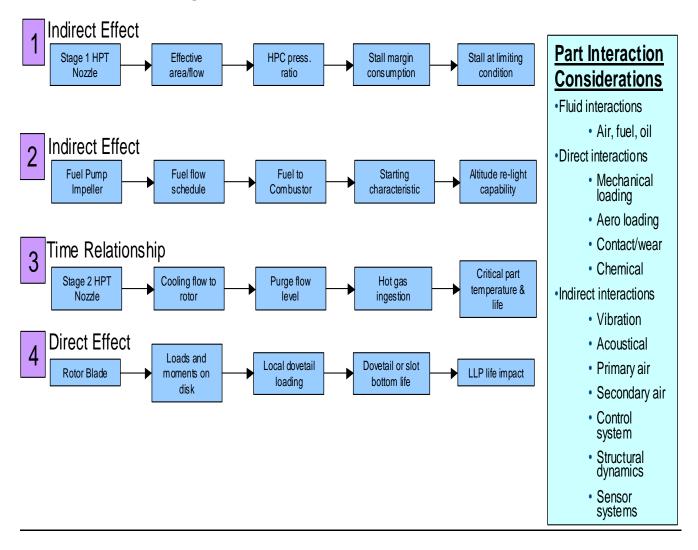


Figure A1.2. Part Interaction Considerations

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.

Template Number	Title	Page
1	Bearing Compartment and Carbon Seal	15
	Parts Family	
2	High Pressure Turbine (HPT) Blade	25
	Part Family	
3	Low Pressure Compressor (LPC) –	36
	High Pressure Compressor (HPC) Blade	
	Part Family	
4	Blades – Low Pressure Turbine (LPT)	46
5	Combustor Part Family	55
6	Externals Part Family (Tubes,	66
	Manifolds, Ducts, Brackets)	
7	Fuel Nozzle Part Family	75
8	Gearbox Housing Assembly Part	84
	Family (Shafts, Gears, Housings)	0.1
9	Low Pressure Compressor (LPC) –	94
	High Pressure Compressor (HPC)	
	Stator Part Family – Vane Sector (And	
10	Full Ring) Type Stators	102
10	Low Pressure Compressor (LPC) – High Pressor Compressor (LPC) Stater	103
	High Presser Compressor (HPC) Stator Part Family – Fixed Vane Type Stators	
11	Major Engine Cases	112
11 12	Major Rotating (Non-Life Limited) Part	12
12	Family (Excluding Turbine Shaft	121
	Coupling Part Family)	
13	High Pressure Compressor	130
15	(HPC)/High Pressure Turbine	150
	(HPT)/Low Pressure Turbine (LPT)	
	Airseals (Non-Rotating) And Shrouds	
	(Stationary) Part Family	
14	Static Structure Part Family (ducts,	138
	bearing housings, etc.)	
15	Low Pressure Compressor (LPC) –	148
	High Pressure Compressor (HPC)	
	Stator Part Family – Variable Vane	
	Type Stators	
16	HPT Vane Part Family	157

 Table A2-1.
 Sample Templates.

17	Low Pressure Turbine (LPT) Vane Part	166
	Family	

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	REPAIR DESCRIPTION
REPAIRS	
1.	Restoration of Protective Coating
	This repair includes touch-up coating
2.	Weld or Braze Repair
	This repair excludes detail part replacement
3.	Weld or Braze Repair
	This repair includes detail part replacement
4.	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.
5.	Blend Repair
б.	Dimensional Restoration by Coating or Plating
7.	Bushing/Helicoil Repair
8.	Straightening, Re-twist, or Reforming Repair
	This repair includes straightening of bent knife edges
9.	Surface Treatment Repair
	• This repair includes peening, vibratory tumble (e.g.; restoration of surface
	finish/texture)
10.	Machining Repair
	• 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.

		CATEGORIES OF REPAIR										
Req No.	Repair Design Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9	10	11
1.	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.											
	 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. 		1	1		1	1	1	1	I		

			CATEGORIES OF REPAIR											
Req No.	Repair Design Requirements to b Identified and Substantiated.	e 1	2	3	4	5	6	7	8	9	10	11		
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:													
	Mechanical Properties:													
	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 Modulush. Natural Frequencies													
	n. Natural Frequencies													
	Metallurgical Properties:													
	i. Chemical Composition													
	(Alloy constituents)													
	j. Microstructure (grain size	_												
	shape - boundary													
	precipitates, gamma prime													
	size and volume fraction,													
	etc.)													
	k. Melting Pointl. Corrosion Resistance													
	m. Oxidation Resistance													
	n. Wear Resistance (Conside	r												
	wear types in (1)(e))	L												
	o. Crack Propagation Rate													
	Physical Properties:													
	p. Density (weight)													
	q. Coefficient of Thermal													
	Expansion													
	r. Refractive Index (X-Rays)													
	s. Center of Gravity													
	t. Polar Moment of Inertia													

					CATI	EGOF	RIES	OF R	EPAI	R		
Req No.	Repair Design Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9	10	11
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.											
	 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	Repair Design Requirements to be	1	2	3	4	5	6	7	8	9	10	11		
No.	Identified and Substantiated.													
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.													
	evaluated for all worthiness.													
	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)													
	1. 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	1												
	airworthiness:													
	a. Burnishing													
	b. Peening													
	c. Butterfly Polish													
	d. Mass Media Finishing													

		CATEGORIES OF REPAIR										
Req	Repair Design Requirements to be	1	2	3	4	5	6	7	8	9	10	11
No.	Identified and Substantiated.											
6.	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.											
	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											
	1.Stress Intensity Factor (Kt)											
	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.	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. Secondemy Airflow 												
	c. Secondary Airflowd. Aerodynamicse. Weightf. Center of Gravity												
	g. Moment of Weight									1	1		
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): Surface finish/texture Shotnoor Interview/Conserved 												
	 Shotpeen Intensity/Coverage Bearing bore dimensions and location characteristics 												
	 Pressure Strength Test Flow Capacity test Dimensions, including heat 												
	distortion effects 1) Roundness												
	2) Flatness3) Parallelism4) Concentricity												
	5) True Position Tolerances6) Edge Distance Requirements7) Finish Dimensions												
10.	RequirementsSignificant Operations Identified for Validation that would include parameter variability limits.												

		CATEGORIES OF REPAIR											
Req	Repair Design Requirements to be	1	1 2 3 4 5 6 7 8 9 10 11										
No.	Identified and Substantiated.												
11.	Manufacturing requirements for												
	fabrication of repair details or												
	replacement sections used to												
	accomplish repair:												
	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												
16.	Construction; General												
10.	33.14 Start-stop cyclic stress (low cycle fatigue)												
17.	33.15 Materials												
17.	33.17 Fire prevention		-					-					
10.	33.19 Durability (Note that 33.19 is		-						<u> </u>				
19.	associated with 33.27; 33.63; 33.83;		1										
	33.87; 33.88; and 33.90)		1		1								

		CATEGORIES OF REPAIR be 1 2 3 4 5 6 7 8 9 10 11										
Req No.	Repair Design Requirements to be Identified and Substantiated.	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											

		CATEGORIES OF REPAIR										
Req No.	Airworthiness Standards to be Substantiated	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											
10	(operability aspects of ingestion)											
40.	33.78 Rain and hail ingestion											
41.	33.79 Fuel burning thrust augmentor											<u> </u>
	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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Overcoat Repair (without stripping)
2.	Strip and Re-coat Repair
	This repair removes and replaces all types of coatings.
3.	Weld or Braze Repair (excludes detail parts replacement)
	Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair
	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.

