Certification Memorandum

TURBINE DRIVE ARM ROTOR INTEGRITY COMPLIANCE

EASA CM No.: CM–PROP-002 Issue 1 issued 25/11/2024

Regulatory requirement(s): CS-E

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Log of issues

Issue	Issue date	Change description
1	25.11.2024	First issue.

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1. Identification of Issue

Turbine Drive Arms fulfil the same torque transmission function as conventional shafts, and their failure consequences are similar, including the potential for Hazardous complete loss of load on a turbine rotor. Several Turbine Drive Arms failures in service have highlighted inconsistencies in application CS-E to these features. To ensure a consistently high level of safety, this Certification Memorandum establishes the applicability of CS-E regulations to Turbine Drive Arms and outlines acceptable approaches to showing compliance.

For the purpose of this Certification Memorandum, “Turbine Drive Arm” refers to a feature delivering torque between a turbine disc and a turbine shaft, as well as to a feature delivering torque between turbine rotor stages, also referred to here as an “Interstage Turbine Drive Arm”. Turbine Drive Arms are typically integral to the turbine disc itself, although they can also be separate components. Turbine Drive Arms are considered to meet the definition of “Shafts” in AMC E 850(1)(a).

Where drive is delivered to or from a turbine disc via features directly mounted on the disc (e.g. via a curvic coupling, or bolted flange), these should be considered as part of the disc and not as a Turbine Drive Arm.

1.1. Background

A review of past certification practice shows that Turbine Drive Arm failures were not routinely considered as potential causes of loss of load events under the CS-E 840(c) assessment, or as potential causes of Hazardous Engine Effects under CS-E 850(a). Particularly for integral Turbine Drive Arms, the failure consequence and the component reliability were considered the same as those of the turbine disc itself. Application of the CS- E 515 critical part requirements were considered sufficient to meet an Extremely Remote objective for the primary reliability of the part. Threats external to the part (e.g. oil fires or rotor-stator contact) were considered adequately addressed by CS-E 510, which requires that Hazardous Engine Effects should occur at a rate not in excess of Extremely Remote (ER).

Service events have shown that this approach is not equivalent to meeting CS-E rotor integrity and shaft safety objectives. CS-E 840(c) is intended to eliminate Hazardous turbine overspeed due to loss of load failures by requiring turbine disc integrity to be maintained up to 105% of maximum terminal speed. CS-E 850(a) requires demonstration that shaft failures will not result in a Hazardous Engine Effect. In situations where this failsafe objective cannot be achieved for “certain shaft elements”, the strict integrity criteria of CS-E 850(b)(2) must be satisfied. These include a requirement to show that, for threats external to the part (e.g. due to oil fires and rotor stator contact), “the surrounding environment of the elements considered is such that it is accepted that a shaft Failure owing to this environment can be judged as sufficiently unlikely that the Failure mode can be discounted”.

Therefore, EASA considers that, in order to prevent turbine rotor overspeed burst, all Turbine Drive Arms, including Interstage Turbine Drive Arms, should be shown to be compliant with CS-E 840(c) and CS-E 850. These requirements are considered applicable and are significantly more stringent than would be delivered by compliance with CS-E 510 and CS-E 515 when certifying Turbine Drive Arms.

1.2. Discussion

Service events have shown that it is important to include all Turbine Drive Arms when complying CS-E 840(c) and CS-E 850. The preferred approach to compliance is to show a failsafe outcome following Turbine Drive Arm failure. This requires the applicant to show an adequate margin between the resultant turbine rotor terminal speed and burst speed, and to demonstrate that failure will not cause any Hazardous Engine Effect. Means to achieve this include showing that loss of turbine rotor axial/radial location will ensure sufficient rotor- stator contact to prevent Hazardous overspeed, and implementation of effective mechanical or electronic turbine overspeed protection systems. Guidance for demonstrating that shaft failure will not be Hazardous is contained in EASA CM-PIFS-003.

Where it is impracticable to demonstrate a failsafe outcome, the alternative approach to demonstrate high integrity of “certain elements of a shaft” by complying with the criteria of CS-E 850(b)(2) can, in principle, be acceptable. This approach was initially developed to exclude Low Pressure Compressor (LPC) shafts forward of the LPC bearing chamber from compliance with rotor integrity and shaft requirements, but guidance has recently been developed to extend the approach to the HP shaft system, including HPT interstage drive arms, as published in EASA Certification Memorandum CM-PIFS-017. The same approach has also been used to extend the CS-E 850(b)(2) provisions to the certification of certain LP Turbine Drive Arms.

