



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

# Advisory Circular

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**Subject:** Developing Data for Major  
Repairs of Turbine Engine Parts

**Date:** 4/30/10  
**Initiated by:** ANE-110

**AC No:** 33-9

## 1. Purpose.

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

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

## 2. Applicability.

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

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

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

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

**3. Related References.** Please check the FAA's website at [http://www.faa.gov/regulations\\_policies/](http://www.faa.gov/regulations_policies/) for the latest revision of the following documents.

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

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

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

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

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

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

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

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

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

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

#### **4. Background.**

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

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

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

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

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

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

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

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

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

**Table 1. Category 1 Engine Parts**

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

**Table 2. Category 2 Engine Parts**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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



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

A handwritten signature in black ink, appearing to read "Francis A. Favara".

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

## APPENDIX 1. FAILURE MODES AND EFFECTS ASSESSMENT

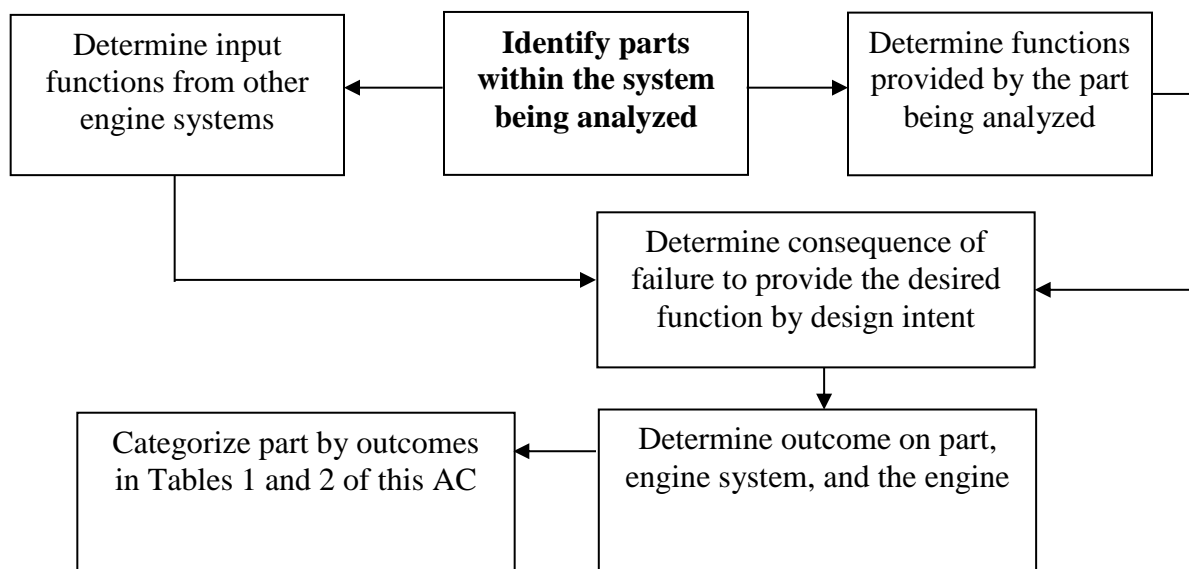
1. A failure modes and effects assessment is a qualitative process, independent of failure rates and probabilities, by which each failure mode of a part in the engine system is analyzed. Some top-level functions typically considered in an engine failure modes and effects assessment are:

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

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

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

**Figure A1.1. Process Flow Diagram**



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

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

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

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

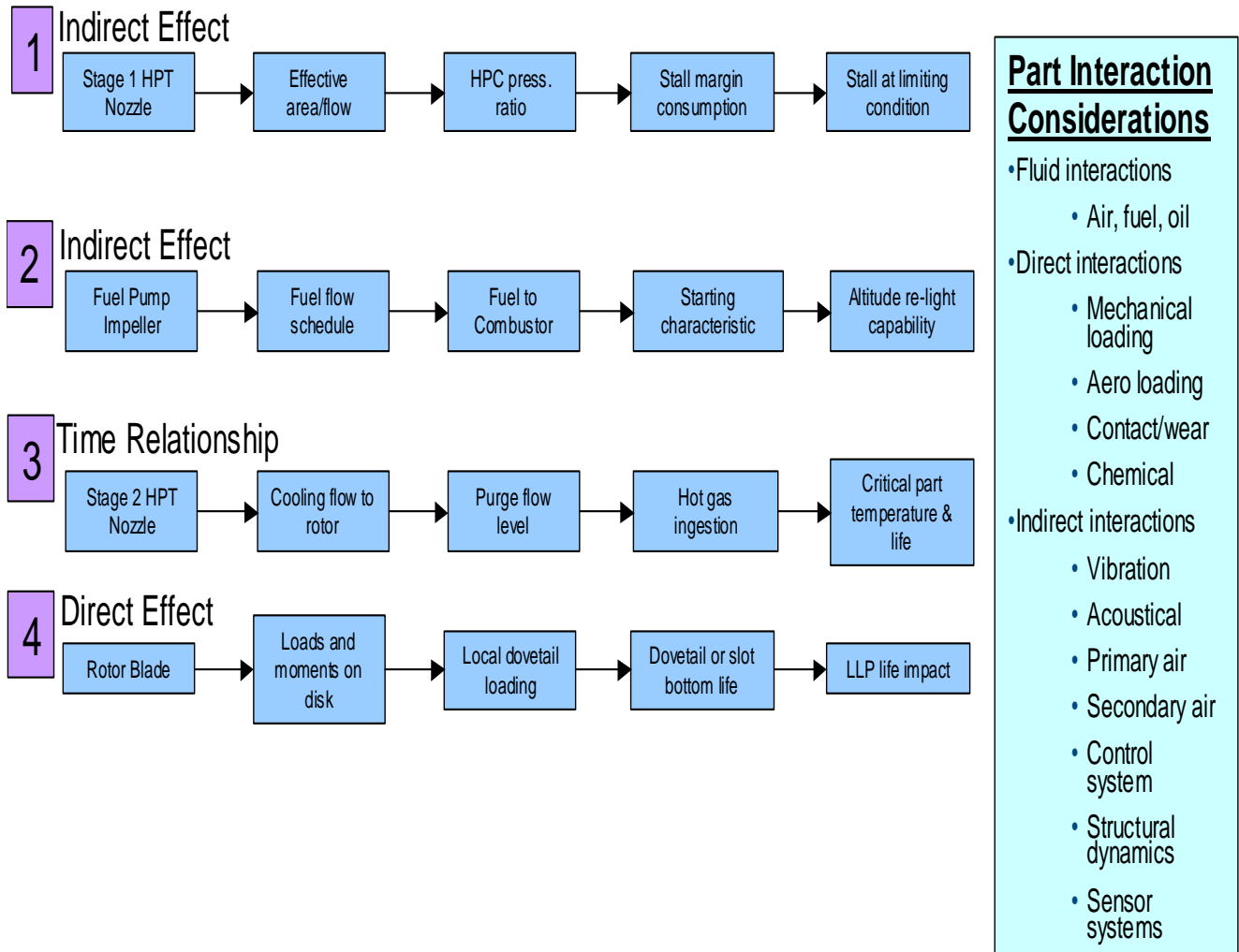
(3) Function is the action(s) the part is designed to perform in the engine.

