APPENDIX 1

1. Purpose. Templates provide guidelines for developing technical and substantiation data to support repair designs and their accompanying substantiation plans for category 2 parts. This appendix includes templates for recurrent major repairs and major alterations related to 17 engine part families. 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 applicant in developing appropriate technical and substantiation data.

2. Instructions on use of the templates. Each template shows both shaded and un-shaded (clear) cells corresponding to a typical repair and specific engineering, technical and regulatory considerations. Shaded cells are usually not applicable to the repair or alteration indicated at the top of the table. However, if the applicant concludes that the cell is applicable, he should provide the subsequent substantiation. The engineering and technical considerations associated with the clear cells were developed based on part family characteristics. The applicant is responsible to determine which apply for the specific repair or alteration proposed within that part family. The applicant should then review the associated regulatory considerations, determine applicability and identify the corresponding methods of compliance and provide the supporting substantiation data. Typical methods of showing compliance are identified as follows:

- D - Documentation, e.g. Instructions for Continued Airworthiness.
- 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.

- S - Similarity to previously FAA approved data. This method requires substantiation that the data is applicable to the proposed repair.

3. Applicable Airworthiness Requirements.

a. Historically the regulations repair applicants typically identified for compliance of major repairs on turbine engine parts were §§ 33.15, Materials and 33.19, Durability. Sample statements, such as the material is the same, therefore durability is not affected, were often provided as the substantiation with little to no data to support those statements. Conventional compliance to §33.19 is usually based on successful compliance to many other regulations found in part 33. For engines type certificated to part 33 pre-Amendment 6 regulations, compliance to §33.19 was based on test data extrapolated from §§33.87, Endurance test and 33.83, Vibration test, test or analysis from §33.63, Vibration as well as other regulations when determined applicable, such as §33.27, Turbine rotors. Part 33 Amendment 6 adopted new requirements, such as §33.88 Overtemperature test, and §33.90, Initial maintenance inspection (IMI) test. The preamble to §33.90 Amendment 6 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."

This information clearly links endurance and IMI testing as means of compliance in support of §33.19. Thus, substantiation for durability must include data used to show compliance to other applicable regulations.

b. The templates identify the latest part 33 regulations, Amendments 1-20, inclusive, applicable to turbine engines. Clear cells are used to show regulations that can be affected by the individual proposed repair types for each part family and require substantiation. The applicant is still responsible to review the repair and assess the adequacy and applicability of the guidance offered. The applicant can elect to default to those regulations that were identified as part of the certification basis of the engine on which the repaired or altered part is to be installed on, or elect to comply with the latest amendment; we ask only that the applicant declare which basis they are following and supply the necessary substantiating data to support those regulations that were identified as applicable.

c. Using the guidance offered in each template provides the FAA with the basis to assess the repaired or altered part's capability 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.

4. **Listing of Available Templates.**

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

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 • This repair includes touch-up coating
2.	Weld or Braze Repair • This repair excludes detail part replacement
3.	Weld or Braze Repair • This repair includes detail part replacement
4.	Assembly and/or Disassembly ➢ This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
5.	Blend Repair
6.	Dimensional Restoration by Coating or Plating
7.	Bushing / Helicoil Repair
8.	Straightening, Re-twist, or Reforming Repair • This repair includes straightening of bent knife edges
9.	Surface Treatment Repair • This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)
10.	Machining Repair • This repair includes lapping, skim cut, non-conventional machining
11.	Restoration of adhesives, bonding agents, potting compound

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

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

Req No.	Repair Design Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9	10	11
1.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc											

Req No.	Repair Design Requirements to be Identified and Substantiated.	1	2	3	4	5	6	7	8	9	10	11
2.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness: **<u>Mechanical Properties:</u>** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **<u>Metallurgical Properties:</u>** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **<u>Physical Properties:</u>** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia											

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

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.											
	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: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing											

Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8	9	10	11
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											

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 • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements											
10.	Significant Operations Identified for Validation that would include parameter variability limits											

Req No.	Repair Design Requirements to be Identified and Substantiated, 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: • 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; and 33.90)											

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											

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 augmenter											
	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											

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 • This repair removes and replaces all types of coatings.
3.	Weld or Braze Repair (excludes detail parts replacement) • Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair • Includes detail parts replacement
5.	Surface Treatment Repair Including shot-peen, glass bead peen, and vibratory tumble (e.g.; restoration of surface finish/texture).
6.	Blend Repair
7.	Blade Internal Cavity Cleaning Repair
8.	Sulfidation or Corrosion Repair
9.	Assembly and/or disassembly. This repair removes and replaces details parts without the use of permanent attachment techniques (i.e.: welding or brazing) but assembly is either bolted or riveted.