				CATE	EGOR	IES (OF RF	EPAIR	Ł	
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.	 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. 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:									

				CATI	EGOR	RIES (OF RE	PAIR			
Req No.	Identifi Proper	Design Requirements to be ied and Substantiated. Repair ties and Requirements to be ied and Substantiated.	1	2	3	4	5	6	7	8	9
		Mechanical Properties:									
	a.	Stress-Strain									
	b.	Fracture Toughness									
	с.	Fatigue Strength (S-N, Goodman,									
		Dwell Time)									
	d.	Creep									
	e.	Tensile Properties (Yield,									
		Strength, Elongation)									
	f.	Hardness									
	g.	Young's Modulus									
	h.	Natural Frequencies									
		Metallurgical Properties:									
	i.	Chemical Composition (Alloy									
		constituents)									
	j.	Microstructure (grain size – shape									
		- boundary precipitates, gamma									
		prime size and volume fraction,									
		etc.)									
	k.	Melting Point Corrosion Resistance									
	1.	Oxidation Resistance									
		Wear Resistance (consider wear									
	n.	types in (1)(e))									
	о.	Crack Propagation Rate									
		Physical Properties:									
		Density (weight)									
	p.	Coefficient of Thermal Expansion									
	q. r.	Refractive Index (X-Rays)									
	1. S.	Center of Gravity									
	s. t.	Polar Moment of Inertia									

				CATI	EGOR	RIES (OF RE	EPAIR	2	
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.	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.									
	 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) 									

				CATI	EGOR	IES ()F RE	PAIR	1	
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.	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 									

Req No. Repair Properties and Requirements to be Identified and Substantiated. 1 2 3 4 5 6 7 8 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 6. 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. a Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d straightening, 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 stress Intensity Factor (K_i) m. Heat Treatment (time, temp, atmosphere, etc.) n. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination					CATI	EGOR	IES ()F RF	EPAIR	ł	
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 6. 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. 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 Stress Intensity Factor (K,) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating Dimensional Short-falls p. Repetitive or Conflicting Repairs 			1	2	3	4	5	6	7	8	9
 a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 6. 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. 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 	5.	Select Surface Treatment that applies (Without Material Removal) and evaluate									
 b. Peening c. Butterfly Polish d. Mass Media Finishing 6. 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. 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 (K₁) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs 		effect(s), if any, on airworthiness:									
 c. Butterfly Polish d. Mass Media Finishing 6. 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. 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 											
d. Mass Media Finishing 6. 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. 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											
6. 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. 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											
function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. 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		d. Mass Media Finishing									
processes, when applicable, and assess its impact, if any, on existing ICAs. 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	6.										
 impact, if any, on existing ICAs. 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 (K₁) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs 											
 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 											
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		impact, if any, on existing ICAs.									
 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 		a. Machining, Milling, Broaching, or									
 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 											
 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 		e									
 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 											
 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 											
 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 											
 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 											
 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 		8									
 i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents 1. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs 											
 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 											
 Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents 1. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs 											
Cleaning Agents Stress Intensity Factor (K_t) Heat Treatment (time, temp, atmosphere, etc.) Plating Dimensional Short-falls Repetitive or Conflicting Repairs 											
 Stress Intensity Factor (Kt) Heat Treatment (time, temp, atmosphere, etc.) Plating Dimensional Short-falls Repetitive or Conflicting Repairs 		k. Residual Plating, Stripping, or									
 m. Heat Treatment (time, temp, atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs 											
atmosphere, etc.) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs											
n. Platingo. Dimensional Short-fallsp. Repetitive or Conflicting Repairs											
o. Dimensional Short-fallsp. Repetitive or Conflicting Repairs											
p. Repetitive or Conflicting Repairs											
q. Contamination											
		q. Contamination									

				CATI	EGOR	RIES (OF RE	PAIR	2	
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 									

		CATEGORIES OF REPAIRs to12345678										
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9		
	Critical Measurable Characteristics											
9.	 Establish Measurable Characteristics 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 Parallelism Concentricity True Position Tolerances Edge Distance Requirements g. Airfoil Profile Leading & Trailing Edge Contour Concave & convex contours Thickness Chord & Airfoil Length Twist/Lean/Bow 											
	h. Tip Length											
10.	i. Airfoil wall thickness Part Weight:			<u> </u>								
10.	a. Mass											
	b. Moment											

		CATEGORIES OF REPAIR 0 1 2 3 4 5 6 7 8 9										
Req	Repair Properties and Requirements to		1					1		8	9	
No.	be Identified and Substantiated.											
11.	Platform width & (angel wing) Cross											
10	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											
15.	Operations Identified for Repair Source											
	Qualification											
14.	Process Demonstration (including variability											
17.	requirements)											
15.	Part Demonstration/Inspection											
15.	i art Demonstration, inspection											
16.	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											
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;											
01	General						-					
21.	33.14 Start-stop cyclic stress (low cycle											
	fatigue)											

		CATEGORIES OF REPAIR												
Req No.	Repair Properties and Requirements to be Identified and Substantiated.		1	2	3	4	5	6	7	8	9			
22.	33.15 Materials													
23.	33.17 Fire prevention													
23.	33.19 Durability (Note that 33.19 is													
27.	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													
20.	structure													
27.	33.25 Accessory attachments													
27.	33.27 Turbine, compressor, fan, and turbo-													
20.	supercharger rotors													
29.	33.28 Electrical and electronic control													
2).	systems													
30.	33.29 Instrument connection													
50.	Subpart E – Design and Construction;													
	Turbine Aircraft Engines													
31.	33.62 Stress analysis													
32.	33.63 Vibration						-				<u> </u>			
33.	33.65 Surge and stall characteristics										<u> </u>			
55.	(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													

		CATEGORIES OF REPAIR									
Req No.	Repair Properties and Requirements to be Identified and Substantiated.		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										

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
	• This repair removes and replaces any and all types of coatings
2.	Weld or Braze Repair (excludes detail parts replacement)
	• This repair includes restoration of airfoil tip and chord length
3.	Weld or Braze Repair
	This repair includes detail parts replacement
4.	Assembly or Disassembly
	• 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
	This repair includes dent repair
9.	Surface Treatment Repair
	• This repair includes shot-peen, glass bead peen, vibratory tumble (e.g., restoration of surface finish/texture)

			CA	ATEG	ORIE	S OF	REPA	IR		
Req	Repair Design Requirements to be	1	2	3	4	5	6	7	8	9
No.	Identified and Substantiated.									
1.	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.									
	 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. 		L	L				L		

		CATEGORIES OF REPAIR									
Req	Repair Design Requirements to be	1	2	3	4	5	6	7	8	9	
No.	Identified and Substantiated.										
2.	Select all mechanical, metallurgical, and	l I									
	physical properties of the part affected										
	by the repair design, and assess their										
	impact on the part's airworthiness:										
	Mechanical Properties:										
	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										
	Metallurgical Properties:										
	i. Chemical Composition (Alloy										
	constituents)										
	j. Microstructure (grain size –										
	shape - boundary precipitates,										
	gamma prime size and volume										
	fraction, etc.)										
	k. Melting Point										
	1. Corrosion Resistance										
	m. Oxidation Resistance										
	n. Wear Resistance (Consider wear transmission $(1)(z)$)										
	types in (1)(e)) o. Crack Propagation Rate										
	o. Crack Propagation Rate										
	Physical Properties:										
	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.	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.										
	 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. 4. 1	Repair Design Requirements to beIdentified and Substantiated. RepairProperties and Requirements to beIdentified and Substantiated.Select all CoatingProperties/Characteristics that applyand evaluate them and their interface withthe parent metal. The effect of anychanges to the part's physical andoperational capability as a result of thecoating should be evaluated for		1	2	3	4	5	6	7	8	9	
	 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											

			C	ATEG	ORIE	S OF	REPA	IR		
Req No.	Repair Properties & Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9
6.	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.									
	 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.									