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

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

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

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

**Figure A1.2. Part Interaction Considerations**

## APPENDIX 2. SAMPLE TEMPLATES

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

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

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

b. Acceptable methods are identified as follows:

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

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

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

**Table A2-1. Sample Templates.**

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

|    |   |     |
|----|---|-----|
| 17 | Low Pressure Turbine (LPT) Vane Part Family | 166 |
|----|---|-----|

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>  |
|------------------------------|--|
| 1.                           | Restoration of Protective Coating <ul style="list-style-type: none"> <li>• This repair includes touch-up coating</li> </ul>  |
| 2.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>• This repair excludes detail part replacement</li> </ul>  |
| 3.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>• This repair includes detail part replacement</li> </ul>  |
| 4.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>• 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.</li> </ul> |
| 5.                           | Blend Repair   |
| 6.                           | Dimensional Restoration by Coating or Plating  |
| 7.                           | Bushing/Helicoil Repair  |
| 8.                           | Straightening, Re-twist, or Reforming Repair <ul style="list-style-type: none"> <li>• This repair includes straightening of bent knife edges</li> </ul>  |
| 9.                           | Surface Treatment Repair <ul style="list-style-type: none"> <li>• This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)</li> </ul>  |
| 10.                          | Machining Repair <ul style="list-style-type: none"> <li>• This repair includes lapping, skim cut, non-conventional machining.</li> </ul>   |
| 11.                          | Restoration of Adhesives, Bonding Agents, Potting Compound   |

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

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



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

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

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

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

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

| Req No. | Repair Design Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |    |    |
|---------|---|----------------------|---|---|---|---|---|---|---|---|----|----|
|         |   | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> 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):<br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>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):<br><br><ul style="list-style-type: none"> <li>• Surface finish/texture</li> <li>• Shotpeen Intensity/Coverage</li> <li>• Bearing bore dimensions and location characteristics</li> <li>• Pressure Strength Test</li> <li>• Flow Capacity test</li> <li>• Dimensions, including heat distortion effects</li> </ul> 1) Roundness<br>2) Flatness<br>3) Parallelism<br>4) Concentricity<br>5) True Position Tolerances<br>6) Edge Distance Requirements<br>7) Finish Dimensions Requirements |                      |   |   |   |   |   |   |   |   |    |    |
| 10.     | Significant Operations Identified for Validation that would include parameter variability limits.   |                      |   |   |   |   |   |   |   |   |    |    |

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

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



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

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

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

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

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

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

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

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

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

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



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

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

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

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

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>   |
|------------------------------|---|
| 1.                           | Strip and Re-coat Repair <ul style="list-style-type: none"> <li>This repair removes and replaces any and all types of coatings</li> </ul>   |
| 2.                           | Weld or Braze Repair (excludes detail parts replacement) <ul style="list-style-type: none"> <li>This repair includes restoration of airfoil tip and chord length</li> </ul>   |
| 3.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>This repair includes detail parts replacement</li> </ul>  |
| 4.                           | Assembly or Disassembly <ul style="list-style-type: none"> <li>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.</li> </ul> |
| 5.                           | Blend Repair  |
| 6.                           | Remove and Restore Anti-gallant Coating   |
| 7.                           | Dimensional Restoration by Coating or Plating   |
| 8.                           | Straightening, Re-twist or Re-forming Repair <ul style="list-style-type: none"> <li>This repair includes dent repair</li> </ul>   |
| 9.                           | Surface Treatment Repair <ul style="list-style-type: none"> <li>This repair includes shot-peen, glass bead peen, vibratory tumble (e.g., restoration of surface finish/texture)</li> </ul>  |

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

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

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



| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 4.      | <p>Select all <b>Coating Properties/Characteristics</b> that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part’s physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <p>a. Coating Material Composition</p> <p>b. Thickness, Coverage &amp; Uniformity</p> <p>c. Coating and Diffusion Zone Microstructure</p> <p>d. Coating Hardness</p> <p>e. Sintering</p> <p>f. Strip Requirements/Process</p> <p>g. Residual Stress</p> <p>h. Resistance to Spalling</p> <p>i. Thermal Resistance (coefficient of thermal expansion for the coating)</p> <p>j. Erosion Resistance</p> <p>k. Bonding (interface contamination)</p> <p>l. Hydrogen Embrittlement (plating)</p> <p>m. Compatibility with Base Material/Other Coatings</p> |                      |   |   |   |   |   |   |   |   |
| 5.      | <p>Select <b>Surface Treatment that applies</b> (without material removal) and evaluate effect(s), if any, on airworthiness:</p> <p>a. Burnishing</p> <p>b. Peening</p> <p>c. Butterfly Polish</p> <p>d. Mass Media Finishing</p>  |                      |   |   |   |   |   |   |   |   |

| Req No. | Repair Properties & Requirements to be Identified and Substantiated.   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 6.      | <p>Evaluate any <b>degradation in the part’s function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"><li>a. Machining, Milling, Broaching, or Grinding</li><li>b. Non-traditional Machining</li><li>c. Welding, Brazing or Coating</li><li>d. Straightening, re-twisting, re-forming</li><li>e. Blending</li><li>f. Honing</li><li>g. Lapping</li><li>h. Grit Blast</li><li>i. Stripping</li><li>j. Cleaning (Chemical, power flash, Ultrasonic)</li><li>k. Residual Plating, Stripping, or Cleaning Agents</li><li>l. Stress Intensity Factor (K<sub>t</sub>)</li><li>m. Heat Treatment (time, temp, atmosphere, etc.)</li><li>n. Plating</li><li>o. Dimensional Short-falls</li><li>p. Repetitive or Conflicting Repairs</li><li>q. Contamination</li></ul> |                      |   |   |   |   |   |   |   |   |
| 7.      | <p>Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>  |                      |   |   |   |   |   |   |   |   |

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|---|
| Req No. | Repair Properties & Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 8.      | Select all that may be potentially affected by the repair design and evaluate system effect(s):<br>Stress<br>a. Heat Transfer<br>b. Secondary Airflow<br>c. Aerodynamics   |                      |   |   |   |   |   |   |   |   |   |
|         | <b>Critical Measurable Characteristics</b>   |                      |   |   |   |   |   |   |   |   |   |
| 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):<br><br>a. Surface finish/texture<br>b. Shotpeen Intensity/Coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure Strength test<br>e. Flow Capacity test<br>f. Dimensions, including heat distortion effects<br>• Roundness<br>• Flatness<br>• Parallelism<br>• Concentricity<br>• True Position Tolerances<br>• Edge Distance<br>Requirements<br>• Finish Dimensions<br>Requirements<br>g. Airfoil Profile<br>• Leading & Trailing Edge Contour<br>• Concave & convex contours<br>• Thickness<br>• Chord & Airfoil Length<br>• Twist/Lean/Bow<br>h. Tip Length<br>i. Airfoil wall thickness |                      |   |   |   |   |   |   |   |   |   |

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

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

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

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

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

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

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



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

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

| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 5.      | Select <b>Surface Treatment that applies</b> (without material removal) and evaluate effect(s), if any, on airworthiness:<br><br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing   |                      |   |   |   |   |   |   |   |
| 6.      | Evaluate any <b>degradation in the part's function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.<br><br>a. Machining, Milling, Broaching, or Grinding<br>b. Non-traditional Machining<br>c. Welding, Brazing or Coating<br>d. Straightening, Re-twisting, Re-forming<br>e. Blending<br>f. Honing<br>g. Lapping<br>h. Grit Blast<br>i. Stripping<br>j. Cleaning (Chemical, power flash, Ultrasonic)<br>k. Residual Plating, Stripping, or Cleaning Agents<br>l. Stress Intensity Factor ( $K_t$ )<br>m. Heat Treatment (time, temp, atmosphere, etc.)<br>n. Plating<br>o. Dimensional Short-falls<br>p. Repetitive or Conflicting Repairs<br>q. Contamination |                      |   |   |   |   |   |   |   |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.   |                      |   |   |   |   |   |   |   |

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

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|         | Critical Measurable Characteristics  |                      |   |   |   |   |   |   |   |   |
| 10.     | Part Weight:<br><br>a. Moment<br>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:<br><br>• Drawings/Specifications<br>• Quality Requirements<br>• Source Substantiation Requirements |                      |   |   |   |   |   |   |   |   |
|         | Applicable 14 CFR Part 33 Requirements   |                      |   |   |   |   |   |   |   |   |
|         | Subpart A – General  |                      |   |   |   |   |   |   |   |   |
| 16.     | 33.4 Instructions for Continuous Airworthiness (ICA's)   |                      |   |   |   |   |   |   |   |   |
| 17.     | 33.5 Instruction manual for installing and operating the engine  |                      |   |   |   |   |   |   |   |   |

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

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

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

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

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



|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
| Req No. | Repair Design Requirements to be Identified and Substantiated.<br>Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1.      | <b>Applicable Degradation Modes:</b><br>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.<br><br><div><div>a.</div>Thermo-Mechanical Fatigue<div>b.</div>Oxidation<div>c.</div>Corrosion<div>d.</div>Elevated Temperature-Induced Changes (Creep, Diffusion, Ageing, Temperature Gradients)<div>e.</div>Wear due to: Adhesion, Abrasion, Corrosion, Erosion, Cavitation, Fretting, Oxidation<div>f.</div>High Cycle Fatigue<div>g.</div>Rubbing, foreign object impact damage, O<sub>3</sub> chemical attack, etc.</div> |                      |   |   |   |   |   |   |   |   |