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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc										
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:										

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
	Mechanical Properties: a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia										

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)										

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.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface l. Contamination) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings										

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.	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										

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
7.	Establish the **Applicability of the Repair** and the **Repair Processing Sequence** or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.										
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight										

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions Requirements g. Airfoil Profile • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist / Lean/ Bow h. Tip Length i. Airfoil wall thickness										
10.	Part Weight: a. Mass b. Moment										

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: • 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)										

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; and 33.90)										
25.	33.21 Engine Cooling										
26.	33.23 Engine mounting attachments and structure										
27.	33.25 Accessory attachments										
28.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors										
	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 augmenter										

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										

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 • This repair removes and replaces any and all types of coatings
2.	Weld or Braze Repair (excludes detail parts replacement) • This repair includes restoration of airfoil tip and chord length
3.	Weld or Braze Repair • This repair includes detail parts replacement
4.	Assembly or Disassembly • This repair removes and replaces detail parts without the use of permanent attachment techniques (i.e.: welding or brazing) but assembly is either bolted or riveted.
5.	Blend Repair
6.	Remove and Restore Anti-gallant Coating
7.	Dimensional Restoration by Coating or Plating
8.	Straightening, Re-twist or Re-forming Repair • This repair includes dent repair
9.	Surface Treatment Repair • This repair includes shot-peen, glass bead peen, vibratory tumble (e.g. restoration of surface finish/texture)

Req No.	Repair Design Requirements to be Identified and Substantiated.	CATEGORIES OF REPAIR								
			1	2	3	4	5	6	7	8	9
1.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc									

		CATEGORIES OF REPAIR									
Req No.	**Repair Design Requirements to be Identified and Substantiated.**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
2.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness:										

Mechanical Properties:

a. Stress-Strain
b. Fracture Toughness
c. Fatigue Strength (S-N, Goodman, Dwell Time)
d. Creep
e. Tensile Properties (Yield, Strength, Elongation)
f. Hardness
g. Young's Modulus
h. Natural Frequencies

Metallurgical Properties:

i. Chemical Composition (Alloy constituents)
j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.)
k. Melting Point
l. Corrosion Resistance
m. Oxidation Resistance
n. Wear Resistance (Consider wear types in (1)(e))
o. Crack Propagation Rate

Physical Properties:

p. Density (weight)
q. Coefficient of Thermal Expansion
r. Refractive Index (X-Rays)
s. Center of Gravity
t. Polar Moment of Inertia

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)										

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.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface 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: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing										

Req No.	Repair Properties & Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
6.	Evaluate any **degradation in the part's function or durability** due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination										
7.	Establish the **Applicability of the Repair** and the **Repair Processing Sequence** or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.										

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 • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge DistanceRequirements • Finish Dimensions Requirements g. Airfoil Profile • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist / Lean/ Bow h. Tip Length i. Airfoil wall thickness										

Req No.	Repair Properties & Requirements to be Identified and Substantiated, 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; and 33.90)										
24.	33.21 Engine Cooling										
25.	33.23 Engine mounting attachments and structure										
26.	33.25 Accessory attachments										

Req No.	Repair Properties & Requirements to be Identified and Substantiated, 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 augmenter										
	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										

		CATEGORIES OF REPAIR									
Req No.	**Repair Properties & Requirements to be Identified and Substantiated, Cont'd.**		**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 • This repair removes and replaces any and all types of coatings
2.	Overcoat Repair (without stripping)
3.	Weld or Braze Repair (excludes detail part replacement) • Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair • Includes detail part replacement
5.	Sulfidation or corrosion Repair
6.	Blend Repair
7.	Straightening, Re-twist, or Reforming Repair
8.	Surface Treatment Repair • This repair includes shot peen, glass bead peen, vibratory tumble (e.g; restoration of surface finish/texture)

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. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc									

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: **Mechanical Properties:** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia									

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. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)									
4.	Coating Material Properties, Characteristics & Processes: a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material									

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. 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.									