		CATEGORIES OF REPAIR										
Req No.	Repair Properties & Requirements to be Identified and Substantiated.		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											
	b. Secondary Airflowc. Aerodynamics											
	Critical Measurable Characteristics											
9.	Establish Measurable Characteristics 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 • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements g. Airfoil Profile • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist/Lean/Bow h. Tip Length • Airfoil wall thickness											

	-		CA	TEG	ORIE	S OF	REPA	IR		
Req	Repair Properties & Requirements to be					_		_		
No.	Identified and Substantiated.	1	2	3	4	5	6	7	8	9
10	Critical Measurable Characteristics									
10. 11.	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:									
	used to accomprish 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									
18.	operating the engine									
18.	33.7 Engine ratings and operating limitations									
19.	33.8 Selection of engine power and thrust									
17.	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;									
24	33.88; and 33.90) 33.21 Engine cooling									
24. 25.	33.23 Engine mounting attachments and									
25.	structure									
26.	33.25 Accessory attachments									
20.	55.25 Hoodson'y attachments									

			CA	TEG	ORIE	S OF	REPA	IR		
Req	Repair Properties & Requirements to be									
No.	Identified and Substantiated.	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									

			CA	ATEG	ORIE	SOF	REPA	IR		
Req No.	Repair Properties & Requirements to be Identified and Substantiated.	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									

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Strip and Re-coat Repair
	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)
	Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair
	Includes detail part replacement
5.	Sulfidation or Corrosion Repair
6.	Blend Repair
7.	Straightening, Re-twist, or Reforming Repair
8.	Surface Treatment Repair
	• This repair includes shot peen, glass bead peen, vibratory tumble (e.g., restoration of surface finish/texture)

_		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.	 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. 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.	Select all mechanical , metallurgical , and physical properties of the part affected by the repair design , and assess their impact on the part's airworthiness:											
	Mechanical Properties:											
	 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 											
	Metallurgical Properties:											
	 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. 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		
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.											
	 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.	Coating Material Properties, Characteristics & Processes:											
	 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 											

		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	
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										
6.	 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. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Reforming 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 										
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 & Requirements to be Identified and Substantiated.12348.Select all that may be potentially affected by the repair design, and evaluate system effect(s):1234a.Structural Strength, including major load pathsa.Structural Strength, including enajor load pathsb.Heat Transfer c.Secondary Airflow d.Aerodynamics ee.Weight f.Center of Gravity	CATEGORIES OF REPAIR 1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 2 3 4 5 6 7 8 1 1 1 1 1 1 1 1 1 1 1<									
 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 	5 6	7	8							
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										
effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight										
 a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight 										
 b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight 										
c. Secondary Airflowd. Aerodynamicse. Weight										
d. Aerodynamicse. Weight										
e. Weight										
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):										
mating part(s).										
a. Surface finish/texture										
b. Shotpeen Intensity/Coverage										
c. Bearing bore dimensions and										
location characteristics										
d. Pressure Strength teste. Flow Capacity test										
e. Flow Capacity test f. Dimensions, including heat										
distortion effects										
Roundness										
• Flatness										
Parallelism										
Concentricity										
True Position Tolerances										
Edge Distance										
Requirements Finish Dimensions										
• Finish Dimensions Requirements										
g. Airfoils Profile										
Leading & Trailing Edge										
Contour										
Concave & convex contours										
Thickness										
Chord & Airfoil Length										
• Twist/Lean/Bow										
h. Tip Length										
i. Airfoil wall thickness j. Throat Area										

				CAT	EGOF	RIES O	F REP	AIR		
Req	Repair Properties and Requirements to									
No.	be Identified and Substantiated.		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									

			(CATEG	ORIE	S OF I	REPAI	R	
Req	Repair Properties and Requirements to								
No.	be Identified and Substantiated.	1	2	3	4	5	6	7	8
	Subpart A – General								
18.	33.7 Engine ratings and operating								
1.0	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								

			CATECORIES OF REPAIR 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 <th1< th=""> 1 1 1<th></th></th1<>						
Req	Repair Properties and Requirements to								
No.	be Identified and Substantiated.	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								

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Strip & Recoat Repair
	This repair removes and replaces any and all types of coatings.
2.	Blend Repair
3.	Straightening, Re-twist, or Reforming Repair
	This repair includes straightening of bent flanges
4.	Weld/Braze Repair
	Excludes Detail Part Replacement
5.	Weld/Braze Repair
	Includes Detail Part Replacement
6.	Assembly and/or Disassembly
	• 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.

			CA	TEGO	RIES O	F REP	AIR		
Req No.	Repair Design Requirements to beIdentified and Substantiated.Repair Properties andRequirements to be Identified andSubstantiated.Applicable Degradation Modes:Select all that apply based on the	1	2	3	4	5	6	7	8
	function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.								
	 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.	Select all mechanical , metallurgical , and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:										
	Mechanical Properties:										
	 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 										
	<u>Within gitar 1 toperates.</u>										
	 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 n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate 										
	Physical Properties:										
	 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 1 2 3 4 5 6 7 8									
Req	Repair Design Requirements to be					_					
No.	Identified and Substantiated.	1	2	3	4	5	6	7	8		
	Repair Properties and										
	Requirements to be Identified and										
3.	Substantiated. Select all Material										
3.											
	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.										
	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)										
	Material Properties/Degradation										
	Modes/Product Qualities/etc.										
	Technical Substantiation										
4.	Requirements Coating & Plating Material										
4.	Properties Characteristics &										
	Processes:										
	110005505.										
	a. Deposit material	 1									
	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 Resistancek. Erosion Resistance										
	k. Erosion Resistancel. Bonding (Interface										
	~										
	m. Contamination) n. Environmental										
	Resistance										
	o. Diffusion Zone										
	p. Hydrogen										
	Embrittlement Free										
	Plating										
	q. Compatibility with base										
	material										

			CATEGORIES OF REPAIR 1 2 3 4 5 6 7 8										
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			
5.	tolerances f features and	tics and the allowable for the repaired part d for any replacement d give due consideration art(s): Surface finish/texture Shotpeen intensity/coverage Bearing bore dimensions and location characteristics											

_			CA	TEGOI	RIES O	F REPA	AIR		
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
6.	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.								
	 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 								
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.								

		1	CA	TEGC	RIES (OF REF	PAIR	•	1
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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):								
	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								
	g. Roundness h. Flatness								
	i. Parallelism								
	j. Concentricity								
	k. True Position Tolerances								
	1. 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								

			CA	TEGOR	IES O	F REP	AIR		
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
10.	Cooling Feature Characteristics: a. Airflow								
	b. Hole Diameterc. Blocked Hole Quantity/Location								
	 d. Cooling Slot Height/Length/Location e. Quantity of Holes/Slots 								
11.	Thermal Barrier Coating:								
	a. Thicknessb. Coveragec. Type								
	Repair Process Capability Technical Substantiation Requirements								
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification								

				CATEG	ORIES C)F REP	AIR		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8
-	Repair Process Capability Technical								
	Substantiation Requirements								
13.	Process Demonstration Including:								
1.4	a. Variability Requirements								
14.	Part Demonstration/Inspection								
15.	Manufacturing Requirements for fabrication of repair details or								
	replacement sections to accomplish								
	repair:								
	Topun:								
	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								
17.	Airworthiness (ICA's)								
17.	33.5 Instruction Manual for Installing and Operating the Engine								
18.	33.7 Engine Ratings and Operating		-	-					
10.	Limitations								
19.	33.8 Selection of Engine Power and								
17.	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								

				CA	TEGO	RIES C	F REI	PAIR		
Req	Repair Properties and									
No.	Requirements to be Identified and	1	l	2	3	4	5	6	7	8
	Substantiated.									
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									
	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									

			CA	TEGO	RIES O	F REF	PAIR		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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								

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	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.
2.	Weld or Braze Repair
	This repair excludes detail part replacement
3.	Weld or Braze Repair
	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
	This repair includes dent repair
9.	Repairs to Restore Adhesives, Bonding Agents, Potting Compounds.
10.	Machining Repair
	This repair includes lapping, skim cut, non-conventional machining