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

| Req No. | Repair Design Requirements to be Identified and Substantiated.<br>Repair Properties and Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|---|----------------------|---|---|---|---|---|---|---|
|         |   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 3.      | Select all <b>Material Properties/Characteristics for weldments or brazed joints</b> 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.<br>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)<br>b. Porosity (weldment)<br>c. Diffusion Zone (brazing)<br>d. Heat Affected Zone (welding)                              |                      |   |   |   |   |   |   |   |
|         | <b>Material Properties/Degradation Modes/Product Qualities/etc. Technical Substantiation Requirements</b>   |                      |   |   |   |   |   |   |   |
| 4.      | Coating & Plating Material Properties Characteristics & Processes:<br><br>a. Deposit material composition<br>b. Thickness, Coverage, and Uniformity<br>c. Microstructure<br>d. Hardness<br>e. Sintering<br>f. Strip process<br>g. Residual stress<br>h. Lubricant properties<br>i. Spalling Resistance<br>j. Thermal Resistance<br>k. Erosion Resistance<br>l. Bonding (Interface Contamination)<br>m. Environmental Resistance<br>n. Diffusion Zone<br>o. Hydrogen Embrittlement Free Plating<br>q. Compatibility with base material |                      |   |   |   |   |   |   |   |

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
| Req No. | Repair Design Requirements to be Identified and Substantiated.<br>Repair Properties and Requirements to be Identified and Substantiated.   |                      | 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):<br><br>a. Surface finish/texture<br>b. Shotpeen intensity/coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure strength test<br>e. Flow capacity test<br>f. Dimensions, including heat distortion effects <ul style="list-style-type: none"><li>• Roundness</li><li>• Flatness</li><li>• Parallelism</li><li>• Concentricity</li><li>• True position tolerances</li><li>• Edge distance requirements</li><li>• Finish dimensions requirements</li></ul> |                      |   |   |   |   |   |   |   |   |

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

|         |   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|---|----------------------|---|---|---|---|---|---|---|---|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.  |                      | 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):<br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>g. Moment of Weight   |                      |   |   |   |   |   |   |   |   |
|         | <b>Critical Measurable Characteristics</b>  |                      |   |   |   |   |   |   |   |   |
| 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):<br><br>a. Surface finish/texture<br>b. Shotpeen Intensity/Coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure Strength test<br>e. Flow Capacity test<br>f. Dimensions, including heat distortion effects<br>g. Roundness<br>h. Flatness<br>i. Parallelism<br>j. Concentricity<br>k. True Position Tolerances<br>l. Edge Distance Requirements<br>m. Finish Dimensions Requirements<br>n. Diameter/Locating<br>o. Air Swirler Features<br>p. Mixing Air (dilution) Features<br>q. Datum Location Features<br>r. Air Cooling Hole Diameter<br>s. Flowpath Exit Features<br>t. Sealing Features<br>u. Aft Seal<br>v. Fuel Nozzles<br>w. Igniter interfaces<br>x. Flanges |                      |   |   |   |   |   |   |   |   |

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

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



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

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

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>  |
|------------------------------|--|
| 1.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>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.</li> </ul> |
| 2.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>This repair excludes detail part replacement</li> </ul>  |
| 3.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>Includes detail part replacement</li> </ul>  |
| 4.                           | Blend Repair   |
| 5.                           | Sulfidation or Corrosion Repair  |
| 6.                           | Dimensional Restoration by Coating or Plating  |
| 7.                           | Bushing/Helicoil Repair  |
| 8.                           | Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> <li>This repair includes dent repair</li> </ul>   |
| 9.                           | Repairs to Restore Adhesives, Bonding Agents, Potting Compounds.   |
| 10.                          | Machining Repair <ul style="list-style-type: none"> <li>This repair includes lapping, skim cut, non-conventional machining</li> </ul>  |

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

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

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

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

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |    |
|---------|--|----------------------|---|---|---|---|---|---|---|---|---|----|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> 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):<br><br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>g. Moment of Weight   |                      |   |   |   |   |   |   |   |   |   |    |
|         | <b>Critical Measurable Characteristics</b>   |                      |   |   |   |   |   |   |   |   |   |    |
| 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):<br><br>a. Surface finish/texture<br>b. Shotpeen intensity/coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure strength test<br>e. Flow capacity test<br>f. Dimensions, including heat distortion effects <ul style="list-style-type: none"><li>• Roundness</li><li>• Flatness</li><li>• Parallelism</li><li>• Concentricity</li><li>• True position tolerances</li><li>• Edge distance requirements</li><li>• Finish dimensions requirements</li></ul> |                      |   |   |   |   |   |   |   |   |   |    |
| 10.     | Coating Coverage Definition  |                      |   |   |   |   |   |   |   |   |   |    |
| 11.     | Blend Area Proximity Limits Defined  |                      |   |   |   |   |   |   |   |   |   |    |



|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |    |
|---------|--|----------------------|---|---|---|---|---|---|---|---|---|----|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 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:<br><br>• Drawings/Specifications<br>• Quality Requirements<br>• Source Substantiation Requirements |                      |   |   |   |   |   |   |   |   |   |    |
|         | Applicable 14 CFR Part 33 Requirements   |                      |   |   |   |   |   |   |   |   |   |    |
|         | Subpart A – General  |                      |   |   |   |   |   |   |   |   |   |    |
| 16.     | 33.4 Instructions for Continuous Airworthiness (ICA's)   |                      |   |   |   |   |   |   |   |   |   |    |
| 17.     | 33.5 Instruction manual for installing and operating the engine  |                      |   |   |   |   |   |   |   |   |   |    |
| 18.     | 33.7 Engine ratings and operating limitations  |                      |   |   |   |   |   |   |   |   |   |    |
| 19.     | 33.8 Selection of engine power and thrust ratings  |                      |   |   |   |   |   |   |   |   |   |    |
|         | Subpart B – Design and Construction; General   |                      |   |   |   |   |   |   |   |   |   |    |
| 20.     | 33.14 Start-stop cyclic stress (low cycle fatigue)   |                      |   |   |   |   |   |   |   |   |   |    |
| 21.     | 33.15 Materials  |                      |   |   |   |   |   |   |   |   |   |    |
| 22.     | 33.17 Fire prevention  |                      |   |   |   |   |   |   |   |   |   |    |
| 23.     | 33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)   |                      |   |   |   |   |   |   |   |   |   |    |
| 24.     | 33.21 Engine cooling   |                      |   |   |   |   |   |   |   |   |   |    |
| 25.     | 33.23 Engine mounting attachments and structure  |                      |   |   |   |   |   |   |   |   |   |    |
| 26.     | 33.25 Accessory attachments  |                      |   |   |   |   |   |   |   |   |   |    |
| 27.     | 33.27 Turbine, compressor, fan, and turbo-supercharger rotors  |                      |   |   |   |   |   |   |   |   |   |    |

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

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

**Template 7****REPAIR SUBSTANTIATION CHECKLIST - FUEL NOZZLE PART FAMILY**

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

| CATEGORIES OF REPAIRS | REPAIR DESCRIPTION   |
|-----------------------|--|
| 1.                    | Blend Repair   |
| 2.                    | Thread Restoration and Functional Testing.   |
| 3.                    | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>Repair removes and replaces detail parts without use of permanent attachment techniques, (i.e. welding or brazing) but assembly is either bolted or riveted.</li> </ul> |
| 4.                    | Machining Repair <ul style="list-style-type: none"> <li>Includes lapping, skim cut, non-conventional machining.</li> </ul>   |
| 5.                    | Weld or Braze Repair <ul style="list-style-type: none"> <li>Excludes Detail Part Replacement</li> </ul>  |
| 6.                    | Weld or Braze Repair <ul style="list-style-type: none"> <li>Includes Detail Part Replacement</li> </ul>  |
| 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.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1.      | <b>Applicable Degradation Modes:</b> 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.<br><br>a. Thermo-mechanical fatigue<br>b. Oxidation<br>c. Corrosion<br>d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients)<br>e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation<br>f. High-cycle fatigue<br>g. Rubbing, foreign object impact damage, O <sub>3</sub> chemical attack, etc. |                      |   |   |   |   |   |   |   |

