Initial Airworthiness Special Condition

Turbine Engines Rotor Integrity – Critical Overspeed resulting from Failure Conditions – Margin for Rotor Growth Assessment

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European Union Aviation Safety Agency	**Special Condition** **Turbine Engines Rotor Integrity – Critical Over-speed resulting from Failure Conditions – Margin for Rotor Growth Assessment**	Doc. No.: **SC E-20** Issue : 1 Date : 19 May 2021 Proposed ☐ Final ☒

SUBJECT	:	**Turbine Engines Rotor Integrity – Critical Over-speed resulting from Failure Conditions – Margin for Rotor Growth Assessment**
REQUIREMENTS incl. Amdt.	:	**CS-E 840 (from CS-E Initial Issue to amendment 6)**
ASSOCIATED IM/MOC[1]	:	Yes☒ / No ☐
ADVISORY MATERIAL	:	

INTRODUCTORY NOTE:

The following Special Condition has been classified as important and as such shall be subject to public Consultation in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) of which states:

"2. *Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

IDENTIFICATION OF ISSUE:

CS-E 840 (d) requires that:

> *(d) In addition, for each fan, compressor, and turbine rotor, it must be established by test, analysis, or combination thereof, that a rotor which has the most adverse combination of material properties and dimensional tolerances allowed by its type design and which is operated in the Engine for five minutes at* ***100% of the most critical speed and temperature conditions resulting from any Failure or combination of Failures considered under CS-E 840(b)(3)*** *and (b)(4), will meet the acceptance criteria prescribed below in CS-E 840(d)(1) and (d)(2).*
>
> *However, where the Failure condition is of a sudden transient nature, such as loss of load, and it precludes any further operation of the affected rotor, the time period of that Failure condition is an acceptable duration for showing compliance by means of an Engine test.*
>
> *Test rotors which do not have the most adverse combination of material properties and dimensional tolerances must comply at appropriately adjusted test parameters, e.g. speed, temperature, loads.*
>
> *(1)* ***Growth of the rotor*** *while it is operating at the applicable conditions must not cause the Engine to:*
>
> *(i) Catch fire,*

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[1] In the case of a SC, the associated Interpretative Material and/or Means of Compliance may be published for awareness only and they are not subject to public consultation.

(ii) Release high energy debris through the Engine's casing or result in a hazardous Failure of the Engine's casing,

(iii) Generate loads greater than those ultimate loads for which the Engine's mountings have been designed in compliance with CS-E 100(b), or

(iv) Lose the capability of being shut down.

(2) After the applicable period of operation, the rotor must not exhibit conditions such as cracking or distortion which preclude the safe operation of the Engine during any likely continued operation following such an over-speed event in service.

For the purpose of CS-E 840(d), the specifications for ***Failure or combination of Failures considered under CS-E 840(b)(3)*** are copied hereafter from the burst requirement of CS-E 840(b):

(b) *When determining the operating conditions applicable to each rotor for compliance with CS-E 840(a) and (c), each of the following speeds must be evaluated in conjunction with their associated temperatures and temperature gradients, throughout the Engine's operating envelope:*

(1) …

(2) …

(3) *105% of the highest rotor speed that would result from either -*

(i) The Failure of the component or system which, in a representative installation of the Engine, is the most critical with respect to over-speeding when operating at any rating condition except OEI ratings of less than 2½-minutes, or

(ii) The Failure of any component or system in a representative installation of the Engine, in combination with any other Failure of a component or system that would not normally be detected during a routine pre-flight check or during normal flight operation that is the most critical with respect to over-speeding, except as provided by CS-E 840(c), when operating at any rating condition except OEI ratings of less than 2½-minutes.

