Proposed Special Condition on CS25.901(c) at Amdt 11 - "Fan blade loss - effects at aircraft level"

Applicable to Airbus A319/A320/A321 NEO (equipped with CFM LEAP-1A engines)

Introductory note:

The hereby presented Special Condition has been classified as an important Special Condition 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.*"

Statement of Issue

The CFM LEAP-1A engine manufacturer is considering demonstrating fan blade failure (ref. CS-E 810) using a reduced fragment size compared with the usual interpretation recorded in the AMC E 810, which guidelines are to release the blade at the top of the retention member. Instead, it is proposed to release the blade fragment at the flowpath, leaving a part of the fan blade in the disk.

Fan blade separation is normally classified at worst as 'major', based upon design precautions taken at engine and aircraft levels, respectively the fan containment system and an airframe sized to sustain fan blade out loads as well as demonstration of the ability of the airframe and systems to sustain engine windmilling.

Under this interpretation of CS-E 810, liberation of a full fan is not taken into account for the fan blade out demonstration. This directly impact several related areas which are interconnected with aircraft certification, including the fan containment system dimensioning, the fan blade out loads and fan windmilling characteristics.

Paragraphs 25.901(c) and 25.1309(b) introduce a requirement for having no catastrophic condition resulting from a single failure. This is applicable to the complete aircraft, engine included. From CS-25 Amendment 1, CS 25.901(c) has been modified and lists exceptions to that principle, for engine case burnthrough, uncontained engine failure and propeller blade release, which are addressed under specific requirement (25.903(d)(1) and 25.907). This does not include fan blade failure, since fan blade failure is addressed by CS-E.

If full blade liberation can still occur as a result of single failure(s) of the fan system, even with a very low probability, the existence of any potential catastrophic consequence(s) constitutes a non-compliance to 25.901(c). This therefore needs to be carefully identified and assessed.

For the LEAP-1A Engine, EASA has issued the following requirements for compliance to the CS E-810, with a means of a CS-E Special Condition:

a) For compliance with CS-E 810, in lieu of the fan blade containment test with the fan blade released at the top of the retention member as specified in the AMC E 810 (2)(b)(i), CFM shall complete the following requirements:

    1) Conduct an engine test demonstrating compliance with CS-E 810(a) with the fan blade released at the inner annulus flow path line;

    2) Substantiate by test and analyses, or other methods acceptable to the Authority, that a minimum material properties fan disk and fan blade retention system can

withstand without failure a centrifugal load equal to twice the maximum load which the retention system could experience within approved engine operating limitations;

3) Using a procedure accepted by the Authority, establish an operating limitation that specifies the maximum allowable number of start-stop stress cycles for the components of the fan blade retention system. The life evaluation shall include the combined effects of high cycle and low cycle fatigue. If the fan blade Approved Life is less than 100,000 start-stop stress cycles, that Approved Life must be published as required in CS-E 25(b). The fan blade retention system includes the portion of the fan blade from the inner annulus flow path line inward to the blade dovetail, the blade retention components, and the fan disk and fan blade attachment features.

b) Substantiate that, during the service life of the engine, the total probability of the occurrence of a Hazardous Engine Effect defined in CS-E 510 due to an individual blade retention system failure from all possible causes will be Extremely Improbable, with a calculated probability of failure of less than 10E-9 per engine flight hour.

c) Substantiate by test or analysis that a lightning strike on the composite fan blade structure will not prevent continued safe operation of the affected engine.

d) Account for the effects of in-service deterioration, manufacturing variations, minimum material properties, and environmental effects during the tests and analyses required by paragraphs (a)(1), (a)(2), (a)(3), (b) and (c) of this Special Condition.

e) Propose a fleet leader sampling program for the engine fan blades that will monitor the effects of usage on the fan blade and on the retention system integrity. This fleet leader sampling program must be accepted by the Authority prior to Engine certification.

f) List the fan blade as an Engine Critical Part and identify it in accordance with Part 21.A.805.

The impact of the CS-E Special Condition on CS25 prompted EASA to also issue the Special Condition E-55, as the absence of the failure case “Fan Blade liberation at the top of the retention mean” declared by CFM does not allow aircraft manufacturer to conclude to the absence of catastrophic consequences should this failure happen. EASA shall then assume that a catastrophic failure may result from a Full Engine Fan Blade Liberation.

Although the terms of the CS-E Special condition required the Full Blade liberation to be Extremely Improbable, i.e. making this failure case compliant to 25.1309(b)(1)(i), this failure case is still remaining not compliant with the 25.1309(b)(1)(ii), i.e. “*and does not result from a single failure*” (i.e. “No Single Failure” criteria for catastrophic failure condition).

Considering the above, EASA is proposing the Special Condition and the associated Interpretative Material as presented below.

Note : The presented Interpretative Materials are mentioned to support the Special Condition, and have no vocation to be commented.

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“Fan blade loss - effects at aircraft level”

Add to CS 25.901(c) the following material:

CS 25.901 **Installation**

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(c) The powerplant installation must comply with CS 25.1309, except that the effects of the following need not comply with CS 25.1309(b):

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(4) fan blade failure at the top of the retention means
(as per LEAP-1A Special Condition, compliance to 25.1309 considers fan blade failure at the inner annulus flowpath line)

Interpratative Materials / Means of Compliance

EASA acknowledges the full responsibility of Engine Manufacturer to provide Aircraft Manufacturer with the required Input Data to support CS25 Large Aeroplane Certification related to Engine Installation. This statement applies in particular to the Engine Fan Blade Out Event per CS E-810 “Compressor and Turbine Blade Failure” and associate consequences, per AMC 25-24 “Sustained Engine Imbalance”.

Should compliance to “Engine Fan Blade Failure at the top of the retention means” scenario according to CS-E 810 and AMC E 810 (2)(b)(i) be not demonstrated during the Engine Certification, the following compliance means shall be performed:

1. In case of a partial* Engine Fan Blade** liberation demonstration, compliance to CS E-810 shall be performed in accordance with CS-E Special condition requirements.

2. Full Fan Blade*** Loss shall be demonstrated to remain Extremely Improbable during the entire Engine Life in accordance with CS-E Special condition requirements.

3. AMC 20-128A *“Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure”* compliance shall be demonstrated with a blade tip with one-third the blade airfoil height as per AMC20-128A definition.

4. AMC 25-24 *“Sustained Engine Imbalance”* compliance shall be demonstrated with unbalance conditions provided by the engine manufacturer, based upon engine type certification data.

Notes:

* Partial Fan Blade: typically, “*Fan blade failing at the inner annulus flowpath line.”*

**Blade: per AC 20-128A, (6) *“[…] The airfoil sections (excluding platform and root) of the fan.”*

*** Full Fan Blade: per AMC E 810(2)(b)(i)) *“[…]One blade should be released at the top of the retention member.*”