EASA	CERTIFICATION MEMORANDUM
	**EASA CM No.: EASA CM - PIFS – 003 Issue: 01** **Issue Date: 31st of July 2012** **Issued by: Propulsion section** **Approved by: Head of Products Certification Department** **Regulatory Requirement(s): CS-E 510(g)(2), CS-E 840, CS-E 850**

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Subject

Turbine Over-speed Resulting from Shaft Failure

Log of Issues

Issue	Issue date	Change description
01	31.07.2012	First issue.

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1. INTRODUCTION

1.1. PURPOSE AND SCOPE

The purpose of **this** Certification Memorandum is to publish the Certification Policy that will be applied as additional guidance when an Applicant is showing compliance with CS-E 850 (b)(1).

This Certification Memorandum clarifies AMC E 850 (2) by detailing the considerations to perform a test for demonstrating the "Non-Hazardous Shaft Failures" in compliance with CS-E 850 (b)(1), and addressing specifically turbine overspeed resulting from shaft failure. Also if compliance is proposed by analysis it clarifies what conditions would be acceptable to the Agency.

1.2. REGULATORY REFERENCES & REQUIREMENTS

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
CS-E 510(g)(2)	Safety Analysis	CS-E	---	---
CS-E 840	Rotor Integrity	CS-E	---	---
CS-E 850	Compressor, Fan and Turbine Shafts	CS-E	---	---

1.3. ABBREVIATIONS

The following abbreviations are used in this Certification Memorandum:

Abbreviation	Meaning
AMC	**A**cceptable **M**eans of **C**ompliance
CM	**C**ertification **M**emorandum
CS	**C**ertification **S**pecification
EASA	**E**uropean **A**viation **S**afety **A**gency

1.4. DEFINITIONS

The following definitions are used in this Certification Memorandum:

Definition	Meaning
Non-Hazardous Shaft Failures	Failure of the shaft systems that will not result in Hazardous Engine Effects, as defined in CS-E 510 (g)(2)

2. BACKGROUND

CS-E 850 (b)(1) requires that when it is claimed that Failures of the shaft systems will not result in Hazardous Engine Effects ("Non-Hazardous Shaft Failures"), a test will normally be required to demonstrate the consequences of these shaft Failures unless it is agreed that the consequences are readily predictable.

Recent service experience has shown that engine behaviour following a shaft failure may not match the results of the predictive analysis, therefore creating the risk of turbine rotor overspeed in excess of the predicted value, and uncontained failure. This may be due to one or more of the following: unforeseen effects of improved aerodynamics and/or control logic, inaccurate compressor surge predictions, improper assumptions of rotor to stator friction and/or clashing effects, etc…

AMC E 850 provides the following guidance for (2) Non Hazardous Shaft Failures:

(a) Where it is claimed that Hazardous Engine Effects are avoided by ensuring that rotating components are retained substantially in their normal plane of rotation and the control of overspeed is by means of:

- Disc rubbing;
- Blade interference, spragging or shedding;
- Engine surge or stall;
- Over-speed protection devices.

This may be substantiated by analysis. This analysis should be based upon relevant service or test experience.

(b) To substantiate compliance by analysis, it should be shown that all likely Failure modes have been identified in the analysis (including loss of loads caused by Failure of any gearboxes supplied by the aircraft manufacturer). The Failure analysis should take into consideration the effect of Failures in terms of contact and loads on the surrounding structure of the Engine and determine whether the affected rotor components are retained substantially in their rotational plane. It would also demonstrate that the structural components, when the loads resulting from the Failure are applied, do not exceed their ultimate stress capability and lead to a Hazardous Engine Effect.

3. EASA CERTIFICATION POLICY

3.1. EASA POLICY

Per CS-E 850 (b)(1), when it is claimed that Failures of the shaft systems will not result in Hazardous Engine Effects ("Non-Hazardous Shaft Failures") caused by turbine overspeed, a test will normally be required.

For shaft failure resulting in turbine rotor overspeed, EASA considers the following:

- The test should be performed by initiating the shaft failure at the worst case operating conditions within the flight envelope, in any dispatchable configuration, which will maximise the rotor overspeed and subsequent effects. Where it is impractical to fully duplicate the worst case conditions, the Applicant may propose a test at suitably representative conditions to account for the worst case. Those test conditions would need to be submitted to the Agency for acceptance. In addition to initial rotor speed other aspects should also be taken into consideration, such as shaft torque and relevant engine pressures and temperatures. Failures predicted to occur with a probability of Extremely Remote or less do not need to be taken into account, if they meet all requirements of CS-E 850 (b)(2).

- If compliance is not shown with a full engine test but with a system or component rig test(s), it should be shown that the test(s) is(are) sufficiently representative in term of the key characteristics of the shaft failure and its consequences on all relevant engine parts and sub-systems behaviour, as it would occur on a full engine.
- If compliance is shown by analysis as allowed by AMC E 850 (2), the following aspects should be considered, whether or not the affected rotor components are designed to be retained substantially in their rotational plane:
    - The analysis should be validated against an actual engine or system or component rig test(s) and/or service events, showing a sufficient degree of similarity with the engine model for which compliance is sought. This similarity should encompass all relevant aspects of the failure mechanism and its consequences such as, but not limited to, aerodynamics, surge characteristics, engine control logic, rotor speeds and associated acceleration characteristics, relevant rotor and stator design features, materials, clearances, etc… and should be submitted to the Agency for acceptance.

Note: AMC E 850 (1)(a) states: “A shaft is the system that transmits torque between the disc driving flange or shaft attachment member of the system that produces power (e.g. turbine) and the system that uses this power (e.g. compressor/fan or driving flange) and for which the mechanical restraints are mainly torsional. This includes any Engine gearbox in that transmission system…”. Therefore if the Engine includes an Engine gearbox in its transmission system the relevant drive shafts and gears should be considered in the application of this CM.

3.2. WHO THIS CERTIFICATION MEMORANDUM AFFECTS

Applicants to Turbine Engine Type Certificates

This Certification Memorandum should also be considered in case of changes to Turbine Engine Type Certificates, in case CS-E 850 is affected by the change.

4. REMARKS

1. Suggestions for amendment(s) to this EASA Certification Memorandum should be referred to the Certification Policy and Planning Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu or fax +49 (0)221 89990 4459.
2. For any question concerning the technical content of this EASA Certification Memorandum, please contact:

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