			(CATE	GOR	IES ()F RI	EPAII	R		
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	10
1.	 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. 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.		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:											
	Mechanical Properties:											
	 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 											
	Metallurgical Properties:											
	 i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, 											
	 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 											
	Physical Properties:											
	 p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 											

			(CATE	GOR	IES ()F RI	EPAII	R		
Req	Repair Design Requirements to be										
No.	Identified and Substantiated. Repair	1	2	3	4	5	6	7	8	9	10
	Properties and Requirements to be										
	Identified and Substantiated.										
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.										
	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.	Coating & Plating Material Properties										
r.	Characteristics & Processes:										
	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										
	1. Bonding (Interface										
	Contamination)										
	m. Environmental Resistance										
	n. Diffusion Zone										
	o. Hydrogen Embrittlement Free (Plating)										
	p. Compatibility With Base										
	Material										
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										

			(CATE	GOR	IES ()F RI	EPAI	R		
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	10
6.	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.										
	 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 										

			(CATE	GOR	IES (OF RI	EPAI	R		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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.	1			-			1	0	,	10
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 • 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. 1 2 3 4 5 6 7 8 9 Repair Process Capability Technical Substantiation Requirements 1 2 3 4 5 6 7 8 9 12. Verification Plan with Significant Operations Identified for Repair Source Qualification 1					(CATE	GOR	IES (OF RI	EPAI	R		
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Substantiation Requirements Image: Substantiation Requirements 12. Verification Plan with Significant Operations Identified for Repair Source Qualification Image: Substantiation 13. Process Demonstration (including variability requirements) Image: Substantiation 14. Part Demonstration/Inspection Image: Substantiation 15. Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: Image: Substantiation Image: Substantiation Requirements Image: Substantiation Requirements Image: Substantiation Requirements Applicable 14 CFR Part 33 Requirements Image: Substantiation Requirements Image: Substantiation Requirements 16. 33.4 Instruction for Continuous Airworthiness (ICA's) Image: Substantiation operating the engine Image: Substantiation Requirements 17. 33.5 Instruction manual for installing and operating the engine Image: Substantiation Requirements Image: Substantiation Requirements 18. 33.7 Engine ratings and operating Imitations Image: Substantiation Remeral	No.			1	2	3	4	5	6	7	8	9	10
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20. 33.14 Start-stop cyclic stress (low cycle fatigue)													
fatigue)	20.												
21. 33.15 Materials	21.												
22. 33.17 Fire prevention													
23. 33.19 Durability (Note that 33.19 is			1	1	1		1				1		
associated with 33.27; 33.63; 33.83; 33.87;													
33.88; and 33.90)													
24. 33.21 Engine cooling	24.												
25. 33.23 Engine mounting attachments and													
structure		· ·											
26. 33.25 Accessory attachments	26.												
27. 33.27 Turbine, compressor, fan, and turbo-													
supercharger rotors													

			(CATE	GOR	IES ()F RI	EPAI	R		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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										

				CATH	EGOF	RIES	OF R	EPAI	R		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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										

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Blend Repair
2.	Thread Restoration and Functional Testing.
3.	Assembly and/or Disassembly
	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
	 Includes lapping, skim cut, non-conventional machining.
5.	Weld or Braze Repair
	Excludes Detail Part Replacement
6.	Weld or Braze Repair
	Includes Detail Part Replacement
7.	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		1	2	3	4	5	6	7			
	Identified and Substantiated.											
1.	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.											
	 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.	Select all mechanical , metallurgical , and physical properties of the part affected by the repair design and assess their impact on the part's airworthiness:									
	 Mechanical Properties: 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 Metallurgical Properties: 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 Physical Properties: 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.	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.								
	 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.	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 								

	-	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.	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								
6.	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.								
	 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 								
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.								

			CATEC	GORIES	S OF F	REPAIL	R	
No. and S Requi	r Design Requirements to be Identified ubstantiated. Repair Properties and irements to be Identified and antiated.	1	2	3	4	5	6	7
8. Select the rep	all that may be potentially affected by pair design and evaluate system effect(s):							
a. b. c. d. e. f. g	load paths Heat Transfer Secondary Airflow Aerodynamics Weight Center of Gravity Moment of Weight							
	al Measurable Characteristics							
allowa feature	 Shotpeen intensity/coverage Bearing bore dimensions and location characteristics Pressure strength test Flow capacity test Dimensions, including heat distortion effects Roundness Flatness Parallelism Concentricity True position tolerances Edge distance requirements Finish dimensions requirements Diameter/locating Air swirler features Mixing air (dilution) features Datum location features Air cooling hole diameter Flowpath exit features Aft seal Flanges 							

			CATE	GORIE	S OF I	REPAIL	R	
Req	Repair Properties and Requirements to be							
No.	Identified and Substantiated, Cont'd.	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				1	r	r	
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:							
	 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							

		(CATEG	GORIE	S OF F	REPAI	R	
Req	Repair Properties and Requirements to be							_
No.	Identified and Substantiated.	1	2	3	4	5	6	7
22	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							

		C	ATEG	ORIE	S OF R	EPAI	R	
Req	Repair Properties and Requirements to be							
No.	Identified and Substantiated.	 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							

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Restoration of Protective Coating
	Includes Touch Up Coating
2.	Weld or Braze Repair
	This repair excludes detail part replacement
3.	Weld or Braze Repair
	Includes detail part replacement
4.	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.
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
	This repair includes straightening of bent knife edges
10.	Surface Treatment Repair
	• This repair includes peening, vibratory tumble (e.g.; restoration of surface
	finish/texture)
11.	Machining Repair
	This repair includes lapping, skim cut, non-conventional machining
12.	Restoration of Adhesives, Bonding Agents, Potting Compounds.

		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	10	11	12
1.	 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. 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. 													

				CA	TEC	GOR	IES	OF I	REP	AIR			
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	10	11	12
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:												
	Mechanical Properties:												
	 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 												
	Metallurgical Properties:												
	 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 												
	Physical Properties:												
	 p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 												

				CA	TE	GOR	IES	OF I	REP	AIR			
Req	Repair Design Requirements to be												
No.	Identified and Substantiated.	1	2	3	4	5	6	7	8	9	10	11	12
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.												
	 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.	Coating & Plating Material Properties Characteristics & Processes:												
	 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 												

					CA	ATE(GOR	IES	OF	REP	AIR	-		
Req	Repair Design Requirements to be			-			_	_						
No.	Identified and Substantiated.		1	2	3	4	5	6	7	8	9	10	11	12
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													
6.	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		I						I		I			
	ICAs.													
	a. Machining, Milling, Broaching,													
	or Grinding													
	b. Non-traditional Machiningc. 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													
	1. Stress Intensity Factor (K_t)													
	m. Heat Treatment (time, temp,													
	atmosphere, etc.)													
	n. Plating o. Dimensional Short-falls													
	o. Dimensional Short-fallsp. Repetitive or Conflicting													
	Repairs													
	q. Contamination													
	4 . Containination													
L	1	_I												

				CA	TE	GOR	IES	OF 1	REP	AIR			
Req No.	Repair Design Requirements to be Identified and Substantiated.	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 												

		CATEGORIES OF REPAIR												
Req	Repair Design Requirements to be													
No.	Identified and Substantiated.		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 testf. Dimensions, including heat													
	g. distortion effects													
	Roundness													
	Flatness													
	PratiessParallelism													
	Concentricity													
	• True position tolerances													
	• Edge distance requirements													
	Finish dimensions													
	requirements													

