

APPENDIX 1

1. Purpose. Checklists provide DERs guidelines when determining substantiation requirements as they prepare Repair Substantiation Plans. The templates in this appendix provide guidance about how to develop the checklists for 17 common repair families and alterations DERs encounter, by identifying substantiation requirements for common repairs. Each template includes a technical section (Section 1), a regulatory section (Section 2), and common categories of repairs in a table format to assist the DER in ensuring that needed information is provided.

2. Instructions on use of the templates:

Each template shows both shaded and unshaded cells. Shaded cells are usually not applicable to the particular category of repair indicated at the top of the table. However, if the DER concludes the cell is applicable, he should provide substantiation. Un-shaded (clear) cells are usually applicable and the DER should provide substantiation. DERs may find that only certain items are applicable for a repair even though the checklist provides for a clear cell. In those cases, the DER should provide substantiating data as otherwise indicated, together with a short statement of why the DER concludes other items are not applicable.

3. Substantiation codes (use as applicable):

- N/A - Not Applicable (explain why separately).
- D - Documented FAA accepted methods, techniques and practices.
- A - Analysis of relevant data.
- I - Inspection (i.e, Metallurgical examination, Hardness Testing, NDT Inspection, etc).
- R - Rig testing.
- C - Component Testing.
- E - Engine Testing.

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- S - Similarity to a process successfully applied to an airworthy part. This position must be documented by relevant adequate data.

4. Sections 33.19 (Durability) and 33.91 (Engine Component Tests).

- a. The standards of §33.19 and 33.91 require further discussion because they are unique.

For pre-Amendment 6 engines, compliance to §33.19 Durability was based on test data extrapolated from the endurance engine demonstration. Amendment 6 adopted a new requirement for initial maintenance inspection, §33.90. The preamble to this amendment states:

“The present regulations do not require a direct demonstration of durability. Past practice relied largely upon extrapolation of the results of the 150-hr endurance qualification test, which is an accelerated severity test. Experience with recent new type engines indicates the desirability of a simulated service test to demonstrate the initial period prior to the first overhaul.”

Therefore, §33.90 is directly associated with demonstration of durability.

b. Compliance with §33.19 by the TC holders is accomplished through compliance with §§33.27, 33.63, 33.83, 33.87, 33.88, 33.90 by engine tests, and §33.91 by component tests. Section 33.91 allows alternative endurance testing when the FAA determines that engine testing cannot adequately substantiate compliance for some systems or components. Some TC holders have developed cyclic endurance tests, which are more representative of in-service operations, to evaluate later product improvements for certain parts, such as turbine blades. TC holders have used these alternative tests by to demonstrate compliance with the regulations pertinent to durability. Similarly, the FAA working with several TC holders has developed a

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list of component tests, generally referred to as the 36-items list, which enumerates a list of tests relevant to component qualification.

c. Using the repair requirements in each template provides FAA with the basis to assess the repaired component relative to its' original or properly altered condition with regard to aerodynamic function, structural strength, quality, reliability, operational characteristics or other characteristics affecting its' airworthiness. This assessment will also help identify the need to ICAs and aid FAA in ensuring quality controls are followed.

d. The following templates found in this appendix apply to typical repairs of class 2 parts:

Template	Title	Page
1	Bearing Compartment and Carbon Seal Parts Family	XX
2	Blades – High Pressure Turbine (HPT)	XX
3	Blades – Low Pressure Compressor (LPC) – High Pressure Compressor (HPC)	XX
4	Blades – Low Pressure Turbine (LPT)	XX
5	Combustor Parts Family	XX
6	Externals Parts Family	XX
7	Fuel Nozzle Parts family	XX
8	Gearbox Housing Assembly Parts Family	XX
9	LPC-HPC Stators – Vane Sector & Full Ring	XX
10	LPC – HPC Stators – Fixed	XX
11	Major Engine Cases	XX
12	Major Rotating Non-Life Limited Parts Family	XX
13	Seals Non-Rotating & Shrouds – HPC – HPT – LPT	XX
14	Static Parts (Other than Major Engine Cases)	XX

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15	Stators – Variable – LPC – HPC	XX
16	Vanes – HPT	XX
17	Vanes – LPT	XX

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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 based. If no repair description is appropriate, contact the FAA Advisor for guidance.

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

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

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

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

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

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

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Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8	9	10	11
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.											
	<p>a. Coating Material</p> <p>Composition</p> <p>b. Thickness, Coverage & Uniformity</p> <p>c. Coating and Diffusion Zone Microstructure</p> <p>d. Coating Hardness</p> <p>e. Sintering</p> <p>f. Strip Requirements / Process</p> <p>g. Residual Stress</p> <p>h. Resistance to Spalling</p> <p>i. Thermal Resistance (coefficient of thermal expansion for the coating)</p> <p>j. Erosion Resistance</p> <p>k. Bonding (Interface Contamination)</p> <p>l. Hydrogen Embrittlement (Plating)</p> <p>n. Compatibility With Base Material/Other Coatings</p>											
5.	Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness: <p>a. Burnishing</p> <p>b. Peening</p> <p>c. Butterfly Polish</p> <p>d. Mass Media Finishing</p>											

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

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

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Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8	9	10	11
11.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specs • Quality Requirements • Critical Process Validation needs 											
	Applicable FAR Part 33 Requirements											
	Subpart A General											
12.	33.04 Instructions for Continuous Airworthiness (ICA's)											
13.	33.05 Instruction manual for installing and operating the engine											
14.	33.07 Engine ratings and operating limitations											
	Airworthiness Standards to be Substantiated											
	Subpart A General											
15.	33.08 Selection of engine power and thrust ratings											
	Subpart B – Design and Construction; General											
16.	33.14 Start-stop cyclic stress (low cycle fatigue)											
17.	33.15 Materials											
18.	33.17 Fire prevention											
19.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; 33.90; and 33.91)											