Req No.	Repair Properties & 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): 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.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements g. Airfoils Profile • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist / Lean/ Bow h. Tip Length i. Airfoil wall thickness j. Throat Area									

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: • 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									

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; and 33.90)									
24.	33.21 Engine Cooling									
25.	33.23 Engine mounting attachments and structure									
26.	33.25 Accessory attachments									
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
28.	33.28 Electrical and electronic control systems									
29.	33.29 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									

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 augmenter									
	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									

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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 • This repair removes and replaces any and all types of coatings.
2.	Blend Repair
3.	Straightening, Re-twist, or Reforming Repair • This repair includes straightening of bent flanges
4.	Weld / Braze Repair • Excludes Detail Part Replacement
5.	Weld / Braze Repair • Includes Detail Part Replacement
6.	Assembly and/or Disassembly • This repair removes and replaces detail parts without use of permanent attachment technique, (i.e. weld or braze); assembly is either bolted or riveted.
7.	Bushing / Helicoil Repair
8.	Dimensional Restoration by Coating or Plating.

		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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc									

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:									

Mechanical Properties:

a. Stress-Strain
b. Fracture Toughness
c. Fatigue Strength (S-N, Goodman, Dwell Time)
d. Creep
e. Tensile Properties (Yield, Strength, Elongation)
f. Hardness
g. Young's Modulus
h. Natural Frequencies

Metallurgical Properties:

i. Chemical Composition (Alloy constituents)
j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.)
k. Melting Point
l. Corrosion Resistance
m. Oxidation Resistance
n. Wear Resistance (Consider wear types in (1)(e))
o. Crack Propagation Rate

Physical Properties:

p. Density (weight)
q. Coefficient of Thermal Expansion
r. Refractive Index (X-Rays)
s. Center of Gravity
t. Polar Moment of Inertia

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. 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.	Coating & Plating Material Properties Characteristics & Processes: 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									

		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**
5.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements									

		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**
6.	Evaluate any **degradation in the part's function or durability** due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.									
	a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination									
7.	Establish the **Applicability of the Repair** and the **Repair Processing Sequence** or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.									

		CATEGORIES OF REPAIR								
Req No.	**Repair Properties and Requirements to be Identified and Substantiated, Cont'd.**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s):									
	a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight									
	Critical Measurable Characteristics									
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects g. Roundness h. Flatness i. Parallelism j. Concentricity k. True Position Tolerances l. Edge Distance Requirements m. Finish Dimensions Requirements n. Diameter / Locating o. Air Swirler Features p. Mixing Air (dilution) Features q. Datum Location Features r. Air Cooling Hole Diameter s. Flowpath Exit Features t. Sealing Features u. Aft Seal v. Fuel Nozzles w. Igniter interfaces x. Flanges									

Req No.	Repair Design Requirements to be Identified and Substantiated, 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									

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; and 33.90)									
24.	33.21 Engine									
25.	33.23 Engine mounting attachments and structure									
26.	33.25 Accessory attachments									

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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 augmenter									
	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									

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

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 • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted.
2.	Weld or Braze Repair • This repair excludes detail part replacement
3.	Weld or Braze Repair • Includes detail part replacement
4.	Blend Repair
5.	Sulfidation or corrosion repair
6.	Dimensional Restoration by Coating or Plating
7.	Bushing / Helicoil Repair
8.	Straightening, re-twist or reforming repair • This repair includes dent repair
9.	Repairs to restore adhesives, bonding agents, potting compounds.
10.	Machining Repair • This repair includes lapping, skim cut, non-conventional machining

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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc											

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.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness:											

Mechanical Properties:

a. Stress-Strain
b. Fracture Toughness
c. Fatigue Strength (S-N, Goodman, Dwell Time)
d. Creep
e. Tensile Properties (Yield, Strength, Elongation)
f. Hardness
g. Young's Modulus
h. Natural Frequencies

Metallurgical Properties:

i. Chemical Composition (Alloy constituents)
j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.)
k. Melting Point
l. Corrosion Resistance
m. Oxidation Resistance
n. Wear Resistance (Consider wear types in (1)(e))
o. Crack Propagation Rate

