Proposed Equivalent Safety Finding on CS-E 840/850 – Rotor Integrity/Shafts

Introductory Note

The following Equivalent Safety Finding (ESF) has been classified as an important ESF 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

Adverse service experience with secondary/tertiary rotor shaft designs (LP and IP shaft for three shaft engines) has previously lead to the development of Rotor Integrity and Shaft rules in CS-E that force the consideration of shaft failure. Consequently CS-E 840(c) (Rotor Integrity) now requires that loss-of-load on a turbine rotor must be considered when deriving the terminal rotor speed for the test unless it can be shown to be Extremely Remote under the provisions of CS-E 850 (Shafts).

Having applied for certification to CS-E of a high bypass three shaft engine design the applicant has concluded following analysis that loss-of-load to the HP turbine may result in over-speed to burst of the HP turbine disc under the most extreme conditions of thrust and temperature. This would render the design non-compliant for the HP turbine disc with CS-E 840 (Rotor Integrity) and for the HP rotor with 850 (Shafts) unless compliance with CS-E 850(a)(3) can be shown. CS-E 850(a)(3) does allow an Extremely Remote argument to be used for certain elements of the shaft. For this application the certain elements criteria would need to be applied to the complete torque carrying part of the shaft. Redesign of the engine to meet the letter of the rule would involve significant compromise of the currently well understood and reliable design practices.

Applicant's Proposal

The applicant proposes that adequate safety is achieved however, if the HP rotor drive arms (effectively the shaft) can be shown to have a failure rate of Extremely Remote as allowed in some cases by CS-E 840, which the applicant believes is substantiated by service experience of similar designs on their other engine types. Furthermore the applicant argues that this rulemaking was established to address unpredictable failure modes resulting from the numerous threats to

integrity from the complex environments surrounding secondary/tertiary rotor shaft designs, which are largely not applicable to the core (HP) rotor shaft. The applicant has requested that EASA assess a proposed means of compliance for the HP turbine to CS-E840(c) and the HP rotor CS-E 850 (Shafts) based on an argument of Extremely Remote rate of failure to justify non-consideration of the loss-of-load failure mode. The applicant requests the agreement of the Agency.

Applicants Safety Equivalency Demonstration

The applicant will substantiate an anticipated Extremely Remote failure rate by analysis of service experience on their other engine types of designs for which similarity can be justified, and by analysis of all potential threats to shaft integrity including those highlighted by the current CS-E 850 rule and guidance.

EASA Position

The Agency considers that a showing of Extremely Remote failure rate to all causes for the core rotor shaft (as distinct from secondary and tertiary shafts), if fully substantiated as proposed, could be accepted by the Agency. Further the Agency considers that, for the purposes of CS-E 840 and CS-E 850, a showing of Extremely Remote failure rate for the core rotor shaft, as proposed, provides an equivalent level of safety to the showing of non-hazardous for shaft failures occurring at a rate greater than Extremely Remote.