…

In regards to the specification of CS-E 840(d) for rotor growth, EASA has considered so far that *"100% of the most critical speed and temperature conditions resulting from any Failure or combination of Failures considered under CS-E 840(b)(3)"* is to be understood as 100% of the speed resulting from the conditions listed in CS-E 840(b)(3)(i) and CS-E 840(b)(3)(ii), without additional margin. However some third country authorities have considered that a 105% additional margin was to be applied, similarly to the burst requirement.

It is recognised that in the past years applicants have improved their understanding of rotor overspeed following failure in turbine engines, notably using modern simulation tools validated through engine testing and/or actual events. In view of this, EASA also determined that a safety risk may exist in case an applicant would use insufficiently validated tools to determine the maximum speed resulting from failure, and therefore identified the need for additional margin.

A propulsion industry/authority advisory working group *(*)* has reviewed the above data, as well as the relevant provisions contained in both CS-E and CFR Part 33, and recommended improvements to clarify and harmonise the specifications / requirements for rotor growth assessment in case of over-speed resulting from failure conditions.

(*) Advisory Working Group from Aerospace Industry Association (AIA) Civil Aviation Regulatory and Safety (CARS) Committee, Propulsion Subcommittee – abbreviated AIA WG later in this document

On 5 August 2019, the AIA WG issued a report entitled "Decision Method for Selecting a Speed Margin to Protect Against Hazardous Rotor Growth during Transient Overspeed Conditions". This report is included in Annex 1 of this SC.

EASA POSITION:

In view of the above, EASA considers that an potential unsafe condition may develop if a suitable margin to rotor growth following failure conditions of CS-E 840(b)(3)(i) and (b)(3)(ii) is not applied consistently. To address this, EASA considers that the specifications recommended by the AIA WG are adequate, and that a new Special Condition (SC) is required in accordance with point 21.B.75(a)(3).

The first paragraph of CS-E 840(d) is not applied, and instead the following specification shall apply:

> *In addition, for each fan, compressor, and turbine rotor, it must be established by test, analysis, or combination thereof, that a rotor which has the most adverse combination of material properties and dimensional tolerances allowed by its type design will meet the acceptance criteria prescribed below in CS-E 840(d)(1) and (d)(2) after it is operated in the Engine for five minutes at the highest rotor speed that would result from either-*
>
> *(i) The Failure of the component or system which, in a representative installation of the Engine, is the most critical with respect to over-speeding when operating at any rating condition except OEI ratings of less than 2½-minutes, and*
>
> *(ii) The Failure of any component or system in a representative installation of the Engine, in combination with any other Failure of a component or system that would not normally be detected during a routine pre-flight check or during normal flight operation that is the most critical with respect to over-speeding, except as provided by CS-E 840(c), when operating at any rating condition except OEI ratings of less than 2½-minutes,*
>
> *with a suitable margin above 100% of this speed.*

The AIA WG report attached in Annex 1 of this SC provides means of compliance and guidance to comply with this Special Condition, by providing criteria for establishing and justifying the *"suitable margin"* required by the special condition above. Additionally, the report provides guidance for the definition of a *"rotor which has the most adverse combination of material properties and dimensional tolerances allowed by its type design"* as specified in CS-E 840(a).

This Special Condition shall be applied for new turbine engine Type Certification (TC), as well as major changes to TCs of turbine engines where applicable per point 21.A.101 of Part-21 and where the affected areas include rotor elements to be considered under CS-E 840(d).

Annex 1

MOC and Guidance to Special Condition SC E-20

Turbine Engines Rotor Integrity – Critical Over-speed resulting from Failure Conditions – Margin for Rotor Growth Assessment

AIA CARS Committee *(*)*
Propulsion Subcommittee
Advisory Working Group Report

Decision Method for Selecting a Speed Margin to Protect Against Hazardous Rotor Growth during Transient Overspeed Conditions

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Issued on 5 August 2019

PDF

AIA CARS WG
Hazardous Rotor Gro *(**)*

(*) Aerospace Industries Association – Civil Aviation Regulatory and Safety Committee

(**) AIA CARS agreed to include the report in this EASA SC.