(Public comments phase August 2006)

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.

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• 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.

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- 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.

Template 1	Title Bearing Compartment and Carbon Seal Parts Family	Page XX
2	Blades – High Pressure Turbine (HPT)	XX
3	Blades – Low Pressure Compressor (LPC) – High Pressure Compressor (HPC)	XX
4	Blades – Low Pressure Turbine (LPT)	XX
5	Combustor Parts Family	XX
6	Externals Parts Family	XX
7	Fuel Nozzle Parts family	XX
8	Gearbox Housing Assembly Parts Family	XX

9	LPC-HPC Stators – Vane Sector & Full Ring	XX
10	LPC – HPC Stators – Fixed	XX
11	Major Engine Cases	XX
12	Major Rotating Non-Life Limited Parts Family	XX
13	Seals Non-Rotating & Shrouds – HPC – HPT – LPT	XX
14	Static Parts (Other than Major Engine Cases)	XX
15	Stators – Variable – LPC – HPC	XX
16	Vanes – HPT	XX
17	Vanes – LPT	XX

(Public comments phase August 2006)

Template 1

REPAIR SUBSTANTIATION CHECKLIST - BEARING COMPARTMENT AND CARBON SEAL PART FAMILIES

<u>Categories of Bearing Compartment & Carbon Seal Part Family Repair</u>. 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
-	Disciplination
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.

ble Degradation Modes: Il that apply based on the of the part and its operating ment in the engine. This section is the background for ning the substantiation ments.											
Thermo-Mechanical Fatigue Oxidation Corrosion Elevated Temperature-Induced hanges (Creep, Diffusion, geing, Temperature Gradients) Wear due to: Adhesion, brasion, Corrosion, Erosion, avitation, Fretting, Oxidation											
ge V bi	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion,	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, vitation, Fretting, Oxidation High Cycle Fatigue	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	Eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact	Eing, Temperature Gradients) Vear due to: Adhesion, rasion, Corrosion, Erosion, ritation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact

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:											
	Mechanical Properties:											
	Mechanical Floperties.											
	a. Stress-Strain											
	b. Fracture Toughness											
	c. Fatigue Strength (S-N,											
	Goodman, Dwell Time)											
	d. Creepe. 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	Repair Design Requirements to be	1	2	3	4	5	6	7	8	9	10	11
3.	Identified and Substantiated, Cont'd. 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. Burnishingb. Peening											
	c. Butterfly Polish											
	d. Mass Media Finishing											

6. Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K _t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating	Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8	9	10	11
Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re- forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (Kt) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating	6.	function or durability due to the following processes, when applicable, and assess its impact, if any, on existing											
p. Repetitive or Conflicting Repairs q. Contamination		Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re- forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (Kt) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs											

Req	Repair Design Requirements to be	1	2	3	4	5	6	7	8	9	10	11
No. 7.	Identified and Substantiated, Cont'd.	<u> </u>			1			1	<u> </u>			
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											
	<u>C</u>											
	Requirements											
	Finish Dimensions											
10	Requirements	1							1		-	
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	1										
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				1							
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	Repair Design Requirements to be	1	2	3	4	5	6	7	8	9	10	11
No.	Identified and Substantiated, Cont'd.		-								10	
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						l					
	(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	Airworthiness Standards to be	1	2	3	4	5	6	7	8	9	10	11
No.	Substantiated											
	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											
49.	(HCF/LCF bench testing) 33.92 Rotor locking tests											
50.	33.93 Teardown inspection											
51.	33.94 Blade containment and rotor											
31.	unbalance tests (Weight changes)											
52.	33.95 Engine-propeller system tests											
53.	33.96 Engine tests in auxiliary power											
55.	unit (APU) mode											
54.	33.97 Thrust Reversers											
55.	33.99 General conduct of block tests											
	FAR 33 -Appendix A – Instructions											
	for Continued Airworthiness				1							
	FAR 33 -Appendix B- Certification											
	Standard Atmospheric											
	Concentrations of Rain and Hail											
	FAR 34 – Exhaust Emissions											

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Template 2

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

<u>Categories of HPT Blade Part Family Repair</u>. 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.

		CATEGORIES OF REPAIR									
Req No.	Repair Design Requirements to be Identified and Substantiated.Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		1	2	3	4	5	6	7	8	9
1.	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										
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:										

				CA	ATEG	ORIE	S OF	REPA	IR		
Req No.	Repair Design Requirements to Identified and Substantiated.Re Properties and Requirements to Identified and Substantiated, Co	epair be	1	2	3	4	5	6	7	8	9
	Mechanical Properties	S:									
	 a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, G Dwell Time) d. Creep e. Tensile Properties (Yield Elongation) f. Hardness g. Young's Modulus 										
	h. Natural Frequencies										
	Metallurgical Properti	es:									
	i. Chemical Composition (a constituents)j. Microstructure (grain size	e – shape -									
	boundary precipitates, ga prime size and volume fr etc.)										
	k. Melting Pointl. Corrosion Resistance										
	m. Oxidation Resistance n. Wear Resistance (Consident types in (1)(e))	ler wear									
	o. Crack Propagation Rate Physical Properties	s:									
		<u></u>									
	p. Density (weight) q. Coefficient of Thermal E r. Refractive Index (X-Rays										
	s. Center of Gravity t. Polar Moment of Inertia										

			C	ATEG	ORIE	SOF	REPA	IR		
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8	9
3.	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) 				1					

			CA	TEG	ORIE	S OF	REPA	IR		
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8	9
4.	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									

		CATEGORIES OF REPAIR									
Req	Repair Properties and Requirements to be		1	2	3	4	5	6	7	8	9
No.	Identified and Substantiated, Cont'd.										
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										

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

			CATEGORIES OF REPAIR									
Req	Repair Properties and Requirements	s to be		1	2	3	4	5	6	7	8	9
No.	Identified and Substantiated, Cont'd											
	Critical Measurable Characteristics											
9.	Establish Measurable Characteristics a	nd the										
	allowable tolerances for the repaired pa	art										
	features and for any replacement detail	l(s) and										
	give due consideration to mating part(s	s):										
	a. Surface finish/texture											
	b. Shotpeen Intensity / Coverage	e										
	c. Bearing bore dimensions and	location										
	characteristics											
	d. Pressure Strength Test											
	e. Flow Capacity test											
	f. Dimensions, including heat di	istortion										
	effects											
	 Roundness 											
	• Flatness											
	 Parallelism 											
	 Concentricity 											
	True Position Tolera	nces										
	Edge Distance											
	 Requirements 											
	 Finish Dimensions 											
	Requirements											
	g. Airfoil Profile											
	•	Leading										
	& Trailing Edge Contour	-										
	•	Concave										
	& convex contours											
	•	Thickness										
	•	Chord &										
	Airfoil Length											
	•	Twist /										
	Lean/ Bow											
	h. Tip Length											
	 Airfoil wall thickness 											
10.	Part Weight:											
	a. Mass											
	b. Moment											