				CA	TE	GOR	IES	OF I	REP	AIR			
Req	Repair Properties and Requirements to												
No.	be Identified and Substantiated.	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												
1.0	Qualification												
13.	Process Demonstration (including												
1.4	variability requirements)												
14.	Part Demonstration/Inspection												
15.	Manufacturing requirements for fabrication												
	of repair details or replacement sections used to accomplish repair:												
	used to accomptish 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 Image: Construction is a second structure second structure is a second structure second structure is a second structure second structur					CA	ATE	GOR	IES	OF	REP	AIR			
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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. 24. 33.21 Engine cooling 26. 27. 33.25 Accessory attachments and structure 26. 25. 33.25 Accessory attachments 26. 27. 33.27 Turbine, compressor, fan, and turbo supercharger rotors 28. 33.28 Electrical and electronic control systems 27. 33.29 Instrument connection 28. 29. 33.29 Instrument connection 28. 29. 29. 20. 20. 30. 33.62 Stress analysis 29. 20. 20. 20. 20. 31. 33.63 Vibration 20. 20. 20. 20. 20. 33. 33.66 Bleed air system 20. 20. 20. 20. 20. 33. 33.66 Bleed air system 20. 20. 20. 20. 20. 33. 33.66 Bleed air system 20. 20. 20. 20. 20. 33. 33.66 Bleed air system 20. 20. 20. 20. 20. 33. 33.67 Fuel														
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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 29. 33.29 Instrument connection 29. 33.60 Structure 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. 33.71 Lubrication 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. 33.76 Bird ingestion (operability aspects of														
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41. 33.75 Safety analysis		*												
42. 33.76 Bird ingestion (operability aspects of														
ingestion)		ingestion)												

				CA	TE	GOR	IES	OF	REP.	AIR			
Req	Repair Properties and Requirements to												
No.	be Identified and Substantiated.	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												
50	(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												

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.)
	This repair includes touch-up coating
2.	Weld or Braze Repair
	This repair excludes detail part replacement
3.	Weld or Braze Repair
	This repair includes detail part replacement
4.	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
5.	Blend Repair
6.	Dimensional Restoration by Coating or Plating
7.	Surface Treatment Repair
	• This repair includes peening, vibratory tumble (e.g.; restoration of surface
	finish/texture)
8.	Straightening, Re-twist, or Reforming Repair
	This repair includes straightening of bent flanges
9.	Restoration of Adhesives, Bonding Agents & Potting Compounds

			CA	ATEG	ORIE	S OF 1	REPA	IR		
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.	 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. 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	9
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:										
	 Mechanical Properties: 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 Metallurgical Properties: 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 Physical Properties: 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	Repair Design Requirements to be										
No.	Identified and Substantiated. Repair		1	2	3	4	5	6	7	8	9
	Properties and Requirements to be										
	Identified and Substantiated.										
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.										
	Minute the state of the state o										
	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)										
	d. Heat Affected Zoffe (weiding)										
4.	Coating & Plating Material Properties										
	Characteristics & Processes:										
	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										
	1. Bonding (Interface										
	Contamination)										
	m. Environmental Resistance										
	n. Diffusion Zone										
	o. Hydrogen Embrittlement Free										
	(Plating)										
	 p. Compatibility With Base Material 										
	Material										

		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
5.	Select Surface Treatment that applies (without material removal) and evaluate effect(s), if any, on airworthiness:										
	a. Burnishingb. Peeningc. Butterfly Polishd. Mass Media Finishing										
6.	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.										
	 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 										
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.										

		C	АТЕ	GOR	IES	OF I	REPA	AIR			
Req.	Repair Design Requirements to be		1	2	3	4	5	6	7	8	9
No.	Identified and Substantiated, Repair										
	Properties and Requirements to be										
	Identified and Substantiated.										
	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										
	Roundness										
	• Flatness										
	• Parallelism										
	Concentricity										
	True Position										
	Tolerances										
	Edge Distance										
	Requirements										
	• Finish										
	Dimensions										
	Requirements										
	g. Airfoil Profile										
	h. Leading & Trailing Edge Contours										
	i. Concave & Convex Contours										
	j. Thickness										
	k. Chord & Tip Length										
	1. 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										

		CATEGORIES OF REPAIR											
Req	Repair Properties and Requirements to												
No.	be Identified and Substantiated.		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:												
	Drawings/Specifications												
	Quality Requirements												
	Source Substantiation												
	Requirements								-				
	Applicable 14 CFR Part 33												
	Requirements												
10	Subpart A – General 33.4 Instructions for Continuous												
18.													
19.	Airworthiness (ICA's) 33.5 Instruction manual for installing and												
19.	operating the engine												
20.	33.7 Engine ratings and operating												
20.	limitations												
21.	33.8 Selection of engine power and thrust												
21.	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												

		CATEGORIES OF REPAIR									
Req	Repair Properties and Requirements to										
No.	be Identified and Substantiated.		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										
21	systems										
31.	33.29 Instrument connection										
	Subpart E – Design and Construction;										
20	Turbine Aircraft Engines 22 (2) Stress analysis										
32.	33.62 Stress analysis										
33.	33.63 Vibration 33.65 Surge and stall characteristics										
34.	(Note 2)										
35.	33.66 Bleed air system										
35. 36.											
	33.67 Fuel system										
37.	33.68 Induction system icing (operability										
20	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										
43.	aspects of ingestion)										
46.	33.78 Rain and hail ingestion										
40.	33.79 Fuel burning thrust augmentor										
- - 77.	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)										

			CA	ATEG	ORIE	S OF	REPA	IR		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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									

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
	This repair excludes detail part replacement
3.	Blend Repair
4.	Surface Treatment Repair
	• This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)

		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			
1.	 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. 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					
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: <u>Mechanical Properties:</u>										
	 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 Metallurgical Properties:										
	 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. 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			
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.								
	 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.	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 		<u>.</u>						

		CATEGORIES OF REPAIR								
Req No.	Repair Properties & Requirement to be Identified and Substantiated.		1	2	3	4				
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									
6.	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.									
	 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 Contamination 									

		CATEG	ORIES OF	REPAIR	
Req No.	Repair Properties & Requirement to be Identified and Substantiated.	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): 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 d. location characteristics e. Pressure strength test f. Flow capacity test g. Dimensions, including heat distortion effects: • Roundness • Flatness • Parallelism • Concentricity • True position tolerances • Edge distance requirements • Finish dimensions requirements				
	Airfoil Profile				
	 Leading & Trailing Edge Contours Concave & Convex Contours Thickness Chord & Tip Length Twist/Lean/Bow 				

		(CATEGO	RIES OF F	REPAIR	
	Repair Properties & Requirement to be Identified and Substantiated.		1	2	3	4
	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:					
	 Drawings/Specifications Quality Requirements Source Substantiation Requirements 					

		CATEG	ORIES OF	REPAIR	
Req	Repair Properties and Requirements to be				
No.	Identified and Substantiated.	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				
26	33.90)				
26.	33.21 Engine cooling	 	-		-
27.	33.23 Engine mounting attachments and				
29	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				-
51.	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				
57.	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				

		CATEG	ORIES OF	REPAIR	
Req	Repair Properties and Requirements to be				
No.	Identified and Substantiated.	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				

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Weld or Braze Repair
	• This repair includes detail part replacement
2.	Weld or Braze Repair
	• This repair excludes detail part replacement
3.	Straightening, Re-twist or Reforming Repair
	• 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
	 Includes touch-up coating
8.	Assembly and/or Disassembly
	• 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

			CA	TEG	GORI	ES C	F RF	EPAI	RS		
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	10
1.	 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. 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. 										