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Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	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 Instrumentation 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 systems											
30.	33.67 Fuel system											
31.	33.68 Induction system icing (Operability aspects) (Note 2)											
32.	33.69 Ignition system											
33.	33.71 Lubrication system											
34.	33.72 Hydraulic actuating system											
35.	33.73 Power or thrust response											
36.	33.74 Continued rotation											

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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 (Operability aspects of ingestion)											
40.	33.78 Rain / Hail ingestion											
41.	33.79 Fuel burning thrust augments											
	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 over temperature 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											
	FAR 33 -Appendix A – Instructions for Continued Airworthiness											
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail											
	FAR 34 – Exhaust Emissions											

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Template 2

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

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

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

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

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

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

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		CATEGORIES OF REPAIR									
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		1	2	3	4	5	6	7	8	9
4.	<p>Select all Coating Properties / Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.</p> <p>a. Coating Material</p> <p> Composition</p> <p>b. Thickness, Coverage & Uniformity</p> <p>c. Coating and Diffusion Zone Microstructure</p> <p>d. Coating Hardness</p> <p>e. Sintering</p> <p>f. Strip Requirements / Process</p> <p>g. Residual Stress</p> <p>h. Resistance to Spalling</p> <p>i. Thermal Resistance (coefficient of thermal expansion for the coating)</p> <p>j. Erosion Resistance</p> <p>k. Bonding (Interface)</p> <p>l. Contamination</p> <p>m. Hydrogen Embrittlement (Plating)</p> <p>n. Compatibility With Base Material/Other Coatings</p>										

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

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		CATEGORIES OF REPAIR									
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		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): <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 										

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

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Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
11.	Platform width & (angel wing) Cross Notch / Cross Shroud geometry										
12.	Cooling (Total flow, flow split, back flow margin, hole exit geometry/angle/location, cross-over hole size, metering plate)										
	Repair Process Capability Technical Substantiation Requirements										
13.	Verification Plan with Significant Operations Identified for Repair Source Qualification										
14.	Process Demonstration (including variability requirements)										
15.	Part Demonstration/Inspection										
16.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 										
	Applicable FAR Part 33 Requirements										
	Subpart A General										
17.	33.04 Instructions for Continuous Airworthiness (ICA's)										
	Repair Process Capability Technical Substantiation Requirements										
18.	33.05 Instruction manual for installing and operating the engine										
19.	33.07 Engine ratings and operating limitations										
20.	33.08 Selection of engine power and thrust ratings										
	Subpart B – Design and Construction; General										
21.	33.14 Start-stop cyclic stress (low cycle fatigue)										

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Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
22.	33.15 Materials									
23.	33.17 Fire prevention									
24.	33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; 33.90; and 33.91)									
25.	33.21 Engine Cooling									
26.	33.23 Engine mounting attachments and structure									
27.	33.25 Accessory attachments									
28.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
	Subpart B – Design and Construction; General									
29.	33.28 Electrical and electronic control systems									
30.	33.29 Instrumentation connection									
	Subpart E – Design and construction: Turbine aircraft Engines									
31.	33.62 Stress Analysis									
32.	33.63 Vibration									
33.	33.65 Surge and stall characteristics (Note 2)									
34.	33.66 Bleed air systems									
35.	33.67 Fuel system									
36.	33.68 Induction system icing (Operability aspects) (Note 2)									
37.	33.69 Ignition system									
38.	33.71 Lubrication system									
39.	33.72 Hydraulic actuating system									
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 (Operability aspects of ingestion)									
45.	33.78 Rain hail ingestion									
46.	33.79 Fuel burning thrust augments									

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Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
	Subpart F – Block Tests; Turbine Aircraft Engines										
47.	33.83 Vibration test										
48.	33.85 Calibration tests										
49.	33.87 Endurance test										
50.	33.88 Engine over temperature test										
51.	33.89 Operation test (Note 2)										
52.	33.90 Initial maintenance inspection										
	Subpart F – Block Tests; Turbine Aircraft Engines										
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										
	FAR 33 -Appendix A – Instructions for Continued Airworthiness										
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail										
	FAR 34 – Exhaust Emissions										

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(Public comments phase SEPTEMBER 2004)

Template 3

REPAIR SUBSTANTIATION CHECKLIST – LOW PRESSURE COMPRESSURE (LPC) – HIGH PRESSURE COMPRESSURE (HPC) BLADE PART FAMILY

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

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Strip and Re-coat Repair <ul style="list-style-type: none"><li data-bbox="480 537 1187 562">• This repair removes and replaces any and all types of coatings
2.	Weld or Braze Repair (excludes detail parts replacement) <ul style="list-style-type: none"><li data-bbox="480 600 1175 625">• This repair includes restoration of airfoil tip and chord length
3.	Weld or Braze Repair <ul style="list-style-type: none"><li data-bbox="480 663 997 688">• This repair includes detail parts replacement
4.	Assembly or Disassembly <ul style="list-style-type: none"><li data-bbox="480 726 1373 821">• This repair removes and replaces detail parts without the use of permanent attachment techniques (i.e.: welding or brazing) but assembly is either bolted or riveted.
5.	Blend Repair
6.	Remove and Restore Anti-gallant Coating
7.	Dimensional Restoration by Coating or Plating
8.	Straightening, Re-twist or Re-forming Repair <ul style="list-style-type: none"><li data-bbox="480 953 859 978">• This repair includes dent repair
9.	Surface Treatment Repair <ul style="list-style-type: none"><li data-bbox="480 1016 1422 1068">• This repair includes shot-peen, glass bead peen, vibratory tumble (e.g. restoration of surface finish/texture)