		CATEGORIES OF REPAIR									
Req	Repair Properties and Requirements to be		1	2	3	4	5	6	7	8	9
No.	Identified and Substantiated, Cont'd.										
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										
					1						
16.	Manufacturing requirements for fabrication										
	of repair details or replacement sections used										
	to accomplish repair:										
	D										
	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;										
2.1	General										
21.	33.14 Start-stop cyclic stress (low cycle										
	fatigue)										

		CATEGORIES OF REPAIR									
Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	1	2	;	3	4	5	6	7	8	9
22.	33.15 Materials										1
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										

		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
	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										

(Public comments phase August 2006)

Template 3

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

<u>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.</u>

CATEGORIES	REPAIR DESCRIPTION
OF REPAIRS	
1.	Strip and Re-coat Repair
	This repair removes and replaces any and all types of coatings
2.	Weld or Braze Repair (excludes detail parts replacement)
	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)

		CATEGORIES OF REPAIR									
Req	Repair Design Requirements to be		1	2	3	4	5	6	7	8	9
No.	Identified and Substantiated.										
1.	Applicable Degradation Modes: Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.										
	 a. Thermo-Mechanical Fatigue b. Oxidation c. Corrosion d. Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) e. Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O₃ chemical attack, etc 										

Req Repair Design Requirements to be Identified and Substantiated. 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:				CATEGORIES OF REPAIR									
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 m. Oxidation 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				1	2	3	4	5	6	7	8	9	
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 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													
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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 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			y										
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 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													
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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		ivicenumeur i roperties.											
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 m. Oxidation Resistance vypes 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		a. Stress-Strain											
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		b. Fracture Toughness											
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													
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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													
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													
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													
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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		Metallurgical Properties:											
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		i. Chemical Composition (Alloy											
- 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													
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													
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													
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													
1. 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													
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													
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													
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													
o. Crack Propagation Rate Physical Properties: p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity													
Physical Properties: p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity													
p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity		o. Clack Propagation Rate											
q. Coefficient of Thermal Expansionr. Refractive Index (X-Rays)s. Center of Gravity		Physical Properties:											
q. Coefficient of Thermal Expansionr. Refractive Index (X-Rays)s. Center of Gravity													
s. Center of Gravity		q. Coefficient of Thermal Expansion											
t. Polar Moment of Inertia		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	9
3.	Select all Material Properties / Characteristics for weldments or brazed joints that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part's metallurgy, as a result of welds or braze, should be evaluated for airworthiness.										
	 a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.) b. Porosity (weldment) c. Diffusion Zone (brazing) d. Heat Affected Zone (welding) 			•	,						

		CATEGORIES OF REPAIR									
Req	Repair Design Requirements to be		1	2	3	4	5	6	7	8	9
No.	Identified and Substantiated,										
	Cont'd.Repair Properties and										
	Requirements to be Identified and										
4	Substantiated, Cont'd.										
4.	Select all Coating Properties /					L					
	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 (Interfacel. 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. Burnishingb. Peening										
	c. Butterfly Polish										
	d. Mass Media Finishing										

		CATEGORIES OF REPAIR									
Req No.	Repair Properties & Requirements to be Identified and Substantiated, Cont'd.		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, reforming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (Kt) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs q. Contamination 										
7.	Establish the Applicability of the Repair and the Repair Processing Sequence or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.										

		CATEGORIES OF REPAIR									
Req No.	Repair Properties & Requirements to be Identified and Substantiated, Cont'd.		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	<u> </u>		1				l.	ı	I	1
	a. Heat Transfer										
	b. Secondary Airflow										
	c. d. Aerodynamics										
0	Critical Measurable Characteristics										
9.	Establish Measurable Characteristics and the										
	allowable tolerances for the repaired part features and for any replacement detail(s) and										
	give due consideration to mating part(s):										
	grie due consideranion to maning 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	5									
	• Concav	Δ									
	& convex contours										
	• Thickne	ess									
	• Chord &										
	Airfoil Length										
	• Twist /										
	Lean/Bow										
	h. Tip Length										
	i. Airfoil wall thickness										

		CATEGORIES OF REPAIR									
Req	Repair Properties & Requirements to be										
No.	Identified and Substantiated, Cont'd.		1	2	3	4	5	6	7	8	9
	Critical Measurable Characteristics										
10.	Dovetail functional fit test										
11.	Part weight test:										
	N. W. L.										
	a. Mass Weight										
	b. Moment Weight Repair Process Capability Technical										
	Substantiation Requirements										
12.	Technical Plan with Significant Operations										
12.	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										
1.7	Airworthiness (ICA's)										
17.	33.05 Instruction manual for installing and										
18.	operating the engine 33.07 Engine ratings and operating										
10.	limitations										
19.	33.08 Selection of engine power and thrust										
17.	ratings										
	Subpart B – Design and Construction;										
	General										
20.	33.14 Start-stop cyclic stress (low cycle										
	fatigue)										
21.	33.15 Materials										
22.	33.17 Fire prevention										
23.	33.19 Durability(Note that 33.19 is										
	associated with 33.27; 33.63; 33.83; 33.87;										
2.4	33.88; and 33.90)										
24.	33.21 Engine Cooling										
25.	33.23 Engine mounting attachments and										
26	structure										
26.	33.25 Accessory attachments										

	CATEGORIES OF REPAIR										
Req No.	Repair Properties & Requirements to be Identified and Substantiated, Cont'd.		1	2	3	4	5	6	7	8	9
27.	33.27 Turbine, compressor, fan, and turbo-		1		3	4	5	0	/	0	9
27.	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:										
40	Turbine Aircraft Engines 33.74 Continued rotation										
40. 41.	33.75 Safety Analysis										
42.	33.76 Bird Ingestion(Operability aspects of										
42.	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										
	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										

			C	ATEG	ORIE	S OF I	REPA	IR	8 9								
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																

(Public comments phase August 2006)

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	REPAIR DESCRIPTION
OF REPAIRS	
1.	Strip and Re-coat Repair
	This repair removes and replaces any and all types of coatings
2.	Overcoat Repair (without stripping)
3.	Weld or Braze Repair (excludes detail part replacement)
	Includes restoration of airfoil tip and chord length
4.	Weld or Braze Repair
	Includes detail part replacement
5.	Sulfidation or corrosion Repair
6.	Blend Repair
7.	Straightening, Re-twist, or Reforming Repair
8.	Surface Treatment Repair
	 This repair includes shot peen, glass bead peen, vibratory tumble (e.g; restoration of surface finish/texture)

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

			CAT	EGOI	RIES O	F REF	PAIR		
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 of 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 								
	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								