In the above cases, it was possible to demonstrate the absence of integrity threats. This is because, in comparison with turbine shafts, Turbine Drive Arms are typically located at an increased distance both from bearing chambers and from the engine centre line, reducing exposure to oil fires, and their higher diameter provides significantly more stiffness to resist whirling and torsional bending.

In requiring compliance with CS-E 840(c) and CS-E 850 to include all Turbine Dive Arms, including Interstage Turbine Drive Arms, it is acknowledged that it may be impracticable to show a failsafe failure outcome, and applicants may need to apply the provisions of CS-E 850(b)(2). This approach is considered acceptable providing that the integrity criteria are fully satisfied using the additional guidance of CM-PIFS-017. Where justified, the specific guidance may be adapted to reflect application to shafts other than High Pressure shafts.

The question of practicality is particularly important when certifying changes to products, where the product was originally designed and certified without considering Turbine Drive Arm compliance with CS-E 840(c) and CS-E 850. In the interests of proportionality, the original means of compliance will continue to be accepted in these cases, subject to detailed assessment of the changes to the type design, and the applicable service experience, as detailed in the Section 3.

2. Applicability

Turbine Engines

3. EASA Certification Policy

3.1. New Product Certification, and Certification of Changes to Existing Products requiring compliance with CS-E 840(c) and CS-E 850.

For certification of:

- new products,
- changes where the existing Turbine Drive Arm design configuration is not retained (see 3.2(1).) and,
- changes affecting Turbine Drive Arms for which compliance was previously demonstrated to CS-E 840(c) and CS-E 850,

the affected Turbine Drive Arms, including Interstage Turbine Drive Arms, should be shown to be compliant with CS-E 840(c) and CS-E 850.

If the design cannot be shown to be failsafe for "certain shaft elements", EASA considers that a design that is shown to meet the strict criteria of CS-E 850(b)(2) will achieve a consistently high level of turbine rotor integrity. EASA considers that CM-PIFS-017 (Turbine Engines – High Pressure Turbine Shaft Loss of Load and Rotor Integrity) contains appropriate guidance for applying these criteria to all Turbine Drive Arm features. Where justified, the specific guidance may be adapted to reflect application to shafts other than High Pressure shafts.

3.2. Certification of changes to existing products where prior compliance to CS-E 840(c) and CS-E 850 did not specifically address Turbine Drive Arms.

For certification of changes to existing products where prior compliance to CS-E 840(c) and CS-E 850 (or earlier equivalents) did not specifically address Turbine Drive Arms, in the interests of proportionality EASA will continue to accept a demonstration of compliance based on CS-E 515 and 510 as outlined in paragraph 1.1 on the following conditions:

1. The changed product should retain the existing general configuration with no new threats to Turbine Drive Arm integrity being introduced by the change. For instance, a change that exposes the Turbine Drive Arm to new oil fire or rubbing contact threats would not meet this condition.
2. There should be no service experience that indicates that a Hazardous Engine effect due to failure of the affected Turbine Drive Arm(s) of the changed product could occur. This condition need not be applied where it can be shown that the change does not increase the likelihood or consequence of Turbine Drive Arms failure.

4. Supporting Data

4.1. References

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

Reference	Title	Code	Issue	Date
EASA Certification Memorandum CM-PIFS-003	Turbine Over-speed Resulting from Shaft Failure	CS-E	1	31/07/2012
EASA Certification Memorandum CM-PIFS-017	Turbine Engines – High Pressure Turbine Shaft Loss of Load and Rotor Integrity	CS-E	1	20/11/2020

4.2. Definitions

Turbine Drive Arm	"Turbine Drive Arm" refers to a feature connecting a turbine disc to a turbine shaft, as well as to a feature delivering torque between turbine rotor stages, also referred to here as an "Interstage Turbine Drive Arm". Turbine Drive Arms are typically integral to the turbine disc itself, although they can also be separate components. Turbine Drive Arms are considered to meet the definition of "Shafts" in AMC E 850(1)(a). Where drive is delivered to or from a turbine disc via features directly mounted on the disc (e.g. via a curvic coupling, or bolted flange), these should be considered as part of the disc and not as a Turbine Drive Arm.

5. Remarks

For any question concerning the technical content of this EASA Certification Memorandum, please contact:

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