Physical Properties:

p. Density (weight)
q. Coefficient of Thermal Expansion
r. Refractive Index (X-Rays)
s. Center of Gravity
t. Polar Moment of Inertia

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)											
4.	Coating & Plating Material Properties Characteristics & Processes: a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material											
5.	Select **Surface Treatment that applies** (Without Material Removal) and evaluate effect(s), if any, on airworthiness: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing											

Req No.	Repair Design Requirements to be Identified and Substantiated, 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.	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											

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): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight											
	Critical Measurable Characteristics											
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements											
10.	Coating Coverage Definition											
11.	Blend Area Proximity Limits Defined											

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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: • 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; and 33.90)											
24.	33.21 Engine Cooling											
25.	33.23 Engine mounting attachments and structure											
26.	33.25 Accessory attachments											
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors											

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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 augmenter											
	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											

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

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 • Repair removes and replaces detail parts without use of permanent attachment techniques, (i.e. welding or brazing) but assembly is either bolted or riveted.
4.	Machining Repair • Includes lapping, skim cut, non-conventional machining.
5.	Weld or Braze Repair • Excludes Detail Part Replacement
6.	Weld or Braze Repair • Includes Detail Part Replacement
7.	Dimensional Restoration By Coating or Plating

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.								
	a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc								

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:								
	Mechanical Properties: a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia								

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)								
4.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface l. Contamination) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings								

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_t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination								
7.	Establish the **Applicability of the Repair** and the **Repair Processing Sequence** or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.								

Req No.	Repair 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):								
	a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight								
	Critical Measurable Characteristics								
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements g. Diameter/Locating h. Air Swirler Features i. Mixing Air (dilution) Features j. Datum Location Features k. Air Cooling Hole Diameter l. Flowpath Exit Features m. Aft Seal n. Flanges o. Igniter Interfaces								

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
	Critical Measurable Characteristics								
10.	Material Debit Due To:								
	a. Heat Treat b. Weld, Braze, Coat or Plate Processes c. Machine Process d. Blend e. Hone f. Lap g. Grit Blast h. Strip								
11.	Flow Volume								
12.	Flow Pattern								
13.	Pressure / Leak Test								
	Repair Process Capability Technical Substantiation Requirements								
14.	Verification Plan with Significant Operations Identified for Repair Source Qualification								
15.	Process Demonstration (including variability requirements)								
16.	Part Demonstration / Inspection								
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:								
	• 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								

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
	Subpart B – Design and Construction; General								
22.	33.14 Start-stop cyclic stress (Low cycle fatigue)								
23.	33.15 Materials								
24.	33.17 Fire prevention								
25.	33.19 Durability(Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)								
26.	33.21 Engine Cooling								
27.	33.23 Engine mounting attachments and structure								
28.	33.25 Accessory attachments								
29.	33.27 Turbine, Compressor, Fan, and Turbo Supercharger Rotors								
30.	33.28 Electrical and electronic control systems								
31.	33.29 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								

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

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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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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc													

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.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness: **Mechanical Properties:** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia													

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.	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. k. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) l. Porosity (weldment) m. Diffusion Zone (brazing) n. Heat Affected Zone (welding)													
4.	Coating & Plating Material Properties Characteristics & Processes: a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material													

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													

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): 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													

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 • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements													

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

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; and 33.90)													
24.	33.21 Engine Cooling													
25.	33.23 Engine mounting attachments and structure													
26.	33.25 Accessory attachments													
27.	33.27 Turbine, compressor, fan, and turbo supercharger rotors													
28.	33.28 Electrical and electronic control systems													
29.	33.29 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)													

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 augmenter													
	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**													

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.) • This repair includes touch-up coating
2.	Weld or Braze Repair • This repair excludes detail part replacement
3.	Weld or Braze Repair • This repair includes detail part replacement
4.	Assembly and/or Disassembly • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
5.	Blend Repair
6.	Dimensional Restoration by Coating or Plating
7.	Surface Treatment Repair • This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)
8.	Straightening, Re-twist, or Reforming Repair • This repair includes straightening of bent flanges
9.	Restoration of Adhesives, Bonding Agents & Potting Compounds

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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc										

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.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness: **Mechanical Properties:** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia										

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)										
4.	Coating & Plating Material Properties Characteristics & Processes: a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material										

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.										