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

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

| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 |
| 5.      | Select <b>Surface Treatment that applies</b> (without material removal) and evaluate effect(s), if any, on airworthiness:<br><br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing   |                      |   |   |   |   |   |   |
| 6.      | Evaluate any <b>degradation in the part's function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.<br><br>a. Machining, Milling, Broaching, or Grinding<br>b. Non-traditional Machining<br>c. Welding, Brazing or Coating<br>d. Straightening, Re-twisting, Re-forming<br>e. Blending<br>f. Honing<br>g. Lapping<br>h. Grit Blast<br>i. Stripping<br>j. Cleaning (chemical, power flash, Ultrasonic)<br>k. Residual Plating, Stripping, or Cleaning Agents<br>l. Stress Intensity Factor ( $K_t$ )<br>m. Heat Treatment (time, temp, atmosphere, etc.)<br>n. Plating<br>o. Dimensional Short-falls<br>p. Repetitive or Conflicting Repairs<br>q. Contamination |                      |   |   |   |   |   |   |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.   |                      |   |   |   |   |   |   |



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

|         |   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|---|----------------------|---|---|---|---|---|---|---|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated, Cont'd.  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|         | Critical Measurable Characteristics   |                      |   |   |   |   |   |   |   |
| 10.     | Material Debit Due To:  |                      |   |   |   |   |   |   |   |
|         | <div>a. Heat Treat</div> <div>b. Weld, Braze, Coat or Plate Processes</div> <div>c. Machine Process</div> <div>d. Blend</div> <div>e. Hone</div> <div>f. Lap</div> <div>g. Grit Blast</div> <div>h. Strip</div> |                      |   |   |   |   |   |   |   |
| 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:   |                      |   |   |   |   |   |   |   |
|         | <div><div>• Drawings/Specifications</div><div>• Quality Requirements</div><div>• Source Substantiation Requirements</div></div>   |                      |   |   |   |   |   |   |   |
|         | Applicable 14 CFR Part 33 Requirements  |                      |   |   |   |   |   |   |   |
|         | Subpart A – General   |                      |   |   |   |   |   |   |   |
| 18.     | 33.4 Instructions for Continuous Airworthiness (ICA's)  |                      |   |   |   |   |   |   |   |
| 19.     | 33.5 Instruction manual for installing and operating the engine   |                      |   |   |   |   |   |   |   |
| 20.     | 33.7 Engine ratings and operating limitations   |                      |   |   |   |   |   |   |   |
| 21.     | 33.8 Selection of engine power and thrust ratings   |                      |   |   |   |   |   |   |   |

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

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

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>  |
|------------------------------|--|
| 1.                           | Restoration of Protective Coating <ul style="list-style-type: none"> <li>Includes Touch Up Coating</li> </ul>  |
| 2.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>This repair excludes detail part replacement</li> </ul>  |
| 3.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>Includes detail part replacement</li> </ul>  |
| 4.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>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.</li> </ul> |
| 5.                           | Sulfidation or Corrosion Repair  |
| 6.                           | Blend Repair   |
| 7.                           | Dimensional Restoration by Coating or Plating  |
| 8.                           | Bushing/Helicoil Repair  |
| 9.                           | Straightening, Re-twist, or Reforming Repair <ul style="list-style-type: none"> <li>This repair includes straightening of bent knife edges</li> </ul>  |
| 10.                          | Surface Treatment Repair <ul style="list-style-type: none"> <li>This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)</li> </ul>  |
| 11.                          | Machining Repair <ul style="list-style-type: none"> <li>This repair includes lapping, skim cut, non-conventional machining</li> </ul>  |
| 12.                          | Restoration of Adhesives, Bonding Agents, Potting Compounds.   |

| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |    |    |
|---------|---|----------------------|---|---|---|---|---|---|---|---|---|----|----|
|         |   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1.      | <p><b>Applicable Degradation Modes:</b> Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <p>a. Thermo-mechanical fatigue</p> <p>b. Oxidation</p> <p>c. Corrosion</p> <p>d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients)</p> <p>e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation</p> <p>f. High-cycle fatigue</p> <p>g. Rubbing, foreign object impact damage, O<sub>3</sub> chemical attack, etc.</p> |                      |   |   |   |   |   |   |   |   |   |    |    |

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

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



| Req No. | Repair Design Requirements to be Identified and Substantiated.   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |    |    |
|---------|--|----------------------|---|---|---|---|---|---|---|---|---|----|----|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 5.      | Select <b>Surface Treatment that applies</b> (without material removal) and evaluate effect(s), if any, on airworthiness:<br><br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing   |                      |   |   |   |   |   |   |   |   |   |    |    |
|         |  |                      |   |   |   |   |   |   |   |   |   |    |    |
| 6.      | Evaluate any <b>degradation in the part's function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.<br><br>a. Machining, Milling, Broaching, or Grinding<br>b. Non-traditional Machining<br>c. Welding, Brazing or Coating<br>d. Straightening, Re-twisting, Re-forming<br>e. Blending<br>f. Honing<br>g. Lapping<br>h. Grit Blast<br>i. Stripping<br>j. Cleaning (Chemical, power flash, Ultrasonic)<br>k. Residual Plating, Stripping, or Cleaning Agents<br>l. Stress Intensity Factor (K <sub>t</sub> )<br>m. Heat Treatment (time, temp, atmosphere, etc.)<br>n. Plating<br>o. Dimensional Short-falls<br>p. Repetitive or Conflicting Repairs<br>q. Contamination |                      |   |   |   |   |   |   |   |   |   |    |    |
|         |  |                      |   |   |   |   |   |   |   |   |   |    |    |

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |    |    |    |
|---------|--|----------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| Req No. | Repair Design Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> 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):<br><br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>g. Moment of Weight |                      |   |   |   |   |   |   |   |   |   |    |    |    |

|         |   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |    |    |    |
|---------|---|----------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| Req No. | Repair Design Requirements to be Identified and Substantiated.  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|         | Critical Measurable Characteristics   |                      |   |   |   |   |   |   |   |   |   |    |    |    |
| 9.      | Bearing Bore:   |                      |   |   |   |   |   |   |   |   |   |    |    |    |
|         | a.   Dimension<br>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):<br><br>a.   Surface finish/texture<br>b.   Shotpeen intensity/coverage<br>c.   Bearing bore dimensions and location characteristics<br>d.   Pressure strength test<br>e.   Flow capacity test<br>f.   Dimensions, including heat distortion effects<br>•   Roundness<br>•   Flatness<br>•   Parallelism<br>•   Concentricity<br>•   True position tolerances<br>•   Edge distance requirements<br>•   Finish dimensions requirements |                      |   |   |   |   |   |   |   |   |   |    |    |    |

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |    |    |    |
|---------|--|----------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|         | Critical Measurable Characteristics continued  |                      |   |   |   |   |   |   |   |   |   |    |    |    |
| 11      | Oil Nozzle Flow Test   |                      |   |   |   |   |   |   |   |   |   |    |    |    |
|         | Repair Process Capability Technical Substantiation Requirements  |                      |   |   |   |   |   |   |   |   |   |    |    |    |
| 12.     | Verification Plan with Significant Operations Identified for Repair Source 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:<br><br>• Drawings/Specifications<br>• Quality Requirements<br>• Source Substantiation Requirements |                      |   |   |   |   |   |   |   |   |   |    |    |    |
|         | Applicable 14 CFR Part 33 Requirements   |                      |   |   |   |   |   |   |   |   |   |    |    |    |
|         | Subpart A – General  |                      |   |   |   |   |   |   |   |   |   |    |    |    |
| 16.     | 33.4 Instructions for Continuous Airworthiness (ICA's)   |                      |   |   |   |   |   |   |   |   |   |    |    |    |
| 17.     | 33.5 Instruction manual for installing and operating the engine  |                      |   |   |   |   |   |   |   |   |   |    |    |    |
| 18.     | 33.7 Engine ratings and operating limitations  |                      |   |   |   |   |   |   |   |   |   |    |    |    |
| 19.     | 33.8 Selection of engine power and thrust ratings  |                      |   |   |   |   |   |   |   |   |   |    |    |    |