Polar Moment of Inertia

			CAT	EGOR	RIES O	F REP	AIR		
Req	Repair Design Requirements to be								
No.	Identified and Substantiated,	1	2	3	4	5	6	7	8
	Cont'd.Repair Properties and								
	Requirements to be Identified and								
	Substantiated, Cont'd.								
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									
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								
	i. Thermal Resistance								
	k. Erosion Resistance								
	1. Bonding (Interface Contamination)								
	m. Environmental Resistance								
	n. Diffusion Zone								
	o. Hydrogen Embrittlement Free								
	(Plating)								
	p. Compatibility With Base Material								

				CAT	<u>EGO</u> R	RIES O	F REP	AIR		
Req	Repair Design Requirements to be									
No.	Identified and Substantiated,		1	2	3	4	5	6	7	8
	Cont'd.Repair Properties and									
	Requirements to be Identified and									
	Substantiated, Cont'd.									
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	1		1	1					
6.	Evaluate any degradation in the part's									
	function or durability due to the									
	following processes, when applicable, and									
	assess its impact, if any, on existing ICAs.									
	a Mashining Milling Dreaghing									
	 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									
				1	Г	1				ı
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	Repair Properties & Requirements to be									
No.	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									
	h. Weight									
	i. Center of Gravity									
	j. Moment of Weight									
	Critical Measurable Characteristics									
9.	Establish Measurable Characteristics and									
<i>)</i> .	the allowable tolerances for the repaired									
	part features and for any replacement									
	detail(s) and give due consideration to									
	mating part(s):									
	8 F (1)									
	a. Surface finish/texture									
	b. Shotpeen Intensity / Coverage									
	c. Bearing bore dimensions and									
	location characteristics									
	d. Pressure Strength Test									
	e. Flow Capacity test									
	f. Dimensions, including heat									
	distortion effects									
	 Roundness 									
	 Flatness 									
	 Parallelism 									
	 Concentricity 									
	True Position Tolerances									
	Edge Distance Requirements									
	Finish Dimensions									
	Requirements									
	g. Airfoils Profile									
	Leading & Trailing Edge									
	Contour									
	 Concave & convex contours 									
	Thickness									
	Chord & Airfoil Length									
	Twist / Lean/ Bow									
	h. Tip Length									
	i. Airfoil wall thickness									
	j. Throat Area									
	J. 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	
	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										

		CATEGORIES OF REPAIR								
Req	Repair Properties and Requirements to									
No.	be Identified and Substantiated, Cont'd.		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:									
20	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									

(Public comments phase August 2006)

		CATEGORIES OF REPAIR								
Req	Repair Properties and Requirements to									
No.	be Identified and Substantiated, Cont'd.		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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(Public comments phase August 2006)

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

		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	,											

	· ·	•	3									
		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 Toughnessc. Fatigue Strength (S-N,											
	Goodman, Dwell Time) d. Creep e. Tensile Properties (Yield, Strength, Elongation)											

Metallurgical Properties:

g. Young's Modulush. Natural Frequencies

Hardness

f.

- i. Chemical Composition (Alloy constituents)
- j. Microstructure (grain size

 shape boundary
 precipitates, gamma prime
 size and volume fraction,
 etc.)
- k. Melting Point
- 1. Corrosion Resistance
- m. Oxidation Resistance
- n. Wear Resistance (Consider wear 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) 									
	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									

			CA	TEGOI	RIES O	F REPA	AIR		
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.											

Req Repair Properties and Requirements	CATEGORIES OF REPAIR ents											
No. 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												

		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				
10.	Cooling Feature Characteristics: a. Airflow b. Hole Diameter c. Blocked Hole Quantity / Location d. Cooling Slot Height / Length / Location													
11.	e. Quantity of Holes / Slots Thermal Barrier Coating:													
	a. Thickness b. Coverage c. Type Repair Process Capability Technical													
12.	Substantiation Requirements Verification Plan with Significant Operations Identified for Repair Source Qualification													

		CATEGORIES OF REPAIR ts											
Req	Repair Properties and Requirements								_				
No.	to be Identified and Substantiated, Cont'd.		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 Subnert A Concret												
16.	Subpart A General 33.04 Instructions for Continuous												
10.	Airworthiness (ICA's)												
17.	33.05 Instruction Manual for Installing												
17.	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												
20	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												
23.	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												

	Γ	CATEGORIES OF REPAIR ents											
Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	1	I	2	3	4	5	6	7	8			
27.	33.27 Turbine, compressor, fan, and												
28.	turbo supercharger rotors 33.28 Electrical and electronic control												
28.	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 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												
45	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											
Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		1	2	3	4	5	6	7	8			
33.94 Blade containment and rotor unbalance tests (Weight changes)												
33.95 Engine-propeller system tests												
33.96 Engine tests in auxiliary power unit (APU) mode												
33.97 Thrust reversers												
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												
	to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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	Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 33.94 Blade containment and rotor unbalance tests (Weight changes) 33.95 Engine-propeller system tests 33.96 Engine tests in auxiliary power unit (APU) mode 33.97 Thrust reversers 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			

(Public comments phase August 2006)

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

			CATEGORIES OF REPAIR										
Req No.	Identif	Design Requirements to be ied and Substantiated. Repair ties and Requirements to be ied and Substantiated, Cont'd.		1	2	3	4	5	6	7	8	9	10
1.	Applica all that part and engine. backgrosubstan a. b. c. d.	able Degradation Modes: Select apply based on the function of the dissoperating environment in the This section provides the bund for establishing the tiation requirements. Thermo-Mechanical Fatigue Oxidation Corrosion Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact damage, O ₃ chemical attack, etc											

			-	CATE	EGOR	IES (OF RE	EPAII	R		
Req No.	Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8	9	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 										
	p. Density (weight) q. Coefficient of Thermal Expansion r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia										

			(CATE	CGOR	IES ()F RE	PAIR	t		
Req	Repair Design Requirements to be										
No.	Identified and Substantiated,	1	2	3	4	5	6	7	8	9	10
	Cont'd.Repair Properties and										
	Requirements to be Identified and										
	Substantiated, Cont'd.										
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		1								
	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										
	1. Bonding (Interface Contamination)										
	m. Environmental Resistance										
	n. Diffusion Zone										
	o. Hydrogen Embrittlement Free										
	(Plating)										
5	p. Compatibility With Base Material										
5.	Select Surface Treatment that applies (Without Material Removal) and evaluate										
	,										
	effect(s), if any, on airworthiness:										
	a. Burnishingb. Peening										
	8										
	c. Butterfly Polishd. Mass Media Finishing										
	u. Iviass ivieura rimisming										

		CATEGORIES OF REPAIR										
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		1	2	3	4	5	6	7	8	9	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, reforming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (K _t) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls											
	p. Repetitive or Conflicting Repairsq. Contamination											