	Critical Measurable Characteristics										
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight										
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions Requirements g. Airfoil Profile h. Leading & Trailing Edge Contours i. Concave & Convex Contours j. Thickness k. Chord & Tip Length l. Twist/Lean/Bow										
	Critical Measurable Characteristics										
10.	Outer Band Rail Functional Fit										
11.	Inner Band Arc Length										
12.	Outer Band to Inner Band Dim Relationship										
13.	Assembled Honeycomb Inner Radius										

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			1	2	3	4	5	6	7	8	9
	Repair Process Capability Technical Substantiation Requirements										
14.	Verification Plan with Significant Operations Identified for Repair Source Qualification										
15.	Process Demonstration (including variability requirements)										
16.	Part Demonstration/Inspection										
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: • 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; and 33.90)										
26.	33.21 Engine Cooling										
27.	33.23 Engine mounting attachments and structure										
28.	33.25 Accessory attachments										

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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 augmenter										
	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)										

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

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

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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc					

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.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness: **Mechanical Properties:** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia					

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)					
4.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface l. Contamination) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings					

Req No.	Repair Properties & Requirement to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR				
			1	**2**	**3**	**4**
5.	Select **Surface Treatment that applies** (Without Material Removal) and evaluate effect(s), if any, on airworthiness: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing					
6.	Evaluate any **degradation in the part's function or durability** due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination					

		CATEGORIES OF REPAIR				
Req No.	**Repair Properties & Requirement to be Identified and Substantiated, Cont'd.**		**1**	**2**	**3**	**4**
7.	Establish the **Applicability of the Repair** and the **Repair Processing Sequence** or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.					
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics h. Weight i. Center of Gravity j. Moment of Weight					
	Critical Measurable Characteristics					
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements • Airfoil Profile • Leading & Trailing Edge Contours • Concave & Convex Contours • Thickness • Chord & Tip Length 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					
	Repair Process Capability Technical Substantiation Requirements					
14.	Technical Plan with Significant Operations Identified					
15.	Process Demonstration (including variability requirements)					
16.	Part Demonstration/Inspection					
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements					

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; and 33.90)					
26.	33.21 Engine Cooling					
27.	33.23 Engine mounting attachments and structure					
28	33.25 Accessory attachments					
29.	33.27 Turbine, compressor, fan, and turbosupercharger rotors					
30.	33.28 Electrical and electronic control systems					
31.	33.29 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					

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 augmenter					
	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					

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 • This repair includes detail part replacement
2.	Weld or Braze Repair • This repair excludes detail part replacement
3.	Straightening, re-twist or reforming repair • This repair includes dent repair
4.	Dimensional Restoration by Coating or Plating
5.	Restoration of Adhesives, bonding agents, potting compound.
6.	Bushing or Helicoil Repair
7.	Restoration of Protective Coating • Includes touch-up coating
8.	Assembly and/or Disassembly • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without the use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
9.	Remove and Restore Anti-gallant
10.	Blend Repair

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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc											

2.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness:											

Mechanical Properties:

a. Stress-Strain
b. Fracture Toughness
c. Fatigue Strength (S-N, Goodman, Dwell Time)
d. Creep
e. Tensile Properties (Yield, Strength, Elongation)
f. Hardness
g. Young's Modulus
h. Natural Frequencies

Metallurgical Properties:

i. Chemical Composition (Alloy constituents)
j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.)
k. Melting Point
l. Corrosion Resistance
m. Oxidation Resistance
n. Wear Resistance (Consider wear types in (1)(e))
o. Crack Propagation Rate

Physical Properties:

p. Density (weight)
q. Coefficient of Thermal Expansion
r. Refractive Index (X-Rays)
s. Center of Gravity
t. Polar Moment of Inertia

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. 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: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing											

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.	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										

		CATEGORIES OF REPAIRS										
Req No.	**Repair Properties and Requirements to be Identified and Substantiated, Cont'd.**		**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): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements											
	Repair Process Capability Technical Substantiation Requirements											
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification											
13.	Process Demonstration (including variability requirements)											