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

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

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>   |
|------------------------------|---|
| 1.                           | Restoration of Protective Coating (Paint, Aluminizing, Oil, etc.) <ul style="list-style-type: none"> <li>• This repair includes touch-up coating</li> </ul>   |
| 2.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>• This repair excludes detail part replacement</li> </ul>   |
| 3.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>• This repair includes detail part replacement</li> </ul>   |
| 4.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>• 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</li> </ul> |
| 5.                           | Blend Repair  |
| 6.                           | Dimensional Restoration by Coating or Plating   |
| 7.                           | Surface Treatment Repair <ul style="list-style-type: none"> <li>• This repair includes peening, vibratory tumble (e.g.; restoration of surface finish/texture)</li> </ul>   |
| 8.                           | Straightening, Re-twist, or Reforming Repair <ul style="list-style-type: none"> <li>• This repair includes straightening of bent flanges</li> </ul>   |
| 9.                           | Restoration of Adhesives, Bonding Agents & Potting Compounds  |

| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|---|----------------------|---|---|---|---|---|---|---|---|
|         |   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1.      | <p><b>Applicable Degradation Modes:</b> Select all that apply based on the function of the part and its operating environment in the engine. This section provides the background for establishing the substantiation requirements.</p> <p>a. Thermo-mechanical fatigue</p> <p>b. Oxidation</p> <p>c. Corrosion</p> <p>d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients)</p> <p>e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation</p> <p>f. High-cycle fatigue</p> <p>g. Rubbing, foreign object impact damage, O<sub>3</sub> chemical attack, etc.</p> |                      |   |   |   |   |   |   |   |   |



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

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

| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 5.      | Select <b>Surface Treatment that applies</b> (without material removal) and evaluate effect(s), if any, on airworthiness:<br><br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing   |                      |   |   |   |   |   |   |   |   |
| 6.      | Evaluate any <b>degradation in the part's function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.<br><br>a. Machining, Milling, Broaching, or Grinding<br>b. Non-traditional Machining<br>c. Welding, Brazing or Coating<br>d. Straightening, Re-twisting, Re-forming<br>e. Blending<br>f. Honing<br>g. Lapping<br>h. Grit Blast<br>i. Stripping<br>j. Cleaning (Chemical, power flash, Ultrasonic)<br>k. Residual Plating, Stripping, or Cleaning Agents<br>l. Stress Intensity Factor (K <sub>I</sub> )<br>m. Heat Treatment (time, temp, atmosphere, etc.)<br>n. Plating<br>o. Dimensional Short-falls<br>p. Repetitive or Conflicting Repairs<br>q. Contamination |                      |   |   |   |   |   |   |   |   |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.   |                      |   |   |   |   |   |   |   |   |

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

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|---|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|         | Repair Process Capability Technical Substantiation Requirements  |                      |   |   |   |   |   |   |   |   |   |
| 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:<br><br>• Drawings/Specifications<br>• Quality Requirements<br>• Source Substantiation Requirements |                      |   |   |   |   |   |   |   |   |   |
|         | Applicable 14 CFR Part 33 Requirements   |                      |   |   |   |   |   |   |   |   |   |
|         | Subpart A – General  |                      |   |   |   |   |   |   |   |   |   |
| 18.     | 33.4 Instructions for Continuous Airworthiness (ICA's)   |                      |   |   |   |   |   |   |   |   |   |
| 19.     | 33.5 Instruction manual for installing and operating the engine  |                      |   |   |   |   |   |   |   |   |   |
| 20.     | 33.7 Engine ratings and operating limitations  |                      |   |   |   |   |   |   |   |   |   |
| 21.     | 33.8 Selection of engine power and thrust ratings  |                      |   |   |   |   |   |   |   |   |   |
|         | Subpart B – Design and Construction; General   |                      |   |   |   |   |   |   |   |   |   |
| 22.     | 33.14 Start-stop cyclic stress (low cycle fatigue)   |                      |   |   |   |   |   |   |   |   |   |
| 23.     | 33.15 Materials  |                      |   |   |   |   |   |   |   |   |   |
| 24.     | 33.17 Fire prevention  |                      |   |   |   |   |   |   |   |   |   |
| 25.     | 33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)   |                      |   |   |   |   |   |   |   |   |   |
| 26.     | 33.21 Engine cooling   |                      |   |   |   |   |   |   |   |   |   |
| 27.     | 33.23 Engine mounting attachments and structure  |                      |   |   |   |   |   |   |   |   |   |
| 28.     | 33.25 Accessory attachments  |                      |   |   |   |   |   |   |   |   |   |

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

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

**Template 10****REPAIR SUBSTANTIATION CHECKLIST –LOW PRESSURE COMPRESSOR (LPC)  
– HIGH PRESSER COMPRESSOR (HPC) STATOR PART FAMILY – FIXED VANE  
TYPE STATORS (CANTILEVERED AT O.D.)**

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

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



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

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

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

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

| Req No. | Repair Properties & Requirement to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |
|---------|--|----------------------|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> 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):<br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>g. Moment of Weight   |                      |   |   |   |   |
|         | <b>Critical Measurable Characteristics</b>   |                      |   |   |   |   |
| 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):<br><br>a. Surface finish/texture<br>b. Shotpeen intensity/coverage<br>c. Bearing bore dimensions and<br>d. location characteristics<br>e. Pressure strength test<br>f. Flow capacity test<br>g. Dimensions, including heat distortion effects:<br>• Roundness<br>• Flatness<br>• Parallelism<br>• Concentricity<br>• True position tolerances<br>• Edge distance requirements<br>• Finish dimensions requirements<br><br>Airfoil Profile<br><br>• Leading & Trailing Edge Contours<br>• Concave & Convex Contours<br>• Thickness<br>• Chord & Tip Length Twist/Lean/Bow |                      |   |   |   |   |

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

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

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



**Template 11****REPAIR SUBSTANTIATION CHECKLIST -- MAJOR ENGINE CASES**

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>  |
|------------------------------|--|
| 1.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>• This repair includes detail part replacement</li> </ul>  |
| 2.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>• This repair excludes detail part replacement</li> </ul>  |
| 3.                           | Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> <li>• This repair includes dent repair</li> </ul>   |
| 4.                           | Dimensional Restoration by Coating or Plating  |
| 5.                           | Restoration of Adhesives, Bonding Agents, Potting Compound.  |
| 6.                           | Bushing or Helicoil Repair   |
| 7.                           | Restoration of Protective Coating <ul style="list-style-type: none"> <li>• Includes touch-up coating</li> </ul>  |
| 8.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>• 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.</li> </ul> |
| 9.                           | Remove and Restore Anti-gallant  |
| 10.                          | Blend Repair   |

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

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

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

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

| Req No. Repair Properties and Requirements to be Identified and Substantiated. |  | CATEGORIES OF REPAIRS |   |   |   |   |   |   |   |   |   |    |
|--|--|-----------------------|---|---|---|---|---|---|---|---|---|----|
|  |  |                       | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 7.   | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> 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):   |                       |   |   |   |   |   |   |   |   |   |    |
|  | <b>Critical Measurable Characteristics</b>   |                       |   |   |   |   |   |   |   |   |   |    |
| 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):<br><br>a. Surface finish/texture<br>b. Shotpeen intensity/coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure strength test<br>e. Flow capacity test<br>f. Dimensions, including heat distortion effects <ul style="list-style-type: none"><li>• Roundness</li><li>• Flatness</li><li>• Parallelism</li><li>• Concentricity</li><li>• True position tolerances</li><li>• Edge distance requirements</li><li>• Finish dimensions requirements</li></ul> |                       |   |   |   |   |   |   |   |   |   |    |
|  | <b>Repair Process Capability Technical Substantiation Requirements</b>   |                       |   |   |   |   |   |   |   |   |   |    |
| 12.  | Verification Plan with Significant Operations Identified for Repair Source Qualification   |                       |   |   |   |   |   |   |   |   |   |    |
| 13.  | Process Demonstration (including variability requirements)   |                       |   |   |   |   |   |   |   |   |   |    |

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

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



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

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>   |
|------------------------------|---|
| 1.                           | Restoration of Protective Coating (Paint, Aluminizing, Oil, etc.) <ul style="list-style-type: none"> <li>• Includes touch-up coating</li> </ul>   |
| 2.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>• This repair excludes detail part replacement</li> </ul>   |
| 3.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>• 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</li> </ul> |
| 4.                           | Blend Repair  |
| 5.                           | Remove and Restore Anti-gallant   |
| 6.                           | Dimensional Restoration by Coating or Plating   |
| 7.                           | Bushing/Helicoil Repair   |
| 8.                           | Honing Repair   |
| 9.                           | Machining Repair <ul style="list-style-type: none"> <li>• This repair includes lapping, skim cut, non-conventional machining</li> </ul>   |