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	
4.	<p>Select all Coating Properties / Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material <ul style="list-style-type: none"> 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) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings 										
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 										

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties & Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
	Critical Measurable Characteristics									
10.	Dovetail functional fit test									
11.	Part weight test:									
	a. Mass Weight									
	b. Moment Weight									
	Repair Process Capability Technical Substantiation Requirements									
12.	Technical Plan with Significant Operations Identified									
13.	Process Demonstration (including variability requirements)									
14.	Part Demonstration/Inspection									
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:									
	• Drawings/Specifications									
	• Quality Requirements									
	• Source Substantiation Requirements									
	Applicable FAR Part 33 Requirements									
	Subpart A General									
16.	33.04 Instructions for Continuous Airworthiness (ICA's)									
17.	33.05 Instruction manual for installing and operating the engine									
18.	33.07 Engine ratings and operating limitations									
19.	33.08 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; 33.90; and 33.91)									
24.	33.21 Engine Cooling									
25.	33.23 Engine mounting attachments and structure									
26.	33.25 Accessory attachments									

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties & Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
		1	2	3	4	5	6	7	8	9
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
28.	33.28 Electrical and electronic control systems									
29.	33.29 Instrumentation connection									
	Subpart E – Design and Construction : Turbine Aircraft Engines									
30.	33.62 Stress Analysis									
31.	33.63 Vibration									
32.	33.65 Surge and stall characteristics (Note 2)									
33.	33.66 Bleed air systems									
34.	33.67 Fuel system									
35.	33.68 Induction system icing (Operability aspects) (Note 2)									
36.	33.69 Ignition system									
37.	33.71 Lubrication system									
38.	33.72 Hydraulic actuating system									
39.	33.73 Power or thrust response									
	Subpart E – Design and Construction: Turbine Aircraft Engines									
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 hail ingestion									
45.	33.79 Fuel burning thrust augments									
	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 over temperature 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									

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(Public comments phase SEPTEMBER 2004)

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

Template 4

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

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

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
3.	<p>Select all Material Properties / Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness.</p> <p>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)</p> <p>b. Porosity (weldment)</p> <p>c. Diffusion Zone (brazing)</p> <p>d. Heat Affected Zone (welding)</p>								
4.	<p>Coating Material Properties, Characteristics & Processes:</p> <p>a. Deposited Material Composition</p> <p>b. Thickness, Coverage & Uniformity</p> <p>c. Microstructure</p> <p>d. Hardness</p> <p>e. Sintering</p> <p>f. Strip Process</p> <p>g. Residual Stress</p> <p>h. Lubricant Properties</p> <p>i. Spalling Resistance</p> <p>j. Thermal Resistance</p> <p>k. Erosion Resistance</p> <p>l. Bonding (Interface Contamination)</p> <p>m. Environmental Resistance</p> <p>n. Diffusion Zone</p> <p>o. Hydrogen Embrittlement Free (Plating)</p> <p>p. Compatibility With Base Material</p>								

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		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, 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.								

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Critical Measurable Characteristics									
10.	Part Weight: a. Moment b. Mass									
11.	Platform width & (angel wing) Cross Notch /Cross Shroud geometry									
	MPE Repair Process Capability Technical Substantiation Requirements									
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
13.	Process Demonstration (including variability requirements)									
14.	Part Demonstration/Inspection									
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									
	Applicable FAR Part 33 Requirements									
	Subpart A General									
16.	33.04 Instructions for Continuous Airworthiness (ICA's)									
17.	33.05 Instruction manual for installing and operating the engine									

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Subpart A General									
18.	33.07 Engine ratings and operating limitations									
19.	33.08 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; 33.90; and 33.91)									
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 Instrumentation connection									
	Subpart E – Design and construction: Turbine aircraft Engines									
30.	33.62 Stress Analysis									
31.	33.63 Vibration									
32.	33.65 Surge and stall characteristics (Note 2)									
33.	33.66 Bleed air systems									
34.	33.67 Fuel system									
35.	33.68 Induction system icing (Operability aspects) (Note 2)									
36.	33.69 Ignition system									
37.	33.71 Lubrication system									
38.	33.72 Hydraulic actuating system									
39.	33.73 Power or thrust response									

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Subpart E – Design and construction: Turbine aircraft Engines (continued)									
40.	33.74 Continued rotation									
41.	33.75 Safety Analysis									
42.	33.76 Bird Ingestion (Operability aspects of ingestion)									
43.	33.77 Foreign object ingestion (Operability aspects of ingestion)									
44.	33.78 Rain hail ingestion									
45.	33.79 Fuel burning thrust augments									
	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 over temperature 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									
	Subpart F – Block Tests; Turbine Aircraft Engines									
57.	33.96 Engine tests in auxiliary power unit (APU) mode									
58.	33.97 Thrust reversers									
59.	33.99 General conduct of block tests									
	FAR 33 -Appendix A – Instructions for Continued Airworthiness									
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail									
	FAR 34 – Exhaust Emissions									



Template 5

REPAIR SUBSTANTIATION CHECKLIST - COMBUSTOR PART FAMILY

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

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s):									
	<ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight 									
	Critical Measurable Characteristics									
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): <ul style="list-style-type: none"> a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects g. Roundness h. Flatness i. Parallelism j. Concentricity k. True Position Tolerances l. Edge Distance Requirements m. Finish Dimensions Requirements n. Diameter / Locating o. Air Swirler Features p. Mixing Air (dilution) Features q. Datum Location Features r. Air Cooling Hole Diameter s. Flowpath Exit Features t. Sealing Features u. Aft Seal v. Fuel Nozzles w. Igniter interfaces x. Flanges 									