		CATEGORIES OF REPAIR										
Req	Repair Properties and Requirements to											
No.	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):											
	a. Structural Strength, including											
	major load paths											
	b. Heat Transfer											
	c. Secondary Airflow											
	d. Aerodynamics											
	e. Weight											
	f. Center of Gravity											
	g. Moment of Weight											
0	Critical Measurable Characteristics											
9.	Establish Measurable Characteristics and											
	the allowable tolerances for the repaired											
	part features and for any replacement											
	detail(s) and give due consideration to											
	mating part(s):											
	Conformation 1. //											
	a. Surface finish/texture											
	b. Shotpeen Intensity / Coverage											
	 Bearing bore dimensions and location characteristics 											
	d. Pressure Strength Test											
	e. Flow Capacity testf. Dimensions, including heat											
	distortion effects											
	Roundness											
	RoundnessFlatness											
	• Parallelism											
	• Concentricity											
	• True Position											
	Tolerances											
	Edge Distance											
	Requirements											
	 Finish Dimensions 											
	Requirements											
10	Cartina Carana D.C. 'i'											
10.	Coating Coverage Definition											
11.	Blend Area Proximity Limits Defined	l		l	1	ı	ı					

				CATE	EGOR	IES ()F RI	EPA II	2		
Req	Repair Properties and Requirements to				JOIN)	71 / 111	Ì		
No.	be Identified and Substantiated, Cont'd.	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:										
	D 1 /G 151 1										
	Drawings/Specifications										
	Quality Requirements										
	Source Substantiation										
	Requirements										
	Applicable FAR Part 33 Requirements										
	Subpart A General										
16.	33.04 Instructions for Continuous										
1.77	Airworthiness (ICA's)										
17.	33.05 Instruction manual for installing and										
10	operating the engine										
18.	33.07 Engine ratings and operating	 									
19.	limitations 33.08 Selection of engine power and thrust										
19.	ratings										
	Subpart B – Design and Construction;										
	General										
20.	33.14 Start-stop cyclic stress (low cycle										
20.	fatigue)	 									
21.	33.15 Materials										
22.	33.17 Fire prevention										
23.	33.19 Durability(Note that 33.19 is										
	associated with 33.27; 33.63; 33.83; 33.87;										
	33.88; and 33.90)										
24.	33.21 Engine Cooling										
25.	33.23 Engine mounting attachments and										
	structure										
26.	33.25 Accessory attachments										
27.	33.27 Turbine, compressor, fan, and turbo-										
	supercharger rotors										

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

(Public comments phase August 2006)

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

		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, O₃ chemical attack, etc 											

				CATE	GORIE	S OF R	EPAIR		
Req		d							
No.	and Substantiated. Repair Properties and		1	2	3	4	5	6	7
	Requirements to be Identified and								
	Substantiated, Cont'd.								
2.	Select all mechanical, metallurgical, and								
	physical properties of the part affected by t	he							
	repair design , and assess their impact on the								
	part's airworthiness:								
	Mechanical Properties:								
	a. Stress-Strain								
	b. Fracture Toughness								
	c. Fatigue Strength (S-N, Goodman,								
	Dwell Time)								
	d. Creep								
	e. Tensile Properties (Yield, Strength, Elongation)								
	f. Hardness								
	g. Young's Modulus h. Natural Frequencies								
	Metallurgical Properties:								
	i. Chemical Composition (Alloy								
	constituents)								
	j. Microstructure (grain size – shape -								
	boundary precipitates, gamma prime								
	size and volume fraction, etc.)								
	k. Melting Point								
	Corrosion Resistance								
	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								
	D.C: I.I. (XID.)								
	r. Refractive Index (X-Rays)								
	r. Refractive Index (X-Rays) s. Center of Gravity t. Polar Moment of Inertia								

			CATE	GORIE	S OF R	EPAIR	_	
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	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 							

		(CATEG	ORIES	OF R	EPAIR		
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
5.	Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:							
	a. Burnishingb. Peeningc. Butterfly Polishd. Mass Media Finishing							
6.	Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.							
	 a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, re-forming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (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.							

			CATEG	ORIES	OF R	EPAIR	<u> </u>	
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.	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							

			CATE	GORIE	S OF F	REPAIR	CATEGORIES OF REPAIR								
Req	Repair Properties and Requirements to be														
No.	Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7							
	Critical Measurable Characteristics														
10.	Material Debit Due To:														
	a. Heat Treat				I	1	1								
	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														

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

		(CATEG	ORIE	S OF R	EPAIF	₹	
Req	Repair Properties and Requirements to be							
No.	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							

(Public comments phase August 2006)

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	REPAIR DESCRIPTION							
OF REPAIRS								
1.	Restoration of Protective Coating							
	Includes Touch Up Coating							
2.	Weld or Braze Repair							
	This repair excludes detail part replacement							
3.	Weld or Braze Repair							
	Includes detail part replacement							
4.	Assembly and/or Disassembly							
	This repair assembles, disassembles, removes and replaces detail parts, or sub-							
assemblies without use of permanent attachment techniques (i.e.; welding or brazing								
	Assembly is either bolted or riveted							
5.	Sulfidation or Corrosion Repair							
6.	Blend Repair							
7.	Dimensional Restoration by Coating or Plating							
8.	Bushing / Helicoil Repair							
9.	Straightening, Re-twist, or Reforming Repair							
	This repair includes straightening of bent knife edges							
10.	Surface Treatment Repair							
	This repair includes peening, vibratory tumble (e.g.; restoration of surface)							
	finish/texture)							
11.	Machining Repair							
	This repair includes lapping, skim cut, non-conventional machining							
12.	Restoration of Adhesives, Bonding Agents, Potting Compounds.							