				CAT	TEGO	RIES	OF F	REPA	IR		
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	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:										
	Mechanical Properties:		1	1	1	1	I	I	1		
	 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 Metallurgical Properties:										
	 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 										
	Physical Properties:										
	 p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 										

		CATEGORIES OF REPAIRS											
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	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. Burnishingb. Peeningc. Butterfly Polishd. Mass Media Finishing												

		CATEGORIES OF REPAIRS											
No. an R	Repair Design Requirements to be Identified nd Substantiated. Repair Properties and Requirements to be Identified and ubstantiated.		1	2	3	4	5	6	7	8	9	10	
6. E ^v fu pr	 Avaluate any degradation in the part's sunction or durability due to the following rocesses, when applicable, and assess its mpact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, Re-twisting, Reforming 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 Contamination 												

			C	ATEC	GORI	ES O	F RE	PAI	RS		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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 & configurationEstablish 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.b.Shotpeen intensity/coverage c.c.Bearing bore dimensions and location characteristicsd.Pressure strength test e.e.Flow capacity test f.f.Dimensions, including heat distortion effectse.Flatness e.flatness e.Parallelism e.concentricity e.True position tolerances e.Edge distance requirements e.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)										

			C	ATEC	GOR	ES O	F RF	PAI	RS		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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:										
	 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)										

		CATEGORIES OF REPAIRS										
Req No.	Repair Properties and Requirements to be Identified and Substantiated.		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											

			С	ATE	GOR	IES C)F RI	EPAI	RS		
Req	Repair Properties and Requirements to be	1	2	3	4	5	6	7	8	9	10
No.	Identified and Substantiated.										
	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										1
	Continued Airworthiness										
	Part 33 - Appendix B- Certification										
	Standard Atmospheric Concentrations of										
	Rain and Hail										
	Part 34 – Exhaust Emissions										

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	REPAIR DESCRIPTION
OF REPAIRS	
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

		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.	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. 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, O ₃ 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	9
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:										
	Mechanical Properties:										
	 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 										
	Metallurgical Properties:										
	i. Chemical Composition (alloy constituents)										
	 j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) 										
	k. Melting Point										
	 Corrosion Resistance Mathematical Oxidation Resistance 										
	 n. Wear Resistance (consider wear types in (1)(e)) o. Crack Propagation Rate 										
	Physical Properties:										
	 p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia 										

			CA	ATEG	ORIE	S OF I	REPA	IR		
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.	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.									
	 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.	Coating & Plating Material Properties Characteristics & Processes:									
	 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 	1				L	L			

		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
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										
6.	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.										
	 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 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.										

			CA	TEG	ORIE	S OF 1	REPA	IR		
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
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 g. Distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements									
10.	Coating Coverage Definition									
11. 12.	Blend Area Proximity Limits Defined No Grit Blast/Coating in Fillet Radii									

_			CA	ATEG	ORIE	S OF	REPA	IR		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9
110.	Repair Process Capability Technical Substantiation Requirements	1		5		5	U			,
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:									
	 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									

			CA	ATEG	ORIE	S OF	REPA	IR		
Req	Repair Properties and Requirements to									
No.	be Identified and Substantiated.	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									
20	systems									
30.	33.29 Instrument connection	 								
	Subpart E – Design and Construction;									
21	Turbine Aircraft Engines									
31. 32.	33.62 Stress analysis									
<u>32.</u> 33.	33.63 Vibration									
33.	33.65 Surge and stall characteristics (Note 2)									
34.	33.66 Bleed air system									
34.	33.67 Fuel system									
	-									
36.	33.68 Induction system icing (operability									
07	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									

			CA	ATEG	ORIE	S OF 1	REPA	IR		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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									
5.4	bench testing)	 								
54.	33.92 Rotor locking tests									
55.	33.93 Teardown inspection 33.94 Blade containment and rotor									
56.										
57	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									
<u> </u>	33.99 General conduct of block tests									
00.										
	Part 33 - Appendix A – Instructions for Continued Airworthiness									
	Part 33 -Appendix B Certification									
	Standard Atmospheric Concentrations									
	of Rain and Hail									
	Part 34 – Exhaust Emissions									
	Larton L'Anaust L'Anissions									

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	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
2.	Blend Repair
3.	Strip and Re-coat Repair
	 This repair removes and replaces any and all types of coatings
4.	Dimensional Restoration by Coating or Plating
5.	Weld or Braze Repair
	This repair excludes detail part replacement)
6.	Weld or Braze Repair
	This repair includes part detail replacement
7.	Straightening, Re-twist or Reforming Repair
	This repair includes dent repair
8.	Machining Repair
	This repair includes lapping, skim cut, non-conventional machining

			CAT	EGOR	RIES O	F REI	PAIR		
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.	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.								
	 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.	Select all mechanical , metallurgical , and physical properties of the part affected by the repair design , and assess their impact on the part's airworthiness:											
	Mechanical Properties:											
	 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 Metallurgical Properties:											
	 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 											
	Physical Properties:											
	 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	
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.										
	 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.	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 				1	1					

		CATEGORIES OF REPAIR											
Req	Repair Properties and Requirements to be						_		-				
No. 5.	Identified and Substantiated.		1	2	3	4	5	6	7	8			
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			1					1				
6.	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.												
	impact, if any, on existing ICAS.												
	a. Machining, Milling, Broaching, or	<u> </u>											
	Grinding												
	b. Non-traditional Machining												
	c. Welding, Brazing or Coating												
	d. Straightening, Re-twisting, Re-												
	forming												
	e. Blending												
	f. Honing g. Lapping												
	g. Lapping h. Grit Blast												
	i. Stripping												
	j. Cleaning (chemical, power flash,												
	ultrasonic)												
	k. Residual Plating, Stripping, or												
	Cleaning Agents												
	1. Stress Intensity Factor (K _t)												
	m. Heat Treatment (time, temp, atmosphere, etc.)												
	n. Plating												
	o. Dimensional Short-falls												
	p. Repetitive or Conflicting Repairs												
	Contamination												
L									1				
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 Airflowd. Aerodynamics												
	e. Weight												
	f. Center of Gravity												
	g. Moment of Weight												
L	5. moment of monght												

		CATEGORIES OF REPAIR										
Req No.	Repair Properties and Requirements to be Identified and Substantiated.		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): 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 1) Roundness 2) Flatness 3) Parallelism 4) Concentricity 5) True Position Tolerances 6) Edge Distance 7) Requirements 8) Finish Dimensions Requirements											
	Critical Magnuschle Characteristics											
10.	Critical Measurable Characteristics Coating Coverage Definition: a. No Grit Blast b. No coating in Filet Radii											
11.	Blend Area Proximity Limits Defined Repair Process Capability Technical											
12.	Substantiation Requirements Technical Plan with Significant Operations Identified											
13.	Process Demonstration (including variability requirements)											
<u>14.</u> 15.	Part Demonstration/Inspection Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: Drawings/Specifications Quality Requirements Source Substantiation Requirements											

		CATEGORIES OF REPAIR								
Req	Repair Properties and Requirements to be									_
No.	Identified and Substantiated.		1	2	3	4	5	6	7	8
	Applicable 14 CFR Part 33 Requirements									
	Subpart A – General									
16.	33.4 Instructions for Continuous Airworthiness									
17	(ICA's)									
17.	33.5 Instruction manual for installing and									
10	operating the engine									
18.	33.7 Engine ratings and operating limitations33.8 Selection of engine power and thrust									
19.	ratings									
	Applicable 14 CFR Part 33 Requirements									
	Subpart B – Design and Construction; General									
20.	33.14 Start-stop cyclic stress (low cycle									
20.	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;									
20	Turbine Aircraft Engines 33.62 Stress analysis									
30. 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									

		CATEGORIES OF REPAIR									
Req No.	Repair Properties and Requirements to be Identified and Substantiated.		1	2	3	4	5	6	7	8	
110.	Subpart E – Design and Construction;		1		5	-	5	U	1	0	
	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										

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
	• Excludes Detail Part Replacement
3.	Weld/Braze Repairs
	Includes Detail Part Replacement
4.	Assembly and/or Disassembly
	• This repair removes and replaces detail parts without the use of permanent attachmen
	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
	• This repair includes dent 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				
1.	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.											
	 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. 											