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Repair Process Capability Technical Substantiation Requirements								
13.	Process Demonstration Including: a. Variability Requirements								
14.	Part Demonstration/Inspection								
15.	Manufacturing Requirements for fabrication of repair details or replacement sections to accomplish repair: a. Drawings/Specifications b. Quality Requirements c. Source Substantiation Requirements								
	Applicable FAR Part 33 Requirements								
	Subpart A General								
16.	33.04 Instructions for Continuous Airworthiness (ICA's)								
17.	33.05 Instruction Manual for Installing and Operating the Engine								
18.	33.07 Engine Ratings and Operating Limitations								
	Applicable FAR Part 33 Requirements Subpart A General, Continued								
19.	33.08 Selection of Engine Power and Thrust Ratings								
	Subpart B – Design and Construction ; General								
20.	33.14 Start-stop cyclic stress (low cycle fatigue)								
	Subpart B – Design and Construction; General								
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; 33.90; and 33.91)								
24.	33.21 Engine								
25.	33.23 Engine mounting attachments and structure								
26.	33.25 Accessory attachments								

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
27.	33.27 Turbine, compressor, fan, and turbo supercharger rotors								
28.	33.28 Electrical and electronic control systems								
29.	33.29 Instrumentation connection								
	Subpart E – Design and Construction: Turbine Aircraft Engines								
30.	33.62 Stress Analysis								
31.	33.63 Vibration								
32.	33.65 Surge and stall characteristics, (Note 2)								
33.	33.66 Bleed air systems								
34.	33.67 Fuel system								
35.	33.68 Induction system icing, (Operability Aspects) (Note 2)								
36.	33.69 Ignition system								
37.	33.71 Lubrication system								
38.	33.72 Hydraulic actuating system								
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 hail ingestion								
	Subpart E – Design and Construction : Turbine Aircraft Engines, Continued								
45.	33.79 Fuel burning thrust augments								
	Subpart F – Block Tests; Turbine Aircraft Engines continued								
46.	33.83 Vibration test								
47.	33.85 Calibration tests								
48.	33.87 Endurance tests								
49.	33.88 Engine over temperature 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								

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Template 6

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

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

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
		1	2	3	4	5	6	7	8	9	10
3.	<p>Select all Material Properties / Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness.</p> <p>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)</p> <p>b. Porosity (weldment)</p> <p>c. Diffusion Zone (brazing)</p> <p>d. Heat Affected Zone (welding)</p>										
4.	<p>Coating & Plating Material Properties Characteristics & Processes:</p> <p>a. Deposited Material Composition</p> <p>b. Thickness, Coverage & Uniformity</p> <p>c. Microstructure</p> <p>d. Hardness</p> <p>e. Sintering</p> <p>f. Strip Process</p> <p>g. Residual Stress</p> <p>h. Lubricant Properties</p> <p>i. Spalling Resistance</p> <p>j. Thermal Resistance</p> <p>k. Erosion Resistance</p> <p>l. Bonding (Interface Contamination)</p> <p>m. Environmental Resistance</p> <p>n. Diffusion Zone</p> <p>o. Hydrogen Embrittlement Free (Plating)</p> <p>p. Compatibility With Base Material</p>										
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <p>a. Burnishing</p> <p>b. Peening</p> <p>c. Butterfly Polish</p> <p>d. Mass Media Finishing</p>										

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR										
			1	2	3	4	5	6	7	8	9	10
	Repair Process Capability Technical Substantiation Requirements											
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification											
13.	Process Demonstration (including variability requirements)											
14.	Part Demonstration/Inspection											
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 											
	Applicable FAR Part 33 Requirements											
	Subpart A General											
16.	33.04 Instructions for Continuous Airworthiness (ICA's)											
17.	33.05 Instruction manual for installing and operating the engine											
18.	33.07 Engine ratings and operating limitations											
19.	33.08 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; 33.90; and 33.91)											
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											

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR										
			1	2	3	4	5	6	7	8	9	10
	Subpart B – Design and Construction; General											
28.	33.28 Electrical and electronic control systems											
29.	33.29 Instrumentation 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 systems											
34.	33.67 Fuel system											
35.	33.68 Induction system icing (Operability aspects) (Note 2)											
36.	33.69 Ignition system											
37.	33.71 Lubrication system											
38.	33.72 Hydraulic actuating system											
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 / Hail ingestion											
45.	33.79 Fuel burning thrust augments											
	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 over temperature test											

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Template 7

REPAIR SUBSTANTIATION CHECKLIST - FUEL NOZZLE PART FAMILY

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

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
		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.							
	<ul style="list-style-type: none"> a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc 							

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	
3.	<p>Select all Material Properties / Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness.</p> <p>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)</p> <p>b. Porosity (weldment)</p> <p>c. Diffusion Zone (brazing)</p> <p>d. Heat Affected Zone (welding)</p>								
4.	<p>Select all Coating Properties / Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.</p> <p>a. Coating Material Composition</p> <p>b. Thickness, Coverage & Uniformity</p> <p>c. Coating and Diffusion Zone Microstructure</p> <p>d. Coating Hardness</p> <p>e. Sintering</p> <p>f. Strip Requirements / Process</p> <p>g. Residual Stress</p> <p>h. Resistance to Spalling</p> <p>i. Thermal Resistance (coefficient of thermal expansion for the coating)</p> <p>j. Erosion Resistance</p> <p>k. Bonding (Interface Contamination)</p> <p>m. Hydrogen Embrittlement (Plating)</p> <p>n. Compatibility With Base Material/Other Coatings</p>								

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
		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 (K_I) 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.							