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			CATEGORIES OF REPAIR												
Req No.	Identif	Design Requirements to be ied and Substantiated. Repair ties and Requirements to be ied and Substantiated, Cont'd.		1	2	3	4	5	6	7	8	9	10	11	12
1.	Applica all that part and engine. backgrosubstan a. b. c. d.	able Degradation Modes: Select apply based on the function of the distribution provides the bund for establishing the tiation requirements. Thermo-Mechanical Fatigue Oxidation Corrosion Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients) Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation High Cycle Fatigue Rubbing, foreign object impact damage, O ₃ chemical attack, etc													

				CA	TE(GOR	ES (OF R	EPA	IR			
Req	Repair Design Requirements to be												
No.	Identified and Substantiated. Repair	1	2	3	4	5	6	7	8	9	10	11	12
	Properties and Requirements to be												
	Identified and Substantiated, Cont'd.												
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.)
 Melting Point
- I. 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.		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 													

		CATEGORIES OF REPAIR												
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.		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,	l	<u> </u>											
	or Grinding													
	g. Non-traditional Machining													
	h. Welding, Brazing or Coating i. Straightening, re-twisting, re-													
	 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													
	t. Dimensional Short-falls u. Repetitive or Conflicting Repairs													
	v. Contamination													

				CA	TEC	GOR	IES (OF R	EPA	IR			
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.	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												

		CATEGORIES OF REPAIR												
Req	Repair Design Requirements to be													
No.	Identified and Substantiated, Cont'd.		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													
		1		l	l			l		1				

				CA	TE	GOR	IES	OF R	EPA	IR			
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/SpecificationsQuality RequirementsSource 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												

		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
	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								_	L				
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)													

		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
	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													
52	Aircraft Engines													
53. 54.	33.92 Rotor locking tests 33.93 Teardown inspection													
55.	33.94 Blade containment and rotor													
55.	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													

(Public comments phase August 2006)

Template 9

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

<u>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.</u>

CATEGORIES	REPAIR DESCRIPTION
OF REPAIRS	
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

				C	ATEG	ORIE	S OF I	REPA:	IR		
Req No.		Design Requirements to be led and Substantiated. Repair	1	2	3	4	5	6	7	8	9
110.		ties and Requirements to be	•	_		•		U	,	U	
		ied and Substantiated, Cont'd.									
1.		able Degradation Modes: Select									
	all that	apply based on the function of the									
	part and	l its operating environment in the									
		This section provides the									
		ound for establishing the									
	substan	tiation requirements.									
	_	Thomas Machanical Estima									
	a. b.	Thermo-Mechanical Fatigue Oxidation									
		Corrosion									
		Elevated Temperature-Induced									
	u.	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									

			C	ATEG	ORIE	S OF	REPA	IR		
Req	Repair Design Requirements to be									
No.	Identified and Substantiated. Repair	1	2	3	4	5	6	7	8	9
	Properties and Requirements to be									
	Identified and Substantiated, Cont'd.									
2.	Select all mechanical, metallurgical, and									
	physical properties of the part affected by									
	the repair design, and assess their impact									
	on the part's airworthiness:									
	Mechanical Properties:									
	a. Stress-Strain									
	b. Fracture Toughness									
	c. Fatigue Strength (S-N, Goodman,									
	Dwell Time)									
	d. Creep									
	e. Tensile Properties (Yield,									
	Strength, Elongation)									
	f. Hardness									
	g. Young's Modulus									
	h. Natural Frequencies									
	Metallurgical Properties:									
	i. Chemical Composition (Alloy									
	constituents)									
	j. Microstructure (grain size –									
	shape - boundary precipitates,									
	gamma prime size and volume									
	fraction, etc.)									
	k. Melting Point									
	Corrosion Resistance									
	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									

			\mathbf{C}	ATEG	ORIE	S OF I	REPA:	IR		
Req	Repair Design Requirements to be									
No.	Identified and Substantiated,	1	2	3	4	5	6	7	8	9
	Cont'd.Repair Properties and									
	Requirements to be Identified and									
	Substantiated, Cont'd.									
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									
4.	Characteristics & Processes:									
	Characteristics & Frocesses.									
	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									
	Bonding (Interface Contamination) Fracing and a Project and a contamination									
	m. Environmental Resistance									
	n. Diffusion Zone									
	o. Hydrogen Embrittlement Free									
	(Plating) p. Compatibility With Base Material									
	p. Companionity 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		1	2	3	4	5	6	7	8	9
5.	Substantiated, Cont'd. Select Surface Treatment that applies (Without Material Removal) and evaluate effect(s), if any, on airworthiness:					_		_		_	_
	a. Burnishingb. Peeningc. Butterfly Polishe. Mass Media Finishing										
6.	Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.										
	 a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (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 Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 1				C	ATEG	ORIE	S OF	REPA	IR		
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 • 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. 33.88; and 33.90)	Req	Repair Properties and Requirements to									
Substantiation Requirements Verification Plan with Significant Operations Identified for Repair Source Qualification	No.		1	2	3	4	5	6	7	8	9
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 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; 33.68; 33.88; and 33.90)											
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)											
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 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; 33.88; and 33.90)	14.										
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 • Source Substantiation 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; 33.88; and 33.90)											
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 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)		_									
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 Mapplicable 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)	15.										
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)											
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associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)											
33.88; and 33.90)	25.	associated with 33.27: 33.63: 33.83: 33.87:									
	26.	33.21 Engine Cooling									
27. 33.23 Engine mounting attachments and											
structure											
28. 33.25 Accessory attachments	28.										

		CATEGORIES OF REPAIR 1 2 3 4 5 6 7 8 9								
Req	Repair Properties and Requirements to									
No.	be Identified and Substantiated, Cont'd.	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:									
22	Turbine Aircraft Engines									
32. 33.	33.62 Stress Analysis 33.63 Vibration									
34.	33.65 Surge and stall characteristics (Note 2)									
35.	33.66 Bleed air systems									
36.	33.67 Fuel system									
37.	•									
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									
11.	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									
46	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)									

			C	ATEG	ORIE	S OF	REPA	IR		
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									

(Public comments phase August 2006)

Template 10

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

<u>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.</u>

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

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

		CATEG	ORIES 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
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 				

		CATEG	ORIES 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
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				

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

		CATEG	ORIES OF	REPAIR	
Req	Repair Properties & Requirement to be				
No.	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				
0	potential impact on the airworthiness of the part.				
8.	Select all that may be potentially	1			
	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	<u> </u>		<u> </u>	
	features and for any replacement detail(s) and				
	give due consideration to mating part(s):				
	a. Surface finish/texture				
	b. Shotpeen Intensity / Coverage				
	c. Bearing bore dimensions and				
	location characteristics				
	d. Pressure Strength Test				
	e. Flow Capacity testf. Dimensions, including heat distortion				
	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 				

	01:1101			
	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:			
	accomplish repair.			
	Drawings/Specifications			
	Quality Requirements			
	 Source Substantiation Requirements 			

		CATEG	ORIES OF	REPAIR	
Req	Repair Properties and Requirements to be				
No.	Identified and Substantiated, Cont'd.	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				
2.5	33.90)				
26.	33.21 Engine Cooling				
27.	33.23 Engine mounting attachments and				
20	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				
31.	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				

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

(Public comments phase August 2006)

Template 11

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

CATEGORIES	REPAIR DESCRIPTION
OF REPAIRS	
1.	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

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

			CA	TEG	ORI	ES ()FR	EPA	IRS		
Req	Repair Design Requirements to be Identified	1	2	3	4	5	6	7	8	9	10
No.	and Substantiated, Cont'd.Repair Properties										
	and Requirements to be Identified and										
	Substantiated, Cont'd.										
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										
	1. Contamination)										
	m. Hydrogen Embrittlement (Plating)										
	n. Compatibility With Base Material/Other										
	Coatings										
5.	Select Surface Treatment that applies (Without										
٥.	Material Removal) and evaluate effect(s), if any,										
	on airworthiness:										
	a. Burnishing										
	b. Peening										
	c. Butterfly Polish										
	d. Mass Media Finishing										
	d. Mass Media Finishing										