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

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

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

| Req No. Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. |   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---|---|----------------------|---|---|---|---|---|---|---|---|
|   |   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 5.  | Select <b>Surface Treatment that applies</b> (Without Material Removal) and evaluate effect(s), if any, on airworthiness:<br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing  |                      |   |   |   |   |   |   |   |   |
| 6.  | Evaluate any <b>degradation in the part's function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.<br><br>a. Machining, Milling, Broaching, or Grinding<br>b. Non-traditional Machining<br>c. Welding, Brazing or Coating<br>d. Straightening, Re-twisting, Re-forming<br>e. Blending<br>f. Honing<br>g. Lapping<br>h. Grit Blast<br>i. Stripping<br>j. Cleaning (chemical, power flash, ultrasonic)<br>k. Residual Plating, Stripping, or Cleaning Agents<br>l. Stress Intensity Factor (K <sub>t</sub> )<br>m. Heat Treatment (time, temp, atmosphere, etc.)<br>n. Plating<br>o. Dimensional Short-falls<br>p. Repetitive or Conflicting Repairs<br>Contamination |                      |   |   |   |   |   |   |   |   |
| 7.  | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.  |                      |   |   |   |   |   |   |   |   |

| Req No. Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---|--|----------------------|---|---|---|---|---|---|---|---|
|   |  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 8.  | Select all that may be potentially affected by the repair design, and evaluate system effect(s):<br><br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>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):<br><br>a. Surface finish/texture<br>b. Shotpeen intensity/coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure strength test<br>e. Flow capacity test<br>f. Dimensions, including heat<br>g. Distortion effects <ul style="list-style-type: none"><li>Roundness</li><li>Flatness</li><li>Parallelism</li><li>Concentricity</li><li>True Position Tolerances</li><li>Edge Distance Requirements</li><li>Finish Dimensions Requirements</li></ul> |                      |   |   |   |   |   |   |   |   |
| 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.   |                      | 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:<br><br><ul style="list-style-type: none"><li>• Drawings/Specifications</li><li>• Quality Requirements</li><li>• Source Substantiation Requirements</li></ul> |                      |   |   |   |   |   |   |   |   |   |
|         | Applicable 14 CFR Part 33 Requirements   |                      |   |   |   |   |   |   |   |   |   |
|         | Subpart A – General  |                      |   |   |   |   |   |   |   |   |   |
| 17.     | 33.4 Instructions for Continuous Airworthiness (ICA's)   |                      |   |   |   |   |   |   |   |   |   |
| 18.     | 33.5 Instruction manual for installing and operating the engine  |                      |   |   |   |   |   |   |   |   |   |
| 19.     | 33.7 Engine ratings and operating limitations  |                      |   |   |   |   |   |   |   |   |   |
| 20.     | 33.8 Selection of engine power and thrust ratings  |                      |   |   |   |   |   |   |   |   |   |
|         | Subpart B – Design and Construction; General   |                      |   |   |   |   |   |   |   |   |   |
| 21.     | 33.14 Start-stop cyclic stress (low cycle fatigue)   |                      |   |   |   |   |   |   |   |   |   |
| 22.     | 33.15 Materials  |                      |   |   |   |   |   |   |   |   |   |
| 23.     | 33.17 Fire prevention  |                      |   |   |   |   |   |   |   |   |   |
| 24.     | 33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)   |                      |   |   |   |   |   |   |   |   |   |
| 25.     | 33.21 Engine cooling   |                      |   |   |   |   |   |   |   |   |   |



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

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

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>   |
|------------------------------|---|
| 1.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>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</li> </ul> |
| 2.                           | Blend Repair  |
| 3.                           | Strip and Re-coat Repair <ul style="list-style-type: none"> <li>This repair removes and replaces any and all types of coatings</li> </ul>   |
| 4.                           | Dimensional Restoration by Coating or Plating   |
| 5.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>This repair excludes detail part replacement</li> </ul>   |
| 6.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>This repair includes part detail replacement</li> </ul>   |
| 7.                           | Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> <li>This repair includes dent repair</li> </ul>  |
| 8.                           | Machining Repair <ul style="list-style-type: none"> <li>This repair includes lapping, skim cut, non-conventional machining</li> </ul>   |

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

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

| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|
|         |  | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 3.      | <p>Select all <b>Material Properties/Characteristics for weldments or brazed joints</b> that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part’s metallurgy as a result of welds or braze, should be evaluated for airworthiness.</p> <p>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)</p> <p>b. Porosity (weldment)</p> <p>c. Diffusion Zone (brazing)</p> <p>d. Heat Affected Zone (welding)</p>   |                      |   |   |   |   |   |   |   |
| 4.      | <p>Select all <b>Coating Properties/Characteristics</b> that apply and evaluate them and their interface with the parent metal. The effect of any changes to the part’s physical and operational capability as a result of the coating should be evaluated for airworthiness.</p> <p>a. Coating Material Composition</p> <p>b. Thickness, Coverage &amp; Uniformity</p> <p>c. Coating and Diffusion Zone Microstructure</p> <p>d. Coating Hardness</p> <p>e. Sintering</p> <p>f. Strip Requirements/Process</p> <p>g. Residual Stress</p> <p>h. Resistance to Spalling</p> <p>i. Thermal Resistance (coefficient of thermal expansion for the coating)</p> <p>j. Erosion Resistance</p> <p>k. Bonding (interface contamination)</p> <p>l. Hydrogen Embrittlement (plating)</p> <p>m. Compatibility with Base Material/Other Coatings</p> |                      |   |   |   |   |   |   |   |

| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|
|         |  | 1                    | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 5.      | Select <b>Surface Treatment that applies</b> (Without Material Removal) and evaluate effect(s), if any, on airworthiness:<br><br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing   |                      |   |   |   |   |   |   |   |
| 6.      | Evaluate any <b>degradation in the part's function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.<br><br>a. Machining, Milling, Broaching, or Grinding<br>b. Non-traditional Machining<br>c. Welding, Brazing or Coating<br>d. Straightening, Re-twisting, Re-forming<br>e. Blending<br>f. Honing<br>g. Lapping<br>h. Grit Blast<br>i. Stripping<br>j. Cleaning (chemical, power flash, ultrasonic)<br>k. Residual Plating, Stripping, or Cleaning Agents<br>l. Stress Intensity Factor ( $K_I$ )<br>m. Heat Treatment (time, temp, atmosphere, etc.)<br>n. Plating<br>o. Dimensional Short-falls<br>p. Repetitive or Conflicting Repairs Contamination |                      |   |   |   |   |   |   |   |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> 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):<br><br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>g. Moment of Weight   |                      |   |   |   |   |   |   |   |

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|         | Critical Measurable Characteristics  |                      |   |   |   |   |   |   |   |   |
| 9.      | Establish Measurable Characteristics and the allowable tolerances for the repaired part features and for any replacement detail(s) and give due consideration to mating part(s):<br><br>a. Surface finish/texture<br>b. Shotpeen intensity/coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure strength test<br>e. Flow capacity test<br>f. Dimensions, including heat distortion effects<br>1) Roundness<br>2) Flatness<br>3) Parallelism<br>4) Concentricity<br>5) True Position Tolerances<br>6) Edge Distance<br>7) Requirements<br>8) Finish Dimensions Requirements |                      |   |   |   |   |   |   |   |   |
|         | Critical Measurable Characteristics  |                      |   |   |   |   |   |   |   |   |
| 10.     | Coating Coverage Definition:<br>a. No Grit Blast<br>b. No coating in Filet Radii   |                      |   |   |   |   |   |   |   |   |
| 11.     | Blend Area Proximity Limits Defined  |                      |   |   |   |   |   |   |   |   |
|         | Repair Process Capability Technical Substantiation Requirements  |                      |   |   |   |   |   |   |   |   |
| 12.     | Technical Plan with Significant Operations Identified  |                      |   |   |   |   |   |   |   |   |
| 13.     | Process Demonstration (including variability requirements)   |                      |   |   |   |   |   |   |   |   |
| 14.     | Part Demonstration/Inspection  |                      |   |   |   |   |   |   |   |   |
| 15.     | Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:<br><br>• Drawings/Specifications<br>• Quality Requirements<br>• Source Substantiation Requirements   |                      |   |   |   |   |   |   |   |   |