		C.	ATEGO	RIES OI	F REPAI	R	
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
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: <u>Mechanical Properties:</u>						
	 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 						
	Metallurgical Properties:						
	 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 Physical Properties:						
	 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				
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. 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										
Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.		1	2	3	4	5	6				
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											
Material Properties/DegradationModes/Product Qualities/etc. TechnicalSubstantiation RequirementsSelect Surface Treatment that applies(Without Material Removal) and evaluateeffect(s), if any, on airworthiness:a. Burnishingb. Peeningc. Butterfly Polish											
	Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. 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 Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness: a. Burnishing b. Peening	Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. 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. 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 Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness: a. Burnishing b. Peening	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. 1 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. 1 a. Coating Material Composition b. 1 b. Thickness, Coverage & Uniformity 1 c. Coating Material Composition b. 1 b. Thickness, Coverage & Uniformity 1 c. Coating Hardness 1 e. Sintering 1 f. Strip Requirements/Process 1 g. Residual Stress 1 h. Resistance to Spalling 1 i. Thermal Resistance 1 g. Bonding (interface contamination) 1 l. Hydrogen Embrittlement (Plating) 1 m. Compatibility with Base Material/Other Coatings 1 Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements 1 Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. 1 2 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. 1 2 a. Coating Material Composition b. Thickness, Coverage & Uniformity 1 2 c. Coating Material Composition b. Thickness, Coverage & Uniformity 1 2 c. Coating Material Composition b. Thickness, Coverage & Uniformity 1 2 c. Coating Hardness 1 2 e. Sintering 1 1 2 f. Strip Requirements/Process 2 2 2 g. Residual Stress 1 2 3 3 h. Resistance to Spalling 1 1 2 i. Thermal Resistance (coefficient of thermal expansion for the coating) 1 1 2 j. Erosion Resistance 4 Bonding (interface contamination) 4 2 4 4 Material Properties/Degradation Modes/Produc	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. 1 2 3 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. 1 2 3 a. Coating Material Composition b. Thickness, Coverage & Uniformity 1 2 3 c. Coating Hardness 1 1 2 3 g. Coating Hardness 1 1 2 3 ifficient of thermal expansion for the coating) 1 1 2 3 ifficient of thermal expansion for the coating) 5 1 1 1 1 2 3 ifficient of thermal expansion for the coating) 1 1 2 3 3 j. Erosion Resistance K Bonding (interface contamination) 4 <	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. 1 2 3 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. 1 2 3 4 a. Coating Material Composition b. 1 2 3 4 yearstonal capability, as a result of the coating, should be evaluated for airworthiness. 1 2 3 4 a. Coating Material Composition b. 1 2 3 4 b. Thickness, Coverage & Uniformity 1 2 3 4 c. Coating and Diffusion Zone Microstructure 1 2 3 4 d. Coating flatchess 5	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. 1 2 3 4 5 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. 1 2 3 4 5 a. Coating Material Composition b. Thickness, Coverage & Uniformity 1 2 3 4 5 c. Coating Material Composition b. Thickness, Coverage & Uniformity 1 2 3 4 5 a. Coating Hardness 1 2 3 4 5 a. Coating Hardness 1 2 3 4 5 a. Coating Hardness 1 2 3 4 5 g. Residual Stress 1 2 3 4 5 h. Resistance (coefficient of thermal expansion for the coating) 5 5 5 5 j. Erosion Resistance 4 8 4 5 4 4 4 4				

		CATEGORIES OF REPAIR										
Req No	Repair Properties & Requirement to be Identified and Substantiated.		1	2	3	4	5	6				
6.	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.											
	 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.	Cleaning Properties, Characteristics & Material Property Debits: 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.) 											

		CATEGORIES OF REPAIR							
Req No	Repair Properties & Requirement to be Identified and Substantiated.		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 								
9.	Critical Measurable Characteristics 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 • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions Requirements								
10.	Parent material thickness reduction								
L	assessment								
11.	Dimensional & Tolerance								
	Reverse engineered parts Repair Process Capability Technical								
	Substantiation Requirements								
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification								

_		CATEGORIES OF REPAIR							
Req No	Repair Properties & Requirement to be Identified and Substantiated.		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 	L			I		I		
	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								

		CATEGORIES OF REPAIR						
Req No	Repair Properties & Requirement to be Identified and Substantiated.		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							

			С	ATEGO	RIES OF	REPAI	R	
Req	Repair Properties and Requirements							
No	to be Identified and Substantiated.		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	DER						
	for Continued Airworthiness							
	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
	This repair excludes detail part replacement
2.	Blend Repair
3.	Dimensional Restoration by Coating or Plating
4.	Surface Treatment Repair
	• This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)

		CATEGO	ORIES 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
1.	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. 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. 				

			CATEG	ORIES OF	REPAIR	
Req No.	and Substa Requireme Substantiat		1	2	3	4
2.	physical pr	echanical, metallurgical, and operties of the part affected by the gn, and assess their impact on the rthiness:				
		Mechanical Properties:				
	b. Fra c. Fat Dw d. Cre e. Te Elc f. Ha g. Yo	ess-Strain acture Toughness tigue Strength (S-N, Goodman, vell Time) eep nsile Properties (Yield, Strength, ongation) rdness ung's Modulus tural Frequencies				
	<u>1</u>	Metallurgical Properties:				
	j. Mi bou siz k. Me l. Co m. Ox n. We in (emical Composition (Alloy nstituents) crostructure (grain size – shape - undary precipitates, gamma prime e and volume fraction, etc.) elting Point rrosion Resistance idation Resistance ear Resistance (Consider wear types (1)(e)) ack Propagation Rate				
		Physical Properties:				
	q. Co r. Re s. Ce	nsity (weight) efficient of Thermal Expansion fractive Index (X-Rays) nter of Gravity lar Moment of Inertia				

		CATEG	ORIES OF	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				
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. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing)								
4.	d. Heat Affected Zone (welding) 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 Baliah								
	c. Butterfly Polishd. Mass Media Finishing								

		CATEGORIES OF REPAIR						
Req	Repair Properties & Requirement to be							
No.	Identified and Substantiated.	1	2	3	4			
6.	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.							
	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							
	1. Stress Intensity Factor (K _t)							
	m. Heat Treatment (time, temp,							
	atmosphere, etc.)							
	n. Plating							
	o. Dimensional Short-falls							
	p. Repetitive or Conflicting Repairs							
	Contamination							

		CATEGORIES OF REPAIR						
Req	Repair Properties and Requirements to be		_	-	-			
No.	Identified and Substantiated.		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							
0	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							
0	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							
	 roundness 							
	• flatness							
	 parallelism 							
	 concentricity 							
	 true position tolerances 							
	edge distance							
	 requirements 							
	 finish dimensions requirements 							
	g. Airfoil profile							
	 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							
4.5	(Trunnion)							
13.	Outer Spindle (Trunnion) to Inner Spindle (Trunnion)							
	Concentricity							

		CATEGORIES OF REPAIR						
Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		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:							
	 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. 25.	33.17 Fire prevention 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							

		CATEG	ORIES OF	REPAIR	
Req	Repair Properties and Requirements to be				
No.	Identified and Substantiated.	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)				

		CATEG	ORIES OF	REPAIR	
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Strip and Re-coat Repair
	 This repair removes and replaces any and all types of coatings.
2.	Weld or Braze Repair (excludes detail parts replacement)
	Includes restoration of airfoil tip and chord length
3.	Weld or Braze Repair
	Includes detail parts replacement
4.	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.
5.	Blend Repair
6.	Dimensional Restoration by Coating or Plating
7.	Straightening, Re-twist or Reforming Repair

			CATE	GORIE	S OF R	EPAIR		
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.	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.							
	 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. 							