			CATEGORIES OF REPAIRS										
Req No.	and Substar	gn Requirements to be Identified ntiated, Cont'd.Repair Properties		1	2	3	4	5	6	7	8	9	10
	and Require	ements to be Identified and											
	Substantiate	,											
6.		degradation in the part's											
		durability due to the following											
		hen applicable, and assess its											
	impact, if an	y, on existing ICAs.											
		chining, Milling, Broaching, or					1						
		nding											
		n-traditional Machining											
		lding, Brazing or Coating											
		nightening, re-twisting, re-forming											
		nding ·											
	f. Ho												
		pping											
		t Blast											
		pping aning (Chemical, power flash,											
		rasonic)											
		idual Plating, Stripping, or											
		aning Agents											
		ess Intensity Factor (K _t)											
		at Treatment (time, temp,											
		osphere, etc)											
	n. Plat	1 ' '											
		nensional Short-falls											
		petitive or Conflicting Repairs											
		ntamination											

		CATEGORIES OF REPAIRS										
Req	Repair Properties and Requirements to be		1	2	3	4	5	6	7	8	9	10
No.	Identified and Substantiated, Cont'd.											<u> </u>
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)											

			C	ATE(GOR	ES O	F RE	PAII	RS		
Req	Repair Properties and Requirements to be	1	2	3	4	5	6	7	8	9	10
No.	Identified and Substantiated, Cont'd.										
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)										

		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
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											

		CATEGORIES OF REPAIRS										
Req	Repair Properties and Requirements to be		1	2	3	4	5	6	7	8	9	10
No.	Identified and Substantiated, Cont'd.											
	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											
1.5	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											
58.	(APU) mode 33.97 Thrust reversers											
59.	33.99 General conduct of block tests											
39.	FAR 33 -Appendix A – Instructions for											
	Continued Airworthiness											
	FAR 33 -Appendix B- Certification Standard											
	Atmospheric Concentrations of Rain and											
	Hail											
	FAR 34 – Exhaust Emissions											

(Public comments phase August 2006)

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

			CATEGORIES OF REPAIR									
Req		Design Requirements to be										
No.		ied and Substantiated. Repair		1	2	3	4	5	6	7	8	9
		ties and Requirements to be										
		ied and Substantiated, Cont'd.										
1.		able Degradation Modes: Select										
		apply based on the function of the										
		l its operating environment in the										
		This section provides the										
		ound for establishing the										
	substan	tiation requirements.										
	a.	Thermo-Mechanical Fatigue										
	b.	Oxidation										
		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 Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated, Cont'd. 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:	ES OF	ORIES ()F REPA	AIR		
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	5	4	5 6	7	8	9
 a. Stress-Strain b. Fracture Toughness c. Fatigue Strength (S-N, Goodman, Dwell Time) d. Creep 						
Strength, Elongation) f. Hardness						

Metallurgical Properties:

Natural Frequencies

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

Physical Properties:

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

		CATEGORIES OF REPAIR									
Req	Repair Design Requirements to be										
No.	Identified and Substantiated,		1	2	3	4	5	6	7	8	9
	Cont'd.Repair Properties and										
	Requirements to be Identified and										
	Substantiated, Cont'd.										
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 Matarial Duamouties							'			
4.	Coating & Plating Material Properties Characteristics & Processes:										
	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 										

		CATEGORIES OF REPAIR									
Req	Repair Design Requirements to be										
No.	Identified and Substantiated,		1	2	3	4	5	6	7	8	9
	Cont'd.Repair Properties and										
	Requirements to be Identified and										
	Substantiated, Cont'd.										
5.	Select Surface Treatment that applies										
	(Without Material Removal) and evaluate										
	effect(s), if any, on airworthiness:										
	a. Burnishing										
	b. Peening										
	c. Butterfly Polish										
	d. Mass Media Finishing			1	1	1	1	1			
6.	Evaluate any degradation in the part's										
	function or durability due to the										
	following processes, when applicable, and										
	assess its impact, if any, on existing ICAs.										
	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. Strippingj. Cleaning (Chemical, power flash,										
	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										
٠.	and the Repair Processing Sequence or										
	evaluate any changes to an existing repair										
	sequence for potential impact on the										
	airworthiness of the part.										
	an wordings of the part.			l		l	l	l			

		CATEGORIES OF REPAIR									
Req	Repair Design Requirements to be										
No.	Identified and Substantiated,		1	2	3	4	5	6	7	8	9
	Cont'd.Repair Properties and										
	Requirements to be Identified and										
	Substantiated, Cont'd.										
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										
	distortion effects										
	 Roundness 										
	• Flatness										
	Parallelism										
	• Concentricity										
	• True Position										
	Tolerances										
	Edge Distance										
	Requirements										
	Finish Dimensions										
	Requirements										
	Requirements										
10.	Coating Coverage Definition										
11.	Blend Area Proximity Limits Defined										
12.	No Grit Blast / Coating in Fillet Radii										

		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
	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										

		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
	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										

		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
	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										

(Public comments phase August 2006)

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

		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, O₃ chemical attack, etc 												

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

			CAT	EGOR	RIES C	F REI	PAIR		
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) 								
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 								

			CAT	EGOF	RIES C	F REI	PAIR		
Req	Repair Properties and Requirements to be								
No.	Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7	8
5.	Select Surface Treatment that applies (Without								
٥.	Material Removal) and evaluate effect(s), if any, on								
	airworthiness:								
	a. Burnishing			L					
	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.								
	 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. Strippingj. Cleaning (Chemical, power flash,								
	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		1						
	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								
	g. Moment of Weight								
	Critical Measurable Characteristics								
	Officer Measurable Office acteristics								

				CAT	EGOR	RIES C	F REI	PAIR				
Req	Repair Properties and Requirements to be	CATEGORIES OF REPAIR 1 2 3 4 5 6 7										
No. 9.	Identified and Substantiated, Cont'd. Establish Measurable Characteristics and the		1	2	3	4	5	0	1	8		
٦.	allowable tolerances for the repaired part											
	features and for any replacement detail(s) and											
	give due consideration to mating part(s):											
	a. Surface finish/texture											
	b. Shotpeen Intensity / Coverage											
	c. Bearing bore dimensions and location											
	characteristics											
	d. Pressure Strength Test											
	e. Flow Capacity testf. Dimensions, including heat distortion											
	effects											
	• Roundness											
	• Flatness											
	Parallelism											
	Concentricity											
	True Position Tolerances											
	 Edge Distance 											
	• Requirements											
	• Finish Dimensions											
	Requirements											
	Cuitical Massurable Changetonistics											
10.	Critical Measurable Characteristics Coating Coverage Definition:											
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											
12	Identified	+-										
13.	Process Demonstration (including variability											
14.	requirements) Part Demonstration/Inspection	+-+										
15.	Manufacturing requirements for fabrication of	+ -										
13.	repair details or replacement sections used to											
	accomplish repair:											
	r											
	 Drawings/Specifications 							•				
	Quality Requirements											
	Source Substantiation Requirements											