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

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

**Template 14****REPAIR SUBSTANTIATION CHECKLIST - STATIC STRUCTURE PART FAMILY  
(Ducts, Bearing Housings, Etc.)**

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>   |
|------------------------------|---|
| 1.                           | Blend Repair  |
| 2.                           | Weld/Braze Repairs <ul style="list-style-type: none"> <li>• Excludes Detail Part Replacement</li> </ul>   |
| 3.                           | Weld/Braze Repairs <ul style="list-style-type: none"> <li>• Includes Detail Part Replacement</li> </ul>   |
| 4.                           | Assembly and/or Disassembly <ul style="list-style-type: none"> <li>• 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.</li> </ul> |
| 5.                           | Dimensional Restoration Coating or Plating  |
| 6.                           | Straightening, Re-twist or Reforming Repair <ul style="list-style-type: none"> <li>• This repair includes dent repair.</li> </ul>   |

| Req No. |  | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated. |  | CATEGORIES OF REPAIR |   |   |   |   |   |
|---------|--|---|--|----------------------|---|---|---|---|---|
|         |  |   |  | 1                    | 2 | 3 | 4 | 5 | 6 |
| 1.      | <b>Applicable Degradation Modes:</b><br>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.  |   |  |                      |   |   |   |   |   |
|         | <div><div>a. Thermo-mechanical fatigue</div><div>b. Oxidation</div><div>c. Corrosion</div><div>d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients)</div><div>e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation</div><div>f. High-cycle fatigue</div><div>g. Rubbing, foreign object impact damage, O<sub>3</sub> chemical attack, etc.</div></div> |   |  |                      |   |   |   |   |   |

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

| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 |
| 3.      | Select all <b>Material Properties/Characteristics for weldments or brazed joints</b> 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.<br><br>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)<br>b. Porosity (weldment)<br>c. Diffusion Zone (brazing)<br>d. Heat Affected Zone (welding) |                      |   |   |   |   |   |   |

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

|        |   | CATEGORIES OF REPAIR |   |   |   |   |   |   |
|--------|---|----------------------|---|---|---|---|---|---|
| Req No | Repair Properties & Requirement to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 |
| 6.     | <p>Evaluate any <b>degradation in the part’s function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <ul style="list-style-type: none"><li>a. Machining, Milling, Broaching, or Grinding</li><li>b. Non-traditional Machining</li><li>c. Welding, Brazing or Coating</li><li>d. Straightening, Re-twisting, Re-forming</li><li>e. Blending</li><li>f. Honing</li><li>g. Lapping</li><li>h. Grit Blast</li><li>i. Stripping</li><li>j. Cleaning (Chemical, power flash, Ultrasonic)</li><li>k. Residual Plating, Stripping, or Cleaning Agents</li><li>l. Stress Intensity Factor (K<sub>t</sub>)</li><li>m. Heat Treatment (time, temp, atmosphere, etc.)</li><li>n. Plating</li><li>o. Dimensional Short-falls</li><li>p. Repetitive or Conflicting Repairs Contamination</li></ul> |                      |   |   |   |   |   |   |
| 7.     | <p>Cleaning Properties, Characteristics &amp; Material Property Debits:</p> <ul style="list-style-type: none"><li>a. Chemical (solutions, etc.)</li><li>b. Grit Blast (,pressure media etc.)</li><li>c. Power Flush (pressure, solution time, temp, etc.)</li><li>d. Ultrasonic (solution frequency, time, etc.)</li><li>e. Furnace (time, temp, atmosphere, etc.)</li></ul>  |                      |   |   |   |   |   |   |



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

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

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

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

**Template 15****REPAIR SUBSTANTIATION CHECKLIST – LOW PRESSURE COMPRESSOR (LPC)  
– HIGH PRESSURE COMPRESSOR (HPC) STATOR PART FAMILY – VARIABLE  
VANE TYPE STATORS**

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

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

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

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

|         |   | CATEGORIES OF REPAIR |   |   |   |   |
|---------|---|----------------------|---|---|---|---|
| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 |
| 3.      | Select all <b>Material Properties/Characteristics for weldments or brazed joints</b> 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.<br><br>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)<br>b. Porosity (weldment)<br>c. Diffusion Zone (brazing)<br>d. Heat Affected Zone (welding)  |                      |   |   |   |   |
| 4.      | Select all <b>Coating Properties/Characteristics</b> 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.<br><br>a. Coating Material Composition<br>b. Thickness, Coverage & Uniformity<br>c. Coating and Diffusion Zone Microstructure<br>d. Coating Hardness<br>e. Sintering<br>f. Strip Requirements/Process<br>g. Residual Stress<br>h. Resistance to Spalling<br>i. Thermal Resistance (coefficient of thermal expansion for the coating)<br>j. Erosion Resistance<br>k. Bonding (interface contamination)<br>l. Hydrogen Embrittlement (plating)<br>m. Compatibility with Base Material/Other Coatings |                      |   |   |   |   |
| 5.      | Select <b>Surface Treatment that applies</b> (without material removal) and evaluate effect(s), if any, on airworthiness:<br><br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing  |                      |   |   |   |   |



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

|         |  | CATEGORIES OF REPAIR |   |   |   |   |
|---------|--|----------------------|---|---|---|---|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 |
| 7.      | Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> 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):<br>a. Structural Strength, including major load paths<br>b. Heat Transfer<br>c. Secondary Airflow<br>d. Aerodynamics<br>e. Weight<br>f. Center of Gravity<br>g. Moment of Weight  |                      |   |   |   |   |
|         | <b>Critical Measurable Characteristics</b>   |                      |   |   |   |   |
| 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):<br><br>a. Surface finish/texture<br>b. Shotpeen intensity/coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure strength test<br>e. Flow capacity test<br>f. Dimensions, including heat distortion effects <ul style="list-style-type: none"><li>• roundness</li><li>• flatness</li><li>• parallelism</li><li>• concentricity</li><li>• true position tolerances</li><li>• edge distance</li><li>• requirements</li><li>• finish dimensions requirements</li></ul> g. Airfoil profile <ul style="list-style-type: none"><li>• leading &amp; trailing edge contours</li><li>• concave &amp; convex contours</li><li>• thickness</li><li>• chord &amp; tip length</li><li>• twist/lean/bow</li></ul> |                      |   |   |   |   |
|         | <b>Critical Measurable Characteristics</b>   |                      |   |   |   |   |
| 10.     | Spindle (Trunnion) Diameter  |                      |   |   |   |   |
| 11.     | Outer Spindle (Trunnion) to Lever Seating Flat   |                      |   |   |   |   |
| 12.     | Outer Spindle (Trunnion) to Inner Spindle (Trunnion)   |                      |   |   |   |   |
| 13.     | Outer Spindle (Trunnion) to Inner Spindle (Trunnion) Concentricity   |                      |   |   |   |   |

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

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

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

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

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

| <b>CATEGORIES OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>  |
|------------------------------|--|
| 1.                           | Strip and Re-coat Repair <ul style="list-style-type: none"> <li>This repair removes and replaces any and all types of coatings.</li> </ul>   |
| 2.                           | Weld or Braze Repair (excludes detail parts replacement) <ul style="list-style-type: none"> <li>Includes restoration of airfoil tip and chord length</li> </ul>  |
| 3.                           | Weld or Braze Repair <ul style="list-style-type: none"> <li>Includes detail parts replacement</li> </ul>   |
| 4.                           | Assembly and/or disassembly <ul style="list-style-type: none"> <li>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.</li> </ul> |
| 5.                           | Blend Repair   |
| 6.                           | Dimensional Restoration by Coating or Plating  |
| 7.                           | Straightening, Re-twist or Reforming Repair  |

|         |   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|---|----------------------|---|---|---|---|---|---|---|
| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1.      | <b>Applicable Degradation Modes:</b> 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.<br><br>a. Thermo-mechanical fatigue<br>b. Oxidation<br>c. Corrosion<br>d. Elevated temperature-induced changes (creep, diffusion, ageing, temperature gradients)<br>e. Wear due to: adhesion, abrasion, corrosion, erosion, cavitation, fretting, oxidation<br>f. High cycle fatigue<br>g. Rubbing, foreign object impact damage, O <sub>3</sub> chemical attack, etc. |                      |   |   |   |   |   |   |   |

