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|  | <p style="text-align: center;"><b>Turbine Engines</b><br/>Special Condition</p> <p style="text-align: center;"><b>Transient over-temperature, over-speed<br/>and over-torque limit approval</b></p> | <p><b>Issue:</b> 1</p> <p><b>Page</b> 1/4</p> <p><b>Date:</b><br/>05.09.2014</p> |
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**Subject :** Transient over-temperature, over-speed and over-torque limit approval

**Requirement ref. :** Following CS-E<sup>1</sup> requirements: CS-E 25, CS-E 40, CS-E 700, CS-E 740, CS-E 820, CS-E 830 and CS-E 870

<sup>1</sup> CS-E – Certification Specifications for Engines, Amendment 3, dated 23 December 2010

### **Introductory note:**

The following Special Condition (SC) has been classified as an important SC 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."

Following publication for public consultation on 8 July 2014, the Comment Response Document (CRD) was published on 5 September 2014 and this SC was adopted.


### **Statement of Issue:**

Under certain operating conditions, and in particular during acceleration to a given rating, rotorcraft and aeroplane turbine engines can systematically experience transient gas temperature, rotor shaft speed, or torque excursions, exceeding the steady state operating values for that rating.

The definition and requirement of "Maximum Engine Over-torque", "Maximum Engine Over-speed" and "Maximum Engine Over-temperature" of CS-E 820, CS-E 830 and CS-E 870 respectively are intended to address inadvertent occurrences for periods of up to 20 seconds of engine over-torque, over-speed and over-temperature, following which rejection of the engine from service or maintenance action is not required, other than to correct the cause. Such exceedances typically occur as a result of unforeseen operational events or engine system failure conditions, at any time during the use of an engine. They are consequently distinct from transient conditions as described later in this Special Condition and should not be mistaken. CS-E 820, CS-E 830 and CS-E 870 are therefore inadequate to approve such transient conditions.

CS-E 700 Excess Operating Conditions state: "*Where any of the operating conditions (e.g. air or gas pressure, thrust, gas temperature) substantiated elsewhere in this Subpart could be exceeded in any of the normal and likely emergency conditions within the flight envelope declared by the Engine constructor, it shall be established to the satisfaction of the Authority that the most severe conditions likely to occur will have no unacceptable effects on the Engine.*". CS-E 700 foresees that operating conditions could be exceeded, but does not provide specific requirement or guidance on transient over-temperature, over-speed or over-torque.

CS-E 740 (f)(4)(iii) states: "*Engines for Aeroplanes. Where the Engine characteristics are such that an acceleration from cold produces a transient over-temperature in excess of that for*

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*steady state running, a maximum turbine gas temperature limit for acceleration with a time limitation of 2 minutes may be approved by running at the required temperature for the first 2 minutes of each prescribed period at Take-off Power conditions for 5 minutes or more, and for the whole of all the 30-second periods at Take-off Power. Approval for short period transient conditions at 2½-Minute OEI Power will not be considered and any temperature clearance required must be demonstrated normally during the 2½-Minute OEI periods of the endurance test."*

CS-E 740 (f)(4)(iv) states: "Engines for Rotorcraft. Where the Engine characteristics are such that an acceleration from cold produces a transient over-temperature in excess of that for steady state running, a maximum Exhaust Gas Temperature limit for acceleration with a time limitation of 2 minutes may be approved by running at the required temperature for the first 2 minutes of each prescribed period at Take-off Power conditions in excess of 2 minutes (and for the whole of all the 30-second Take-off Power periods for single-engined rotorcraft). Approval for short period transient conditions at 2½-Minute OEI Power will not be considered, and any temperature clearance required must be demonstrated normally during the endurance test."

CS-E 740 (f)(4)(iii) and (iv) only cover temperature transients at Take-off Thrust/Power and at 2½-Minute OEI Thrust/Power conditions. While the prescribed schedule for 2-min temperature transient at Take-off Thrust/Power conditions is accurately laid out, these paragraphs do not reflect, for 2½-Minute OEI Thrust/Power, what is meant by "any temperature clearance required must be demonstrated normally during [...] the endurance test", hence leading to different possible interpretations. In addition, parameters other than temperature and ratings other than Take-off and 2½-Minute OEI are not covered.

AMC E 740 (c)(3) (2) states: "Per CS-E 50 (f), the Engine control should prevent exceedence of the speed limitation associated with the 30-Second OEI Power rating. Nevertheless, for ensuring the shortest time of establishment of the corresponding power, it might be necessary to design the Engine control in such a manner that a short overshoot of the speed will occur at the beginning of the 30 seconds period. This is acceptable if this is validated throughout the CS-E 740 (c)(3)(iii) test."