			CAT	EGOF	RIES C	F REI	PAIR		
Req	Repair Properties and Requirements to be								
No.	Identified and Substantiated, Cont'd.	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:								
20	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								
2.6	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								

			CAT	EGOF	RIES O	F REI	PAIR		
Req	Repair Properties and Requirements to be								
No.	Identified and Substantiated, Cont'd.	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								

(Public comments phase August 2006)

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	REPAIR DESCRIPTION
OF REPAIR	
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.

		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					
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												

		C	ATEGO	RIES OI	F REPAI	R	
Req	Repair Design Requirements to be			0			
No.	Identified and Substantiated. Repair	1	2	3	4	5	6
	Properties and Requirements to be						
	Identified and Substantiated, Cont'd.						
2.	Select all mechanical, metallurgical,						
	and physical properties of the part						
	affected by the repair design, and						
	assess their impact on the part's						
	airworthiness:						
	Mechanical Properties:						
	a. Stress-Strain						
	b. Fracture Toughness						
	c. Fatigue Strength (S-N,						
	Goodman, Dwell Time)						
	d. Creep						
	e. Tensile Properties (Yield,						
	Strength, Elongation)						
	f. Hardness						
	g. Young's Modulus						
	h. Natural Frequencies						
	Metallurgical Properties:						
	i. Chemical Composition (Alloy constituents)						
	j. Microstructure (grain size –						
	shape - boundary precipitates,						
	gamma prime size and						
	volume fraction, etc.)						
	k. Melting Point						
	 Corrosion Resistance 						
	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						
l							

		C	ATEGO	RIES OI	F REPAII	2	
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
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)						

		(CATEGO	RIES O	F REPAIR	₹	
Req	Repair Design Requirements to be						
No.	Identified and Substantiated,	1	2	3	4	5	6
	Cont'd.Repair Properties and						
	Requirements to be Identified and						
	Substantiated, Cont'd.						
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						
	Composition						
	h Thisley on Course of						
	b. Thickness, Coverage &						
	Uniformity c. Coating and Diffusion Zone						
	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						
	1. Contamination)						
	m. Hydrogen Embrittlement						
	(Plating)						
	n. Compatibility With Base						
	Material/Other Coatings						
	E						
	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						

		(CATEGO	RIES OF	REPAI	R	
Req No	Repair Properties & Requirement to be Identified and Substantiated, Cont'd.	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, reforming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping j. Cleaning (Chemical, power flash, Ultrasonic) k. Residual Plating, Stripping, or Cleaning Agents l. Stress Intensity Factor (Kt) m. Heat Treatment (time, temp, atmosphere, etc) n. Plating o. Dimensional Short-falls p. Repetitive or Conflicting Repairs Contamination 						
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							
1.0	Subpart A General							
18.	33.07 Engine ratings and operating limitations							
19.	33.08 Selection of engine power and thrust ratings						1	
	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							

		CA	TEGOI	RIES OF	REPAIR	2	
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							
53.	bench testing) 33.92 Rotor locking tests							
33.	55.92 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	DER			1		1	
	Continued Airworthiness							
	FAR 33=Appendix B- Certification							
	Standard Atmospheric Concentrations							
	of Rain and Hail							
	FAR 34 – Exhaust Emissions							

(Public comments phase August 2006)

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	REPAIR DESCRIPTION
OF REPAIRS	
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)

			CATEGORIES OF REPAIR						
Req No.		Design Requirements to be Identified bstantiated. Repair Properties and		1	2	3	4		
	Requir	ements to be Identified and							
	Substa	ntiated, Cont'd.							
1.	Applica	able Degradation Modes: Select all that							
	apply b	ased on the function of the part and its							
		ng environment in the engine. This							
		provides the background for establishing							
	the sub	stantiation 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							

		CATEGO						
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		
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							
	j. Microstructure (grain size – shape - boundary precipitates, gamma prime size and volume fraction, etc.)							
	k. Melting Point							
	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
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. Burnishingb. Peeningc. Butterfly Polishd. Mass Media Finishing					

		CATEGORIES OF REPAIR						
	Properties & Requirement to be ied and Substantiated, Cont'd.		1	2	3	4		
6. Evalua	te any degradation in the part's							
function	on or durability due to the following							
process	ses, when applicable, and assess its							
impact	, if any, on existing ICAs.							
a. b. c. d. e. f. g. h. i. j. k. l. m. o.	Machining, Milling, Broaching, or Grinding Non-traditional Machining Welding, Brazing or Coating Straightening, re-twisting, re-forming Blending Honing Lapping Grit Blast Stripping Cleaning (Chemical, power flash, Ultrasonic) Residual Plating, Stripping, or Cleaning Agents Stress Intensity Factor (K _t) Heat Treatment (time, temp, atmosphere, etc) Plating Dimensional Short-falls Repetitive or Conflicting Repairs Contamination							

		CATEGORIES OF REPAIR						
Req	Repair Properties and Requirements to be							
No.	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							
0	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							
<i>)</i> .	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							
	 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							
	RequirementsFinish Dimensions Requirements							
	Finish Dimensions Requirements							
	Airfoil Profile							
	 Leading & Trailing Edge Contours 							
	 Concave & Convex Contours 							
	 Thickness 							
	 Chord & Tip Length 							
	• Twist/Lean/Bow							
	Cuitigal Managementa Chamaget							
10	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)							

		CATEGORIES OF REPAIR					
Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		1	2	3	4	
	Repair Process Capability Technical						
1.4	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/SpecificationsQuality 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						
51.	Subpart E – Design and Construction: Turbine						
	Aircraft Engines						
32.	33.62 Stress Analysis						
33.	33.63 Vibration						

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

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

(Public comments phase August 2006)

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, Abrasio Corrosion, Erosion, Cavitation, Fretting, Oxidation f. High Cycle Fatigue g. Rubbing, foreign object impact damage, O ₃ chemical attack, etc	1,										

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

			CATE	GORIE	S OF R	EPAIR		
Req No.	Repair Design Requirements to be Identified and Substantiated, Cont'd.Repair Properties and Requirements to be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7
3.	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. Burnishingb. Peeningc. Butterfly Polishd. Mass Media Finishing							