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
	Critical Measurable Characteristics								
10.	Material Debit Due To:								
	<ul style="list-style-type: none"> a. Heat Treat b. Weld, Braze, Coat or Plate Processes c. Machine Process d. Blend e. Hone f. Lap g. Grit Blast h. Strip 								
11.	Flow Volume								
12.	Flow Pattern								
13.	Pressure / Leak Test								
	Repair Process Capability Technical Substantiation Requirements								
14.	Verification Plan with Significant Operations Identified for Repair Source Qualification								
15.	Process Demonstration (including variability requirements)								
16.	Part Demonstration / Inspection								
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:								
	<ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 								
	Applicable FAR Part 33 Requirements								
	Subpart A General								
18.	33.04 Instructions for Continuous Airworthiness (ICA's)								
19.	33.05 Instruction manual for installing and operating the engine								
20.	33.07 Engine ratings and operating limitations								
21.	33.08 Selection of engine power and thrust ratings								

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
			1	2	3	4	5	6
	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; 33.90; and 33.91)							
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 Instrumentation 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 systems							
36.	33.67 Fuel system							
37.	33.68 Induction system icing (Operability aspects)(Note 2)							
38.	33.69 Ignition system							
39.	33.71 Lubrication system							
40.	33.72 Hydraulic actuating system							
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 hail ingestion							
47.	33.79 Fuel burning thrust augmenter							

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
	Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements								
	Subpart F – Block Tests; Turbine Aircraft Engines								
48.	33.83 Vibration test								
49.	33.85 Calibration tests								
50.	33.87 Endurance test								
51.	33.88 Engine over temperature 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								
	Appendix A – Instructions for Continued Airworthiness								
	Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail								
	FAR 34 – Exhaust Emissions								

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(Public comments phase SEPTEMBER 2004)

Template 8

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

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

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
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.

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
1.	<p>Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <ul style="list-style-type: none"> a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc 												

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
3.	<p>Select all Material Properties / Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness.</p> <p>k. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)</p> <p>l. Porosity (weldment)</p> <p>m. Diffusion Zone (brazing)</p> <p>n. Heat Affected Zone (welding)</p>												
4.	<p>Coating & Plating Material Properties Characteristics & Processes:</p> <p>a. Deposited Material Composition</p> <p>b. Thickness, Coverage & Uniformity</p> <p>c. Microstructure</p> <p>d. Hardness</p> <p>e. Sintering</p> <p>f. Strip Process</p> <p>g. Residual Stress</p> <p>h. Lubricant Properties</p> <p>i. Spalling Resistance</p> <p>j. Thermal Resistance</p> <p>k. Erosion Resistance</p> <p>l. Bonding (Interface Contamination)</p> <p>m. Environmental Resistance</p> <p>n. Diffusion Zone</p> <p>o. Hydrogen Embrittlement Free (Plating)</p> <p>p. Compatibility With Base Material</p>												

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR											
		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 e. 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.												
	f. Machining, Milling, Broaching, or Grinding g. Non-traditional Machining h. Welding, Brazing or Coating i. Straightening, re-twisting, re-forming j. Blending k. Honing l. Lapping m. Grit Blast n. Stripping o. Cleaning (Chemical, power flash, Ultrasonic) p. Residual Plating, Stripping, or Cleaning Agents q. Stress Intensity Factor (K _t) r. Heat Treatment (time, temp, atmosphere, etc) s. Plating t. Dimensional Short-falls u. Repetitive or Conflicting Repairs v. Contamination												

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.												
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): <ul style="list-style-type: none"> a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics o. Weight p. Center of Gravity q. Moment of Weight 												

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR												
			1	2	3	4	5	6	7	8	9	10	11	12
	Critical Measurable Characteristics													
9.	Bearing Bore: a. Dimension b. Location													
10.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements 													

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
	Critical Measurable Characteristics continued												
11	Oil Nozzle Flow Test												
	Repair Process Capability Technical Substantiation Requirements												
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification												
13.	Process Demonstration (including variability requirements)												
14.	Part Demonstration/Inspection												
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 												
	Applicable FAR Part 33 Requirements												
	Subpart A General												
16.	33.04 Instructions for Continuous Airworthiness (ICA's)												
17.	33.05 Instruction manual for installing and operating the engine												
18.	33.07 Engine ratings and operating limitations												
19.	33.08 Selection of engine power and thrust ratings												

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR											
		1	2	3	4	5	6	7	8	9	10	11	12
	Subpart B – Design and Construction ; General												
20.	33.14 Start-stop cyclic stress (low cycle fatigue)												
21.	33.15 Materials												
22.	33.17 Fire prevention												
23.	33.19 Durability(Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; 33.90; and 33.91)												
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 Instrumentation connection												
	Subpart E – Design and Construction: Turbine Aircraft Engines												
30.	33.62 Stress Analysis												
31.	33.63 Vibration												
32.	33.65 Surge and stall characteristics (Note 2)												
33.	33.66 Bleed air systems												
34.	33.67 Fuel system												
35.	33.68 Induction system icing (Operability aspects) (Note 2)												
36.	33.69 Ignition system												
37.	33.71 Lubrication system												
38.	33.72 Hydraulic actuating system												
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)												

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Template 9

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

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

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			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 e. 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 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.										