AMC E 740 (c)(3) (2) therefore acknowledges the possibility of exceeding speed limits associated with 30-second OEI rating at acceleration, provided that such transients are reproduced during the endurance test. Temperature and torque are not addressed.


### **Applicant's proposal:**

The Applicant acknowledges the possible in-service transient speed, temperature, or torque excursions above the to-be-approved steady state limits of certain ratings and requests the approval of these transient limits.

To account for such excursions, the Applicant proposes to reproduce expected in-service transient over-temperature, over-speed, or over-torque conditions as part of the accelerations to these ratings during the endurance test, in a representative manner.

### **EASA Position:**

EASA recognises that, unlike FAR 33, CS-E does not contain specifications appropriate for transients justification and approval and agrees with the broad principle of reproducing transient excursions as part of the endurance test accelerations.

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Some harmonisation exists between FAA and EASA transient-related material: FAA AC 33.87-1 already addresses "Endurance testing for a two-minute transient overtemperature limit approval" for Take-off rating in a similar manner as CS-E 740 (f)(4)(iii) and (iv) do. In addition, two Special Conditions were published by EASA in 2011 and 2012, allowing the Applicants, for demonstration of a 30-second or less transient over-temperature over Take-off Thrust/Power, to perform 50% of the accelerations to Take-Off Thrust/Power of the Endurance Test incorporating the 30 second over-temperature, as per FAR 33.87(a)(8).

Acknowledging the pedigree of FAR 33.87(a)(8) and in the continuity of the above-mentioned Special Conditions, EASA issues the following generic Special Condition addressing transient over-speed, over-temperature and over-torque at any rating. The harmonisation between FAA and EASA rules and advisory material is thereby further increased.

**In accordance with Part 21.A.16B, the following Special Condition is adopted:**

For the purpose of this Special Condition, a transient condition is defined as a temperature, speed, or torque overshoot occurring before reaching steady state limit values during normal engine operation, usually following rapid engine acceleration. It is a predictable and inherent characteristic of the engine design, distinct from the "Maximum Engine Over-torque", "Maximum Engine Over-speed" and "Maximum Engine Over-temperature" of CS-E 820, CS-E 830 and CS-E 870 respectively.

If the number of occurrences of either transient rotor shaft over-speed, transient gas over-temperature or transient engine over-torque is limited in service operation, that number of the accelerations required by paragraphs (c)(1) through (c)(3) of CS-E 740 must be made at the limiting over-speed, over-temperature or over-torque. If the number of occurrences is not limited, half the required accelerations must be made at the limiting over-speed, over-temperature or over-torque.


Even though short on-condition periods such as 30-second take-off Thrust/Power segments may not allow temperature stabilisation following acceleration, these accelerations still count toward the total number of accelerations required by paragraphs (c)(1) through (c)(3) of CS-E 740.

The provisions of CS-E 740(f) and CS-E 740(f)(4)(ii) relative to averaging apply, for the period(s) for which transient approval is sought, to determine the maximum transient value(s) to be approved.

Accelerations may be used for the purpose of justifying transients for more than one parameter (for example speed and temperature), based on the value and duration reached for each parameter following these accelerations.

Each over-speed, over-temperature, or over-torque transient must be defined by its value, time duration limit, and maximum number of occurrences. These attributes must be noted in the TCDS and in the operating instructions of the engine. Any other associated limitation or restriction, for example when a transient limit only applies to a specific rating or cannot be used in conjunction with other ratings, must equally be noted in the TCDS and in the operating instructions of the engine.

While the difficulty of establishing in-flight turbine entry temperature transient values is recognised, efforts should be made, at given test bed conditions, to reproduce during the

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endurance test the turbine entry temperature transient values that may be experienced in flight.

The time duration for a transient should not exceed 10 seconds for the 2½-minute, 2-minute, and 30-second OEI ratings and 30 seconds for all other ratings. For take-off Thrust/Power temperature transients greater than 30 seconds and up to 2 minutes, refer to CS-E 740 (f)(4)(iii) and (iv).

The engine configuration should not be altered for the unique purpose of justifying transients as part of the endurance test.

The impact of the transient over-speed, over-temperature, or over-torque limit approval(s) on other applicable CS-E requirements, such as, but not limited to, CS-E 50, CS-E 500, CS-E 510, CS-E 515, CS-E 520, CS-E 650, CS-E 700, CS-E 840, CS-E 920, must be considered by the applicant.