Req No. Identified and Substantiated, Cont'd. 6. Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast i. Stripping	
6. Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast	
6. Evaluate any degradation in the part's function or durability due to the following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast	7
following processes, when applicable, and assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast	
assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast	
assess its impact, if any, on existing ICAs. a. Machining, Milling, Broaching, or Grinding b. Non-traditional Machining c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast	
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	
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	
 c. Welding, Brazing or Coating d. Straightening, re-twisting, reforming e. Blending f. Honing g. Lapping h. Grit Blast 	
d. Straightening, re-twisting, re- forming e. Blending f. Honing g. Lapping h. Grit Blast	
e. Blending f. Honing g. Lapping h. Grit Blast	
e. Blending f. Honing g. Lapping h. Grit Blast	
f. Honing g. Lapping h. Grit Blast	
g. Lapping h. Grit Blast	
h. Grit Blast	
i. Stripping	
j. Cleaning (Chemical, power flash,	
Ultrasonic)	
k. Residual Plating, Stripping, or	
Cleaning Agents	
1. Stress Intensity Factor (K _t)	
m. Heat Treatment (time, temp,	
atmosphere, etc)	
n. Plating	
o. Dimensional Short-falls	
p. Repetitive or Conflicting Repairs	
Contamination	
7. Establish the Applicability of the Repair	
and the Repair Processing Sequence or	
evaluate any changes to an existing repair	
sequence for potential impact on the	
airworthiness of the part.	
8. Select all that may be potentially	
affected by the repair design, and	
evaluate system effect(s):	
a. Structural Strength, including	
major load paths	
b. Heat Transfer	
c. Secondary Airflow	
d. Aerodynamics	
e. Weight	
f. Center of Gravity	
g. Moment of Weight	

		(CATE	ORIE	S OF F	REPAII	R	
Req	Repair Properties and Requirements to be							
No.	Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7
	Critical Measurable Characteristics							
9.	Dimension of sealing features (leakage,							
10	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							
	h. Tip Length i. Airfoil wall thickness							
	j. Throat Area							
	J. Imourinou							
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							
4.5	Identified		ļ					
13.	Process Demonstration (including variability							
	requirements)]	l .					

			CATE	GORIE	S OF R	EPAIR		
Req	Repair Properties and Requirements to							
No.	be Identified and Substantiated, Cont'd.	1	2	3	4	5	6	7
	Repair Process Capability Technical	 						
1.4	Substantiation Requirements							
14.	Part Demonstration/Inspection							
15.	Manufacturing requirements for fabrication							
	of repair details or replacement sections used to accomplish repair:							
	used to accomplish repair.							
	Drawings/Specifications							
	Quality Requirements							
	Source Substantiation							
	Requirements							
	Applicable FAR Part 33 Requirements							
	Subpart A General				Ì			
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							
20.	fatigue)	 						
21.	33.15 Materials							
22.	33.17 Fire prevention							
23.	33.19 Durability(Note that 33.19 is							
	associated with 33.27; 33.63; 33.83; 33.87;							
	33.88; and 33.90)							
24.	33.21 Engine Cooling							
25.	33.23 Engine mounting attachments and	 						
2.5	structure							
26.	33.25 Accessory attachments							
	Subpart B – Design and Construction; General							
27.	33.27 Turbine, compressor, fan, and turbo-							
27.	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				l	1		

		CATEGORIES OF REPAIR								
Req No.	Repair Properties and Requirements to be Identified and Substantiated, Cont'd.		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									
42	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)				L					
53.	33.92 Rotor locking tests									
54.	33.93 Teardown inspection									
55.	33.94 Blade containment and rotor									
55.	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									

(Public comments phase August 2006)

Template 17

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

<u>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.</u>

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

				CAT	EGOF	RIES O	F REP	AIR		
Req No.	Repair Design Required Identified and Substant Properties and Required	tiated. Repair	1	2	3	4	5	6	7	8
	Identified and Substant									
1.	Applicable Degradation all that apply based on the part and its operating envengine. This section provided background for establish substantiation requireme	n Modes: Select the function of the vironment in the vides the ing the								
	e. Wear due to: An Corrosion, Eros Fretting, Oxidat f. High Cycle Fati g. Rubbing, foreig	erature-Induced o, Diffusion, rature Gradients) dhesion, Abrasion, ion, Cavitation, ion								

(Public comments phase August 2006)

		CATEGORIES OF REPAIR									
Req	Repair Design Requirements to be										
No.	Identified and Substantiated. Repair		1	2	3	4	5	6	7	8	
	Properties and Requirements to be										
	Identified and Substantiated, Cont'd.										
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
- 1. 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	Repair Design Requirements to be												
No.	Identified and Substantiated,		1	2	3	4	5	6	7	8			
	Cont'd.Repair Properties and												
	Requirements to be Identified and												
	Substantiated, Cont'd.												
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.												
	 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												
	1. Contamination)												
	m. Hydrogen Embrittlement (Plating)												
	n. Compatibility With Base												
	Material/Other Coatings												
_	Called Complete Threader 443 4 19	1	l	1									
5.	Select Surface Treatment that applies												
	(Without Material Removal) and evaluate												
	effect(s), if any, on airworthiness:			1					,				
	a. Burnishing												
	b. Peening												
	c. Butterfly Polish												
	d. Mass Media Finishing												

			CAT	EGOF	RIES C	F RE	PAIR		
Req	Repair Properties & Requirement to be								
No.	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. Platingo. Dimensional Short-falls								
7									
7.									
8.	•								
	` '								
	6. Alement of Hongar								
8.	p. Repetitive or Conflicting Repairs Contamination 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. Select all that may be potentially affected by the repair design, and evaluate system effect(s): a. Structural Strength, including major load paths b. Heat Transfer c. Secondary Airflow d. Aerodynamics e. Weight f. Center of Gravity g. Moment of Weight								

		CATEGORIES OF REPAIR								
Req	Repair Properties and Requirements to be					_	_			_
No.	Identified and Substantiated, Cont'd.		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 									
	C									
	• Leading									
	& Trailing Edge Contour									
	• Concave									
	& convex contours									
	• Thickness									
	• Chord &									
	Airfoil Length									
	• Twist /									
	Lean/ Bow									
	h. Tip Length									
	 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									

		CATEGORIES OF REPAIR											
Req	Repair Properties and Requirements to be												
No.	Identified and Substantiated, Cont'd.		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:												
	D : (G : G :												
	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									l			
	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;									l			
20	General												
20.	33.14 Start-stop cyclic stress (low cycle									l			
21	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 Cooling 33.23 Engine mounting attachments and												
۷٥.	structure												
26.	33.25 Accessory attachments												
۷٥.	55.25 Accessory attachments												

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

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