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(Public comments phase SEPTEMBER 2004)

Critical Measurable Characteristics											
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight										
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects <ul style="list-style-type: none"> • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances <ul style="list-style-type: none"> • Edge Distance • Requirements • Finish Dimensions Requirements g. Airfoil Profile h. Leading & Trailing Edge Contours i. Concave & Convex Contours j. Thickness k. Chord & Tip Length l. Twist/Lean/Bow										
Critical Measurable Characteristics											
10.	Outer Band Rail Functional Fit										
11.	Inner Band Arc Length										
12.	Outer Band to Inner Band Dim Relationship										
13.	Assembled Honeycomb Inner Radius										

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Repair Process Capability Technical Substantiation Requirements									
14.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
15.	Process Demonstration (including variability requirements)									
16.	Part Demonstration/Inspection									
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									
	Applicable FAR Part 33 Requirements									
	Subpart A General									
18.	33.04 Instructions for Continuous Airworthiness (ICA's)									
19.	33.05 Instruction manual for installing and operating the engine									
20.	33.07 Engine ratings and operating limitations									
21.	33.08 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; 33.90; and 33.91)									
26.	33.21 Engine Cooling									
27.	33.23 Engine mounting attachments and structure									
28.	33.25 Accessory attachments									

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
	Repair Process Capability Technical Substantiation Requirements										
	Subpart B – Design and Construction ; General										
29.	33.27 Turbine, compressor, fan, and turbosupercharger										
30.	33.28 Electrical and electronic control systems										
31.	33.29 Instrumentation 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 systems										
36.	33.67 Fuel system										
37.	33.68 Induction system icing (Operability aspects) (Note 2)										
38.	33.69 Ignition system										
39.	33.71 Lubrication system										
40.	33.72 Hydraulic actuating system										
41.	33.73 Power or thrust response										
	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 (Operability aspects of ingestion)										
46.	33.78 Rain hail ingestion										
47.	33.79 Fuel burning thrust augments										
	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 over temperature test										
51.	33.89 Operation test (Note 2)										

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Template 10

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

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

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Dimensional Restoration by Coating or Plating
2.	Weld or Braze Repair <ul style="list-style-type: none"><li data-bbox="440 600 967 632">• This repair excludes detail part replacement
3.	Blend Repair
4.	Surface Treatment Repair <ul style="list-style-type: none"><li data-bbox="440 699 1289 753">• This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR			
		1	2	3	4
	Applicable FAR Part 33 Requirements				
	Subpart A General				
18.	33.04 Instructions for Continuous Airworthiness (ICA's)				
19.	33.05 Instruction manual for installing and operating the engine				
20.	33.07 Engine ratings and operating limitations				
21.	33.08 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; 33.90; and 33.91)				
26.	33.21 Engine Cooling				
27.	33.23 Engine mounting attachments and structure				
28.	33.25 Accessory attachments				
29.	33.27 Turbine, compressor, fan, and turbosupercharger rotors				
30.	33.28 Electrical and electronic control systems				
31.	33.29 Instrumentation 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 systems				
36.	33.67 Fuel system				
37.	33.68 Induction system icing (Operability aspects) (Note 2)				
38.	33.69 Ignition system				
39.	33.71 Lubrication system				
40.	33.72 Hydraulic actuating system				
41.	33.73 Power or thrust response				

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR			
		1	2	3	4
	Subpart E – Design and Construction : Turbine Aircraft Engines (continued)				
42.	33.74 Continued rotation				
43.	33.75 Safety Analysis				
44.	33.76 Bird Ingestion (Operability aspects of ingestion)				
45.	33.77 Foreign object ingestion (Operability aspects of ingestion)				
46.	33.78 Rain hail ingestion				
47.	33.79 Fuel burning thrust augments				
	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 over temperature 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				
	FAR 33 -Appendix A – Instructions for Continued Airworthiness				
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail				
	FAR 34 – Exhaust Emissions				

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(Public comments phase SEPTEMBER 2004)

Template 11

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

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
14.	Part Demonstration/Inspection										
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:										
	<ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 										
	Applicable FAR Part 33 Requirements										
	Subpart A General										
16.	33.04 Instructions for Continuous Airworthiness (ICA's)										

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIRS									
		1	2	3	4	5	6	7	8	9	10
17.	33.05 Instruction manual for installing and operating the engine										
18.	33.07 Engine ratings and operating limitations										
19.	33.08 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; 33.90; and 33.91)										
24.	33.21 Engine Cooling										
25.	33.23 Engine mounting attachments and structure										
	Subpart B – Design and Construction; General										
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 Instrumentation connection										
	Subpart E – Design and construction : Turbine aircraft Engines										
30.	33.62 Stress Analysis										
31.	33.63 Vibration										
32.	33.65 Surge and stall characteristics (Note 2)										
33.	33.66 Bleed air systems										
34.	33.67 Fuel system										
35.	33.68 Induction system icing (Operability aspects) (Note 2)										
36.	33.69 Ignition system										
37.	33.71 Lubrication system										
38.	33.72 Hydraulic actuating system										
39.	33.73 Power or thrust response										
	Subpart E – Design and construction : Turbine aircraft Engines (continued)										
40.	33.74 Continued rotation										

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIRS										
			1	2	3	4	5	6	7	8	9	10
	Subpart F – Block Tests; Turbine Aircraft Engines											
41.	33.75 Safety Analysis											
42.	33.76 Bird Ingestion (Operability aspects of ingestion)											
43.	33.77 Foreign object ingestion (Operability aspects of ingestion)											
44.	33.78 Rain hail ingestion											
45.	33.79 Fuel burning thrust augments											
	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 over temperature 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											
	FAR 33 -Appendix A – Instructions for Continued Airworthiness											
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail											
	FAR 34 – Exhaust Emissions											

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(Public comments phase SEPTEMBER 2004)

Template 12

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

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

CATEGORIES OF REPAIRS	REPAIR DESCRIPTION
1.	Restoration of Protective Coating (Paint, Aluminizing, Oil, etc.) <ul style="list-style-type: none">• Includes touch-up coating
2.	Weld or Braze Repair <ul style="list-style-type: none">• This repair excludes detail part replacement
3.	Assembly and/or Disassembly <ul style="list-style-type: none">• This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
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 <ul style="list-style-type: none">• This repair includes lapping, skim cut, non-conventional machining

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			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, 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.	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.									