No. Id P Id 2. So pl by			CATEGORIES OF REPAIR										
	Identified and Substantiated. I	Repair	1	2	3	4	5	6	7				
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: <u>Mechanical Properties:</u> 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 <u>Metallurgical Properties:</u> 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	affected their											
	Mechanical Propertie	es:											
	 b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yiel- Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies 	d,											
	Metallurgical Propertie	<u>28:</u>											
	constituents) j. Microstructure (grain siz shape - boundary precip	ze – itates,											
	 k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consitypes in (1)(e)) 	der wear											
	o. Crack Propagation Rate												
	<u>Physical Properties</u>	<u>•</u>											
	 p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Ray s. Center of Gravity t. Polar Moment of Inertia 												

			CATE	GORIE	S OF R	EPAIR		
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.	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.							
	 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.	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 							

		CATE	GOR	IES	OF F	REPA	IR		
Req	Repair Design Requirements to be								
No,	Identified and Substantiated. Repair		1	2	3	4	5	6	7
	Properties and Requirements to be								
	Identified and Substantiated.								
5.	Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:								
	a. Burnishingb. Peeningc. Butterfly Polishd. Mass Media Finishing							1	1

Req	Repair Properties & Requirement to be		1	2	2	4	_	(-
No. 6.	Identified and Substantiated. Evaluate any degradation in the part's		1	2	3	4	5	6	7
0.	function or durability due to the								
	following processes, when applicable,								
	and assess its impact, if any, on existing								
	ICAs.								
	a. Machining, Milling, Broaching,								
	or Grinding								
	b. Non-traditional Machining								
	c. Welding, Brazing or Coating								
	d. Straightening, Re-twisting, Re-								
	forming e. Blending								
	e. Blending f. Honing								
	g. Lapping								
	h. Grit Blast								
	i. Stripping								
	j. Cleaning (chemical, power								
	flash, ultrasonic)								
	k. Residual Plating, Stripping, or								
	Cleaning Agents								
	1. 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.	Establish the Applicability of the Repair								
7.	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								

		CATEGORIES OF REPAIR 1 2 3 4 5 6 1 2 3 4 5 6 1 1 2 3 4 5 6 1 1 2 3 4 5 6 1 1 2 3 4 5 6 1 1 2 3 4 5 6 1 1 2 3 4 5 6 1 1 1 1 1 1 1 1 1 1 2 3 4 5 6 1 <th1< th=""> 1 1</th1<>							
Req	Repair Properties and Requirements to be Identified and Substantiated.		1	2	2	4	-	(-
No.	Critical Measurable Characteristics		1	<u>_</u>	3	4	5	0	7
9.	Dimension of sealing features (leakage,								
2.	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):								
	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								
	Roundness								
	• Flatness								
	Parallelism								
	Concentricity								
	• True position tolerances								
	Edge distance								
	Requirements								
	Finish dimensions								
	Requirements								
	g. Airfoils Profile								
	• Leading & trailing edge								
	contour								
	• Concave & convex contours								
	• Thickness								
	• Chord & airfoil length								
	• Twist/lean/bow								
	 h. Tip length i. Airfoil wall thickness 								
	j. Throat area								
	J. Thioat area								
11.	Cooling (Total flow, flow split, back flow								
	margin, hole exit geometry, allowable								
	plugged holes)								
	Repair Process Capability Technical								
12	Substantiation Requirements Technical Plan with Significant Operations								
12.	Identified								
13.	Process Demonstration (including								
15.	variability requirements)								
	, and only requirements)	1	1		1				

				CATE	GORIE	S OF R	EPAIR		
Req	Repair Properties and Requirements to								
No.	be Identified and Substantiated.		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:								
	Drawings/Specifications								
	Quality Requirements								
	Source Substantiation								
	Requirements								
	Applicable 14 CFR Part 33								
	Requirements								
	Subpart A – General								
16.	33.4 Instructions for Continuous								
17	Airworthiness (ICA's) 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;								
27	General								
27.	33.27 Turbine, compressor, fan, and turbo- supercharger rotors								
28.	33.28 Electrical and electronic control								
20.	systems								
29.	33.29 Instrument connection								
	Subpart E – Design and construction;								
20	Turbine aircraft Engines								
30.	33.62 Stress Analysis								
31.	33.63 Vibration								

			CATE	GORIE	S OF R	EPAIR		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Strip and Re-coat Repair
	 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)
	Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair
	Includes detail part replacement
5.	Disassembly and/or Assembly
	• 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

		Intified and Substantiated. Repair 1 2 3 4 5 6 perties and Requirements to be ntified and Substantiated. 1 2 3 4 5 6 plicable Degradation Modes: Select			PAIR					
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.	 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. 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, 									

			CATEGORIES OF REPAIR									
Req		Design Requirements to be										
No.		ied and Substantiated. Repair		1	2	3	4	5	6	7	8	
		ties and Requirements to be										
		ied and Substantiated.										
2.		ll mechanical, metallurgical, and										
		al properties of the part affected										
		repair design, and assess their										
	impact	on the part's airworthiness:										
		Mechanical Properties:										
	a.	Stress-Strain										
	b.	Fracture Toughness										
	с.	Fatigue Strength (S-N,										
		Goodman, Dwell Time)										
	d.	Creep										
	e.	Tensile Properties (Yield,										
		Strength, Elongation)										
	f.	Hardness										
	g.	Young's Modulus										
	h.	Natural Frequencies										
		Metallurgical Properties:										
	i.	Chemical Composition (alloy										
		constituents)										
	j.	Microstructure (grain size –										
	5	shape - boundary precipitates,										
		gamma prime size and volume										
		fraction, etc.)										
	k.	Melting Point										
	1.	Corrosion Resistance										
	m.	Oxidation Resistance										
	n.	Wear Resistance (consider wear										
		types in (1)(e))										
	0.	Crack Propagation Rate										
		Physical Properties:										
	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			
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. 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	
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. Burnishingb. Peeningc. Butterfly Polishd. Mass Media Finishing										

		CATEGORIES OF REPAIR											
Req	Repair Properties & Requirement to be						_						
No.	Identified and Substantiated.		1	2	3	4	5	6	7	8			
6.	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.												
	impact, if any, on existing ICAs.												
	a. Machining, Milling, Broaching, or				1	1	1	1					
	Grinding												
	b. Non-traditional Machiningc. 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												
	1. 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.	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	L											
	major load paths												
	b. Heat Transfer												
	c. Secondary Airflow												
	d. Aerodynamics												
	e. Weight												
	f. Center of Gravity												
	g. Moment of Weight												

		CATEGORIES OF REPAIR										
Req	Repair Properties and Requirements to											
No.	be Identified and Substantiated.		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,											
10	cross over hole size, metering plate)											
10.	Dimension of sealing features (leakage,											
1.1	secondary circuits)	-			-			<u> </u>				
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):											
	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											
	Roundness											
	• Flatness											
	Parallelism											
	Concentricity											
	True Position											
	Tolerances											
	Edge Distance											
	Requirements											
	• Finish Dimensions											
	• Requirements											
	g. Airfoils Profile											
	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											
10	Substantiation Requirements											
12.	Verification Plan with Significant											
	Operations Identified for Repair Source											
12	Qualification Process Demonstration (including											
13.	Process Demonstration (including variability requirements)											
14.	Part Demonstration/Inspection											
14.	r art Demonstration/hispection											

		CATEGORIES OF REPAIR								
Req No.	Repair Properties and Requirements to be Identified and Substantiated.		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:									
	 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									

			CAT	EGO	RIES O	F REF	PAIR		
Req No.	Repair Properties and Requirements to be Identified and Substantiated.	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 (Note2)								
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								

		CATEGORIES OF REPAIR										
Req No.	Repair Properties and Requirements to be Identified and Substantiated.		1	2	3	4	5	6	7	8		
1100	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											