Federal Aviation Administration

Memorandum

Date: November 13, 2015

To: Thomas Boudreau, Manager, Engine Certification Office, ANE-140

From: Colleen D'Alessandro, Manager, Engine & Propeller Directorate, ANE-100

Prepared by: William Sobanik, ANE-141

Subject: INFORMATION**:** Equivalent Level of Safety (ELOS) finding for the CFM LEAP-1A and LEAP-1C Series Engines

ELOS Memo #: LEAP1A1C-2014-TC-01-P-11

Regulatory Ref: 14 CFR 21.21 and 33.27

The Engine & Propeller Directorate established an equivalent level of safety finding (ELOS) for the CFM Leap-1A and Leap-1C series engine models, which include the following engine models: LEAP-1A35A, LEAP-1A33, LEAP-1A33B2, LEAP-1A32, LEAP-1A30, LEAP-1A26, LEAP-1A26E1, LEAP-1A24, LEAP-1A24E1, LEAP-1A23, LEAP-1C30, LEAP-1C30B1 AND LEAP-1C28.

Background

On June 27, 2012, CFM International (CFM) submitted an application to the ECO to certify the Leap-1A and Leap-1C series engines.

Title 14, Code of Federal Regulations (14 CFR) 33.27 requires the most critically stressed rotor component of each turbine rotor to be tested for a period of five minutes at the highest of six possible rotor speeds, one of which is 105% of highest speed that would result from failure of the most critical component or system in a representative installation of the engine. Under § 33.27 (f), failure of a shaft section may be excluded from consideration in determining the highest overspeed that would result from a complete loss of load if certain conditions are met. The FAA has historically excluded only the portion of the fan shaft in front of the forward thrust bearing, because field data shows that no hazardous failures in that part of the fan shaft have occurred.

CFM proposed an ELOS to the requirements of § 33.27(c) and (f), using compensating factors in accordance with the provisions of 14 CFR 21.21(b)(1). CFM proposed to exclude under §33.27 (f) the part of the shaft system connecting the high pressure (HP) stage 2 turbine disk to the HP stage 1 turbine disk from the § 33.27(c) requirement to determine the highest speed that would result from a complete loss of load. Excluding the proposed section of the HP shaft by direct compliance is not possible, based on the FAA's historical practice of excluding only the portion of the fan shaft in front of the forward thrust bearing. The ELOS proposal included CFM's design, manufacturing, and maintenance controls; their field experience on engines with similar HP rotor designs; and specific design aspects of the Leap-1A and Leap-1C HP rotor to show that a failure of the excluded shaft element cannot be expected to occur during the life of the engine.

Applicable regulations

14 CFR 21.21, 33.27

Regulation requiring an ELOS finding

14 CFR 33.27(c), (f)

Description of compensating design features or alternative Methods of Compliance (MoC) which allow the granting of the ELOS (including design changes, limitations or equipment need for equivalency)

To address the exclusion of a section of the HPT shaft system in determining the maximum required demonstration speed according to 33.27(c) by an ELOS, the FAA has identified the following compensating factors for the ELOS finding:

1. Type design drawings and processes include improvements in the HPT coupling nut assembly process that were developed for assembly of the similar GEnx HPT rotor.

2. Maintenance assembly requirements in the ICA include processes to preclude quality escapes during engine shop visits that require re-assembly of the HPT rotor.

3. HP turbine aft shafts, that by design are secondary torque carrying components. The primary torque path is through the mid seal. This reduces the torsional shear stress and overall operating stresses in the shaft. This results in adequate margin between the minimum calculated life of the aft shaft sections and the published life of the parts.

4. Robust design and manufacturing:
   a. Both shafts are integral elements of life-limited rotating parts and are subject to all of the controls of life-limited rotating parts (premium quality

materials, manufacturing controls, damage tolerance assessment, and field life limits). The shafts and disks comply with § 33.70 and CS-E 515.
b. The materials and design features are commonly used across the manufacturer's product lines and are well understood.
c. Environmental influences have been addressed in the design process.

5. Lessons learned have been applied to the design of the LEAP HPT architecture from previous manufacturer shaft experience.

6. The LEAP # 4 bearing sump is robust to sump fires.

7. ICA Airworthiness Limitations Section mandatory piece-part level inspections of the shaft areas are part of the maintenance plan. Fluorescent penetrant (FPI) and eddy current (ECI) inspection of the welds in the HPT stage 1 and stage 2 shafts will be specified in the ICA.

8. The overall robustness of this shaft design is supported by successful, relevant field experience on the GE90, GP7200, and GEnx engines.

Explanation of how design features or alternative Methods of Compliance (MoC) provide an equivalent level of safety to the level of safety intended by the regulation

1. In operation, the shaft section that is the subject of the ELOS is not the primary torque-carrying member between the HP stage 1 and HP stage 2 disks. The primary torque path is through the mid seal. This reduces the torsional shear stress and overall operating stresses in the shaft, resulting in high fatigue lives and damage tolerance capabilities.

2. CFM Design Practices and operational experience with similar sump designs ensure the LEAP design is robust to sump fires. The CFM design practices require buffer cavities and dedicated drain passages to carry oil overboard in the event of a failure or interruptions of the normal oil scavenge system. In the turbine sump there is also an additional auxiliary drain completely outboard of the sump to capture leaks from supply lines, scavenge lines, or the sump itself. Analysis at all flight conditions shows that oil will not contact any surfaces hot enough to cause ignition. In the forward bearing sump there are features immediately outboard of the oil seals to catch any leaked oil and direct it to independent drain lines through the frame and overboard. Oil is prevented from entering the airstream and flowing back to the turbine.

3. The ELOS will not exclude the entire shaft and CFM will show by engineering assessment that failure of the excluded shaft element(s) cannot be expected to occur during the life of the engine.

FAA approval and documentation of the ELOS finding:

The FAA has approved the aforementioned ELOS finding in CFM Leap-1A and -1C issue paper P-11. This memorandum provides standardized documentation of the ELOS findings that are nonproprietary and can be made available to the public. The Engine & Propeller Directorate has assigned a unique ELOS Memorandum number (see front page) to facilitate archiving and retrieval of this ELOS. This ELOS Memorandum number will be listed in the Type Certificate Data Sheet under the Certification Basis. An example of an appropriate statement is provided below.

An Equivalent Level of Safety Finding has been made for the following regulation:

14 CFR 33.27 Turbine, Compressor, Fan, and Turbosupercharger Rotor Overspeed.-(documented in ELOS Memo LEAP1A1C-2014-TC-01-P-11)

This ELOS is initially applicable to the engine model(s) listed herein. When the type certificate for that engine model is amended to include other engine model(s) where we find that the compensating factors described herein constitute an ELOS, we will apply this ELOS to the additional engine model(s). In that case, the complete list of models incorporating this ELOS is included in the certification basis section of the Type Certificate Data Sheet.

/s/ Colleen M. D'Alessandro — November 13, 2015

Manager, Engine & Propeller Directorate — Date

Aircraft Certification Service