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Repair Process Capability Technical Substantiation Requirements									
13.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
14.	Process Demonstration (including variability requirements)									
15.	Part Demonstration/Inspection									
16.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									
	Applicable FAR Part 33 Requirements									
	Subpart A General									
17.	33.04 Instructions for Continuous Airworthiness (ICA's)									
18.	33.05 Instruction manual for installing and operating the engine									
19.	33.07 Engine ratings and operating limitations									
20.	33.08 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; 33.90; and 33.91)									
25.	33.21 Engine Cooling									

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
	Subpart B – Design and Construction ; General										
26.	33.23 Engine mounting attachments and structure										
27.	33.25 Accessory attachments										
28.	33.27 Turbine, compressor, fan, and turbo-supercharger										
29.	33.28 Electrical and electronic control systems										
30.	33.29 Instrumentation connection										
	Subpart E – Design and Construction: Turbine Aircraft Engines										
31.	33.62 Stress Analysis										
32.	33.63 Vibration										
33.	33.65 Surge and stall characteristics (Note 2)										
34.	33.66 Bleed air systems										
35.	33.67 Fuel system										
36.	33.68 Induction system icing (Operability aspects) (Note 2)										
37.	33.69 Ignition system										
38.	33.71 Lubrication system										
39.	33.72 Hydraulic actuating system										
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 (Operability aspects of ingestion)										
45.	33.78 Rain hail ingestion										
46.	33.79 Fuel burning thrust augments										

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	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 over temperature 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									
	FAR 33 -Appendix A – Instructions for Continued Airworthiness									
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail									
	FAR 34 – Exhaust Emissions									

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(Public comments phase SEPTEMBER 2004)

Template 13

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

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

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		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 b. 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 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 major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight								
Critical Measurable Characteristics									

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Applicable FAR Part 33 Requirements								
	Subpart A General								
16.	33.04 Instructions for Continuous Airworthiness (ICA's)								
17.	33.05 Instruction manual for installing and operating the engine								
18.	33.07 Engine ratings and operating limitations								
19.	33.08 Selection of engine power and thrust ratings								
	Applicable FAR Part 33 Requirements								
	Subpart B – Design and Construction ; General								
20.	33.14 Start-stop cyclic stress (low cycle fatigue)								
21.	33.15 Materials								
22.	33.17 Fire prevention								
23.	33.19 Durability(Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; 33.90; and 33.91)								
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 Instrumentation connection								
	Subpart E – Design and Construction: Turbine Aircraft Engines								
30.	33.62 Stress Analysis								
31.	33.63 Vibration								
32.	33.65 Surge and stall characteristics (Note 2)								
33.	33.66 Bleed air systems								
34.	33.67 Fuel system								
35.	33.68 Induction system icing (Operability aspects) (Note 2)								
36.	33.69 Ignition system								
37.	33.71 Lubrication system								
38.	33.72 Hydraulic actuating system								
39.	33.73 Power or thrust response								
40.	33.74 Continued rotation								
41.	33.75 Safety Analysis								

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Subpart E – Design and Construction: Turbine Aircraft Engines								
42.	33.76 Bird Ingestion (Operability aspects of ingestion)								
43.	33.77 Foreign object ingestion (Operability aspects of ingestion)								
44.	33.78 Rain hail ingestion								
45.	33.79 Fuel burning thrust augments								
	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 over temperature 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								
	FAR 33 -Appendix A – Instructions for Continued Airworthiness								
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail								
	FAR 34 – Exhaust Emissions								

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(Public comments phase SEPTEMBER 2004)

Template 14

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

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

CATEGORY OF REPAIR	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 attachment Techniques, i.e., welded or brazed, assembly is either bolted or riveted.
5.	Dimensional Restoration Coating or Plating
6.	Straightening, Re-twist or Reforming Repair
	• This repair includes dent repair.

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
4.	<p>Select all Coating Properties / Characteristics that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.</p> <ul style="list-style-type: none"> a. Coating Material <ul style="list-style-type: none"> 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) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings 						
	Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements						
5.	<p>Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:</p> <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 						

DRAFT

(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No	Repair Properties & Requirement to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
			1	2	3	4	5	6
13.	Process Demonstration: • Including variability requirements							
14.	Part Demonstration / Inspection							
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements							
	Applicable FAR Part 33 Requirements							
	Subpart A General							
16.	33.04 Instructions for Continuous Airworthiness (ICA's)							
17.	33.05 Instruction manual for installing and operating the engine							
	Subpart A General							
18.	33.07 Engine ratings and operating limitations							
19.	33.08 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; 33.90; and 33.91)							
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							

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(Public comments phase SEPTEMBER 2004)

Req No	Repair Properties & Requirement to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
			1	2	3	4	5	6
	Subpart B – Design and Construction ; General : continued							
28.	33.28 Electrical and electronic control systems							
29.	33.29 Instrumentation 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 systems							
34.	33.67 Fuel system							

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(Public comments phase SEPTEMBER 2004)

Req No	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR					
		1	2	3	4	5	6
	Subpart E – Design and construction : Turbine aircraft Engines						
35.	33.68 Induction system icing						
36.	33.69 Ignition system						
37.	33.71 Lubrication system						
38.	33.72 Hydraulic actuating system						
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 hail ingestion						
45.	33.79 Fuel burning thrust augments						
	Subpart F – Block Tests; Turbine Aircraft Engines						
46.	33.83 Vibration test						
47.	33.85 Calibration tests						
48.	33.87 Endurance test, Note 2						
49.	33.88 Engine over temperature 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						
	FAR 33=Appendix A – Instructions for Continued Airworthiness	DER					
	FAR 33=Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail						
	FAR 34 – Exhaust Emissions						

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(Public comments phase SEPTEMBER 2004)

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 fit the repair proposal based. If no repair description is appropriate, contact the FAA Advisor for guidance.