		CATEGORIES OF REPAIRS										
Req No.	**Repair Properties and Requirements to be Identified and Substantiated, Cont'd.**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
14.	Part Demonstration/Inspection											
15.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:											
	• Drawings/Specifications • Quality Requirements • Source Substantiation Requirements											
	Applicable FAR Part 33 Requirements											
	Subpart A General											
16.	33.04 Instructions for Continuous Airworthiness (ICA's)											

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; and 33.90)											
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											

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 augmenter											
	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											

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

Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR									
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc										

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.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness: **Mechanical Properties:** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia										

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)										
4.	Coating & Plating Material Properties Characteristics & Processes: a. Deposited Material Composition b. Thickness, Coverage & Uniformity c. Microstructure d. Hardness e. Sintering f. Strip Process g. Residual Stress h. Lubricant Properties i. Spalling Resistance j. Thermal Resistance k. Erosion Resistance l. Bonding (Interface Contamination) m. Environmental Resistance n. Diffusion Zone o. Hydrogen Embrittlement Free (Plating) p. Compatibility With Base Material										

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 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.										

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.	Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight										
	Critical Measurable Characteristics										
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance Requirements • Finish Dimensions Requirements										
10.	Coating Coverage Definition										
11.	Blend Area Proximity Limits Defined										
12.	No Grit Blast / Coating in Fillet Radii										

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										
13.	Verification Plan with Significant Operations Identified for Repair Source Qualification										
14.	Process Demonstration (including variability requirements)										
15.	Part Demonstration/Inspection										
16.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements										
	Applicable 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; and 33.90)										
25.	33.21 Engine Cooling										

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 augmenter										

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										
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										

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 • This repair assembles, disassembles, removes and replaces detail parts, or sub-assemblies without use of permanent attachment techniques (i.e.; welding or brazing). Assembly is either bolted or riveted
2.	Blend Repair
3.	Strip and Re-coat repair • This repair removes and replaces any and all types of coatings
4.	Dimensional Restoration by Coating or Plating
5.	Weld or Braze repair • This repair excludes detail part replacement)
6.	Weld or Braze repair • This repair includes part detail replacement
7.	Straightening, re-twist or reforming repair This repair includes dent repair
8.	Machining Repair This repair includes lapping, skim cut, non-conventional machining

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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. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc									

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: **Mechanical Properties:** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia									

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. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)									
4.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface l. Contamination) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings									

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									

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): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions Requirements									
	Critical Measurable Characteristics									
10.	Coating Coverage Definition: 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: • Drawings/Specifications • Quality Requirements • Source Substantiation Requirements									

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; and 33.90)									
24.	33.21 Engine Cooling									
25.	33.23 Engine mounting attachments and structure									
26.	33.25 Accessory attachments									
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors									
28.	33.28 Electrical and electronic control systems									
29.	33.29 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									

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 augmenter									
	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									

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.

CATEGORI 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.

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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc							

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.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness: **<u>Mechanical Properties:</u>** a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **<u>Metallurgical Properties:</u>** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **<u>Physical Properties:</u>** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia							

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

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.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface l. Contamination) m. Hydrogen Embrittlement (Plating) n. Compatibility With Base Material/Other Coatings							
	Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements							
5.	Select **Surface Treatment that applies** (Without Material Removal) and evaluate effect(s), if any, on airworthiness: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing							

Req No	Repair Properties & Requirement to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR						
			1	**2**	**3**	**4**	**5**	**6**
6.	Evaluate any **degradation in the part's function or durability** due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination							
7.	Cleaning Properties, Characteristics & Material Property Debits: a. Chemical (Solutions, etc.) b. Grit Blast (Pressure Media etc.) c. Power Flush (Pressure, Solution Time Temp., etc) d. Ultrasonic (Solution Frequency, Time, etc.) f. Furnace (Time Temp. Atmosphere, etc.)							