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



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

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|
| Req No, | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 5.      | Select <b>Surface Treatment that applies</b> (Without Material Removal) and evaluate effect(s), if any, on airworthiness:<br><br>a. Burnishing<br>b. Peening<br>c. Butterfly Polish<br>d. Mass Media Finishing |                      |   |   |   |   |   |   |   |

| Req No. | Repair Properties & Requirement to be Identified and Substantiated.   | CATEGORIES OF REPAIR |   |   |   |   |   |   |
|---------|---|----------------------|---|---|---|---|---|---|
|         |   |                      | 1 | 2 | 3 | 4 | 5 | 6 |
| 6.      | <p>Evaluate any <b>degradation in the part's function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <p>a. Machining, Milling, Broaching, or Grinding</p> <p>b. Non-traditional Machining</p> <p>c. Welding, Brazing or Coating</p> <p>d. Straightening, Re-twisting, Re-forming</p> <p>e. Blending</p> <p>f. Honing</p> <p>g. Lapping</p> <p>h. Grit Blast</p> <p>i. Stripping</p> <p>j. Cleaning (chemical, power flash, ultrasonic)</p> <p>k. Residual Plating, Stripping, or Cleaning Agents</p> <p>l. Stress Intensity Factor (<math>K_I</math>)</p> <p>m. Heat Treatment (time, temp, atmosphere, etc.)</p> <p>n. Plating</p> <p>o. Dimensional Short-falls</p> <p>p. Repetitive or Conflicting Repairs</p> <p>Contamination</p> |                      |   |   |   |   |   |   |
| 7.      | <p>Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>   |                      |   |   |   |   |   |   |
| 8.      | <p>Select all that may be potentially affected by the repair design, and evaluate system effect(s):</p> <p>a. Structural Strength, including major load paths</p> <p>b. Heat Transfer</p> <p>c. Secondary Airflow</p> <p>d. Aerodynamics</p> <p>e. Weight</p> <p>f. Center of Gravity</p> <p>g. Moment of Weight</p>  |                      |   |   |   |   |   |   |

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

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

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

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

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

| <b>CATEGORIES<br/>OF REPAIRS</b> | <b>REPAIR DESCRIPTION</b>  |
|----------------------------------|--|
| 1.                               | Strip and Re-coat Repair <ul style="list-style-type: none"> <li>• This repair removes and replaces any and all types of coatings</li> </ul>  |
| 2.                               | Overcoat Repair (without stripping)  |
| 3.                               | Weld or Braze Repair (excludes detail part replacement) <ul style="list-style-type: none"> <li>• Includes restoration of airfoil tip and chord length</li> </ul>   |
| 4.                               | Weld or Braze Repair <ul style="list-style-type: none"> <li>• Includes detail part replacement</li> </ul>  |
| 5.                               | Disassembly and/or Assembly <ul style="list-style-type: none"> <li>• 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.</li> </ul> |
| 6.                               | Blend Repair   |
| 7.                               | Dimensional Restoration Repair (by coating or plating)   |
| 8.                               | Straightening, Re-twist, or Reforming Repair   |

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



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

|         |  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|---|
| Req No. | Repair Design Requirements to be Identified and Substantiated. Repair Properties and Requirements to be Identified and Substantiated.  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 3.      | Select all <b>Material Properties/Characteristics for weldments or brazed joints</b> 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.<br><br>a. Microstructure (grain size, grain shape, grain boundary precipitates, gamma prime size and volume fraction, etc.)<br>b. Porosity (weldment)<br>c. Diffusion Zone (brazing)<br>d. Heat Affected Zone (welding) |                      |   |   |   |   |   |   |   |   |

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

| Req No. | Repair Properties & Requirement to be Identified and Substantiated.  | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |
|---------|--|----------------------|---|---|---|---|---|---|---|
|         |  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 6.      | <p>Evaluate any <b>degradation in the part’s function or durability</b> due to the following processes, when applicable, and assess its impact, if any, on existing ICAs.</p> <p>a. Machining, Milling, Broaching, or Grinding</p> <p>b. Non-traditional Machining</p> <p>c. Welding, Brazing or Coating</p> <p>d. Straightening, Re-twisting, Re-forming</p> <p>e. Blending</p> <p>f. Honing</p> <p>g. Lapping</p> <p>h. Grit Blast</p> <p>i. Stripping</p> <p>j. Cleaning (chemical, power flash, ultrasonic)</p> <p>k. Residual Plating, Stripping, or Cleaning Agents</p> <p>l. Stress Intensity Factor (<math>K_t</math>)</p> <p>m. Heat Treatment (time, temp, atmosphere, etc.)</p> <p>n. Plating</p> <p>o. Dimensional Short-falls</p> <p>p. Repetitive or Conflicting Repairs Contamination</p> |                      |   |   |   |   |   |   |   |
| 7.      | <p>Establish the <b>Applicability of the Repair</b> and the <b>Repair Processing Sequence</b> or evaluate any changes to an existing repair sequence for potential impact on the airworthiness of the part.</p>  |                      |   |   |   |   |   |   |   |
| 8.      | <p>Select all that may be potentially affected by the repair design and evaluate system effect(s):</p> <p>a. Structural Strength, including major load paths</p> <p>b. Heat Transfer</p> <p>c. Secondary Airflow</p> <p>d. Aerodynamics</p> <p>e. Weight</p> <p>f. Center of Gravity</p> <p>g. Moment of Weight</p>  |                      |   |   |   |   |   |   |   |

|         |   | CATEGORIES OF REPAIR |   |   |   |   |   |   |   |   |
|---------|---|----------------------|---|---|---|---|---|---|---|---|
| Req No. | Repair Properties and Requirements to be Identified and Substantiated.  |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|         | Critical Measurable Characteristics   |                      |   |   |   |   |   |   |   |   |
| 9.      | 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):<br>a. Surface finish/texture<br>b. Shotpeen Intensity/Coverage<br>c. Bearing bore dimensions and location characteristics<br>d. Pressure Strength Test<br>e. Flow Capacity test<br>f. Dimensions, including heat distortion effects <ul style="list-style-type: none"><li>Roundness</li><li>Flatness</li><li>Parallelism</li><li>Concentricity</li><li>True Position</li><li>Tolerances</li><li>Edge Distance</li><li>Requirements</li><li>Finish Dimensions</li><li>Requirements</li></ul> g. Airfoils Profile <ul style="list-style-type: none"><li>Leading and Trailing Edge Contour</li><li>Concave and convex contours</li><li>Thickness</li><li>Chord and Airfoil Length</li><li>Twist/Lean/Bow</li></ul> h. Tip Length<br>i. Airfoil wall thickness<br>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 No. | Repair Properties and Requirements to be Identified and Substantiated.   |                      | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|         | Repair Process Capability Technical Substantiation Requirements  |                      |   |   |   |   |   |   |   |   |
| 15.     | Manufacturing requirements for fabrication of repair details or replacement sections used to accomplish repair:<br><br><ul style="list-style-type: none"><li>• Drawings/Specifications</li><li>• Quality Requirements</li><li>• Source Substantiation Requirements</li></ul> |                      |   |   |   |   |   |   |   |   |
|         | Applicable 14 CFR Part 33 Requirements   |                      |   |   |   |   |   |   |   |   |
|         | Subpart A – General  |                      |   |   |   |   |   |   |   |   |
| 16.     | 33.4 Instructions for Continuous Airworthiness (ICA's)   |                      |   |   |   |   |   |   |   |   |
| 17.     | 33.5 Instruction manual for installing and operating the engine  |                      |   |   |   |   |   |   |   |   |
| 18.     | 33.7 Engine ratings and operating limitations  |                      |   |   |   |   |   |   |   |   |
| 19.     | 33.8 Selection of engine power and thrust ratings  |                      |   |   |   |   |   |   |   |   |
|         | Subpart B – Design and Construction; General   |                      |   |   |   |   |   |   |   |   |
| 20.     | 33.14 Start-stop cyclic stress (low cycle fatigue)   |                      |   |   |   |   |   |   |   |   |
| 21.     | 33.15 Materials  |                      |   |   |   |   |   |   |   |   |
| 22.     | 33.17 Fire prevention  |                      |   |   |   |   |   |   |   |   |
| 23.     | 33.19 Durability (Note that 33.19 is associated with 33.27; 33.63; 33.83; 33.87; 33.88; and 33.90)   |                      |   |   |   |   |   |   |   |   |
| 24.     | 33.21 Engine cooling   |                      |   |   |   |   |   |   |   |   |
| 25.     | 33.23 Engine mounting attachments and structure  |                      |   |   |   |   |   |   |   |   |
| 26.     | 33.25 Accessory attachments  |                      |   |   |   |   |   |   |   |   |

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

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