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR			
		1	2	3	4
	Repair Process Capability Technical Substantiation Requirements				
14.	Technical Plan with Significant Operations Identified				
15.	Process Demonstration (including variability requirements)				
16.	Part Demonstration/Inspection				
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 				
	Applicable FAR Part 33 Requirements				
	Subpart A General				
18.	33.04 Instructions for Continuous Airworthiness (ICA's)				
19.	33.05 Instruction manual for installing and operating the engine				
20.	33.07 Engine ratings and operating limitations				
21.	33.08 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; 33.90; and 33.91)				
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 Instrumentation connection				
	Subpart E – Design and Construction: Turbine Aircraft Engines				
32.	33.62 Stress Analysis				
33.	33.63 Vibration				

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR			
		1	2	3	4
	Subpart E – Design and Construction: Turbine Aircraft Engines				
34.	33.65 Surge and stall characteristics (Note 2)				
35.	33.66 Bleed air systems				
36.	33.67 Fuel system				
37.	33.68 Induction system icing (Operability aspects) (Note 2)				
38.	33.69 Ignition system				
39.	33.71 Lubrication system				
40.	33.72 Hydraulic actuating system				
41.	33.73 Power or thrust response				
	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 (Operability aspects of ingestion)				
46.	33.78 Rain hail ingestion				
47.	33.79 Fuel burning thrust augments				
	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 over temperature test				
52.	33.89 Operation test (Note 2)				
53.	33.90 Initial maintenance inspection				
54.	33.91 Engine component tests (HCF/LCF bench testing)				

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Template 16

REPAIR SUBSTANTIATION CHECKLIST - HPT VANE PART FAMILY

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

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

DRAFT

(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
	Repair Process Capability Technical Substantiation Requirements								
14.	Part Demonstration/Inspection								
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 								
	Applicable FAR Part 33 Requirements								
	Subpart A General								
16.	33.04 Instructions for Continuous Airworthiness (ICA's)								
17.	33.05 Instruction manual for installing and operating the engine								
18.	33.07 Engine ratings and operating limitations								
19.	33.08 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; 33.90; and 33.91)								
24.	33.21 Engine Cooling								
25.	33.23 Engine mounting attachments and structure								
26.	33.25 Accessory attachments								
	Subpart B – Design and Construction; General								
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors								
28.	33.28 Electrical and electronic control systems								
29.	33.29 Instrumentation connection								
	Subpart E – Design and construction : Turbine aircraft Engines								
30.	33.62 Stress Analysis								
31.	33.63 Vibration								

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
		1	2	3	4	5	6	7
32.	33.65 Surge and stall characteristics (Note 2)							
33.	33.66 Bleed air systems							
34.	33.67 Fuel system							
35.	33.68 Induction system icing (Operability aspects) (Note 2)							
36.	33.69 Ignition system							
37.	33.71 Lubrication system							
38.	33.72 Hydraulic actuating system							
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 hail ingestion							
45.	33.79 Fuel burning thrust augments							
	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 over temperature test							
	Subpart F – Block Tests; Turbine Aircraft Engines							
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							
	FAR 33 -Appendix A – Instructions for Continued Airworthiness							
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail							
	FAR 34 – Exhaust Emissions							

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(Public comments phase SEPTEMBER 2004)

Template 17

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

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

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

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(Public comments phase SEPTEMBER 2004)

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		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.								
	<ul style="list-style-type: none"> a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc 								

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(Public comments phase SEPTEMBER 2004)

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

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Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		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.								
	<ul style="list-style-type: none"> a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 								

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Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		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.								
	<ul style="list-style-type: none"> a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface Contamination) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings 								
5.	Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness: <ul style="list-style-type: none"> a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing 								

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

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

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Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Repair Process Capability Technical Substantiation Requirements									
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: <ul style="list-style-type: none"> • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements 									
	Applicable FAR Part 33 Requirements									
	Subpart A General									
16.	33.04 Instructions for Continuous Airworthiness (ICA's)									
17.	33.05 Instruction manual for installing and operating the engine									
18.	33.07 Engine ratings and operating limitations									
19.	33.08 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; 33.90; and 33.91)									
24.	33.21 Engine Cooling									
25.	33.23 Engine mounting attachments and structure									
26.	33.25 Accessory attachments									

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Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8
	Subpart B – Design and Construction ; General									
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
28.	33.28 Electrical and electronic control systems									
29.	33.29 Instrumentation connection									
	Subpart E – Design and construction: Turbine aircraft Engines									
30.	33.62 Stress Analysis									
31.	33.63 Vibration									
32.	33.65 Surge and stall characteristics (Note 2)									
33.	33.66 Bleed air systems									
34.	33.67 Fuel system									
35.	33.68 Induction system icing (Operability aspects) (Note 2)									
36.	33.69 Ignition system									
37.	33.71 Lubrication system									
38.	33.72 Hydraulic actuating system									
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 hail ingestion									
45.	33.79 Fuel burning thrust augmenter									

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Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
		1	2	3	4	5	6	7	8
	Subpart F – Block Tests; Turbine Aircraft Engines								
46.	33.83 Vibration test								
47.	33.85 Calibration tests								
48.	33.87 Endurance test								
49.	33.88 Engine over temperature 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								
	FAR 33 -Appendix A – Instructions for Continued Airworthiness								
	FAR 33 -Appendix B- Certification Standard Atmospheric Concentrations of Rain and Hail								
	FAR 34 – Exhaust Emissions								