		CATEGORIES OF REPAIR						
Req No	**Repair Properties & Requirement to be Identified and Substantiated, Cont'd.**		**1**	**2**	**3**	**4**	**5**	**6**
8.	Select all that may be potentially affected by the repair design, and evaluate system effect(s):							
	a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight							
	Critical Measurable Characteristics							
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions Requirements							
10.	Parent material thickness reduction assessment							
11.	Dimensional & Tolerance Reverse engineered parts							
	Repair Process Capability Technical Substantiation Requirements							
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification							

		CATEGORIES OF REPAIR						
Req No	**Repair Properties & Requirement to be Identified and Substantiated, Cont'd.**		**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; and 33.90)							
24.	33.21 Engine Cooling							
25.	33.23 Engine mounting attachments and structure							
26.	33.25 Accessory attachments							
27.	33.27 Turbine, compressor, fan, and turbo supercharger rotors							

		CATEGORIES OF REPAIR						
Req No	**Repair Properties & Requirement to be Identified and Substantiated, Cont'd.**		**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							

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

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

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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc					

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.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness:					

Mechanical Properties:

a. Stress-Strain
b. Fracture Toughness
c. Fatigue Strength (S-N, Goodman, Dwell Time)
d. Creep
e. Tensile Properties (Yield, Strength, Elongation)
f. Hardness
g. Young's Modulus
h. Natural Frequencies

Metallurgical Properties:

i. Chemical Composition (Alloy constituents)
j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.)
k. Melting Point
l. Corrosion Resistance
m. Oxidation Resistance
n. Wear Resistance (Consider wear types in (1)(e))
o. Crack Propagation Rate

Physical Properties:

p. Density (weight)
q. Coefficient of Thermal Expansion
r. Refractive Index (X-Rays)
s. Center of Gravity
t. Polar Moment of Inertia

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)					
4.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface 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: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing					

Req No.	Repair Properties & Requirement to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR				
			1	2	3	4
6.	Evaluate any **degradation in the part's function or durability** due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K_t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination					

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight					
	Critical Measurable Characteristics					
9.	Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions Requirements Airfoil Profile • Leading & Trailing Edge Contours • Concave & Convex Contours • Thickness • Chord & Tip Length • Twist/Lean/Bow					
	Critical Measurable Characteristics					
10.	Spindle (Trunnion) Diameter					
11.	Outer Spindle (Trunnion) to Lever Seating Flat					
12.	Outer Spindle (Trunnion) to Inner Spindle (Trunnion)					
13.	Outer Spindle (Trunnion) to Inner Spindle (Trunnion) Concentricity					

Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR				
			1	**2**	**3**	**4**
	Repair Process Capability Technical Substantiation Requirements					
14.	Technical Plan with Significant Operations Identified					
15.	Process Demonstration (including variability requirements)					
16.	Part Demonstration/Inspection					
17.	Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair: • 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; and 33.90)					
26.	33.21 Engine Cooling					
27.	33.23 Engine mounting attachments and structure					
28.	33.25 Accessory attachments					
29.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors					
30.	33.28 Electrical and electronic control systems					
31.	33.29 Instrumentation connection					
	Subpart E – Design and Construction: Turbine Aircraft Engines					
32.	33.62 Stress Analysis					
33.	33.63 Vibration					

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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 augmenter					
	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)					

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					

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 • This repair removes and replaces any and all types of coatings.
2.	Weld or Braze Repair (excludes detail parts replacement) • Includes restoration of airfoil tip and chord length
3.	Weld or Braze Repair • Includes detail parts replacement
4.	Assembly and/or disassembly • This repair removes and replaces details parts without the use of permanent attachment techniques (i.e., welding or brazing) but assembly is either bolted or riveted.
5.	Blend Repair
6.	Dimensional Restoration by coating or plating
7.	Straightening, re-twist or reforming repair

		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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements. a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc								

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:								

Mechanical Properties:

a. Stress-Strain
b. Fracture Toughness
c. Fatigue Strength (S-N, Goodman, Dwell Time)
d. Creep
e. Tensile Properties (Yield, Strength, Elongation)
f. Hardness
g. Young's Modulus
h. Natural Frequencies

Metallurgical Properties:

i. Chemical Composition (Alloy constituents)
j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.)
k. Melting Point
l. Corrosion Resistance
m. Oxidation Resistance
n. Wear Resistance (Consider wear types in (1)(e))
o. Crack Propagation Rate

Physical Properties:

p. Density (weight)
q. Coefficient of Thermal Expansion
r. Refractive Index (X-Rays)
s. Center of Gravity
t. Polar Moment of Inertia

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.	Select all **Material Properties / Characteristics for weldments or brazed joints** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness. a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding)								
4.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness. a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface 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: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing								

Req No.	Repair Properties & Requirement to be Identified and Substantiated, Cont'd.	CATEGORIES OF REPAIR							
			1	2	3	4	5	6	7
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								

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): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position Tolerances • Edge Distance • Requirements • Finish Dimensions • Requirements g. Airfoils Profile • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist / Lean/ Bow h. Tip Length i. Airfoil wall thickness j. Throat Area								
11.	Cooling (Total flow, flow split, back flow margin, hole exit geometry, allowable plugged holes)								
	Repair Process Capability Technical Substantiation Requirements								
12.	Technical Plan with Significant Operations Identified								
13.	Process Demonstration (including variability requirements)								

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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: • 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; and 33.90)								
24.	33.21 Engine Cooling								
25.	33.23 Engine mounting attachments and structure								
26.	33.25 Accessory attachments								
	Subpart B – Design and Construction; General								
27.	33.27 Turbine, compressor, fan, and turbo-supercharger rotors								
28.	33.28 Electrical and electronic control systems								
29.	33.29 Instrumentation connection								
	Subpart E – Design and construction : Turbine aircraft Engines								
30.	33.62 Stress Analysis								
31.	33.63 Vibration								

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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 augmenter								
	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								

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 • This repair removes and replaces any and all types of coatings
2.	Overcoat Repair (without stripping)
3.	Weld or Braze Repair (excludes detail part replacement) • Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair • Includes detail part replacement
5.	Disassembly and/or Assembly • This repair removes and replaces detail parts without the use of permanent attachment (i.e.; welding or brazing) but assembly is either bolted or riveted.
6.	Blend Repair
7.	Dimensional Restoration Repair (by coating of plating)
8.	Straightening, Re-twist, or Reforming Repair

		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.	**Applicable Degradation Modes**: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.									
	a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O_3 chemical attack, etc									

		CATEGORIES OF REPAIR								
Req No.	**Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
2.	Select all **mechanical, metallurgical, and physical properties of the part affected by the repair design**, and assess their impact on the part's airworthiness:									
	Mechanical Properties: a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation) f. Hardness g. Young's Modulus h. Natural Frequencies **Metallurgical Properties:** i. Chemical Composition (Alloy constituents) j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.) k. Melting Point l. Corrosion Resistance m. Oxidation Resistance n. Wear Resistance (Consider wear types in (1)(e)) o. Crack Propagation Rate **Physical Properties:** p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia									

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

		CATEGORIES OF REPAIR								
Req No.	**Repair Design Requirements to be Identified and Substantiated, Cont'd.Repair Properties and Requirements to be Identified and Substantiated, Cont'd.**		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
4.	Select all **Coating Properties / Characteristics** that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's physical and operational capability, as a result of the coating, should be evaluated for airworthiness.									
	a. Coating Material Composition b. Thickness, Coverage & Uniformity c. Coating and Diffusion Zone Microstructure d. Coating Hardness e. Sintering f. Strip Requirements / Process g. Residual Stress h. Resistance to Spalling i. Thermal Resistance (coefficient of thermal expansion for the coating) j. Erosion Resistance k. Bonding (Interface 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: a. Burnishing b. Peening c. Butterfly Polish d. Mass Media Finishing									

Req No.	Repair Properties & Requirement 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. 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									

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): a. Surface finish/texture b. Shotpeen Intensity / Coverage c. Bearing bore dimensions and location characteristics d. Pressure Strength Test e. Flow Capacity test f. Dimensions, including heat distortion effects • Roundness • Flatness • Parallelism • Concentricity • True Position • Tolerances • Edge Distance • Requirements • Finish Dimensions • Requirements g. Airfoils Profile • Leading & Trailing Edge Contour • Concave & convex contours • Thickness • Chord & Airfoil Length • Twist / Lean/ Bow h. Tip Length i. Airfoil wall thickness j. Throat Area									
	Repair Process Capability Technical Substantiation Requirements									
12.	Verification Plan with Significant Operations Identified for Repair Source Qualification									
13.	Process Demonstration (including variability requirements)									
14.	Part Demonstration/Inspection									

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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: • 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; and 33.90)									
24.	33.21 Engine Cooling									
25.	33.23 Engine mounting attachments and structure									
26.	33.25 Accessory attachments									

Req No.	Repair Properties and Requirements to be Identified and Substantiated, 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									

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									