European Aviation Safety Agency

EASA/FAA Significant Standard Differences (SSD)
Technical Implementation Procedures (TIP)
- Turbine Engines -

TIP Rev	SSD Issue & Date	Standard Amendment Pairs (1)	
Rev 6	Initial Issue 22 March 2018	**CS-E**	Amendment 4
		CFR 14 Part 33	Amendment 34

SSD #	Title	CS-E paragraph(s)	Remarks
1	Fire Protection	130 (g)	Engine mounts/attachment points are required to be fireproof.
2	Shafts	850	Consideration of all hazardous effects from shaft failures, in addition to turbine loss of load. *See further details in Appendix.*
3	Critical Parts	515	Consideration of all parts with potentially hazardous primary failure modes, in addition to rotating and major structural parts. *See further details in Appendix.*
4	Engine Control System	50(g)(1)	Consideration of the thrust or power command signal. *See further details in Appendix.*
5	Safety Analysis	510(c),(e)(1); 520(d); 60(e); 860	Various differences. *See further details in Appendix.*
6	Strength	520(b)	E 520(b) requires to address hazardous consequences of rubbing between static and rotating parts.
7	Fuel System	560(a),(f)	E 560(a) and 560(f) include fuel specification requirements, including protection for pressure tapping features.
8	Bleed Air Contamination	690(b)	E 690(b) requires cabin air bleed contamination level to be determined.
9	Excess Operating Conditions	700	E 700 requires consideration of excess operating conditions.
10	Endurance Test	740(f)(4)(ii)	E 740(f)(4)(ii) requires adjustment of maximum exhaust gas temperature. *See further details in Appendix.*
11	Thrust Reverser Tests	890(d)	E 890(d) requires testing in case of intended in-flight usage.
12	Maximum Over-speed, Over-temperature	830; 870	E 830 and E 870 are optional requirements that have no equivalent in Part 33. Those may be confused with “normal” transients. *See further details in Appendix.*
13	Compressor and Turbine Blade Failure	810(a)	Applicable to blisks: 33.94 (a)(1) states “… for integrally bladed rotor discs, at least 80% of the blade must fail”; E 810 (a) requires a “single blade” to be contained. *See further details in Appendix.* **[SEI]**

14	Time Limited Dispatch	1030	E 1030 has no equivalent rule in Part 33. FAA Policy PS-ANE100-2001-1993-33.28TLD-R1 refers, but it does not preclude faults other than loss of EECS redundancy as TLD items. See also AMC E 1030 and CM-MMEL-001 for guidance. **[SEI]**
15	ETOPS	1040	E 1040 requires demonstration of an IFSD rate; service experience since EIS is to be assessed if applicable. **[SEI]**
16	Exposure to Volcanic Cloud Hazards	1050	E 1050 has no equivalent in Part 33. See acceptable means of compliance in AMC E 1050. **[SEI]**

Notes:

(1) For earlier applicable amendment pairs, refer to EASA Certification Memorandum CM-PIFS-008. EASA may be consulted for confirmation of applicable SSD.

[SEI] : This SSD is identified as a Safety Emphasis Item (SEI).

Appendix

Guidance for EASA/FAA SSD

CS-E Amendment 4 vs. CFR 14 Part 33 Amendment 34

SSD #2 CS-E 850 Compressor, Fan and Turbine Shafts

CS-E 850 vs. 14 CFR Part 33.27 and 33.75

CS-E 850 addresses the historically poor reliability of shafts, requiring that shafts are shown to be failsafe to prevent **ANY** Hazardous Engine Effect, unless specific integrity criteria are met for “certain shaft elements”. CS-E 850 also establishes a minimum reliability target for shafts, and requires a test to demonstrate a non-hazardous outcome of shaft failure, unless the consequence of the failure is “readily predictable”.

There is no dedicated shaft rule in Part 33. 33.27(c) addresses the threat of shaft failures leading to turbine rotor burst or hazardous turbine rotor growth, and applies the similar integrity criteria for excluding “certain shaft elements”. However, other hazardous shaft failures (e.g. uncontained multiple turbine blade failure, loss of fan/compressor retention, uncontrolled fire, propeller release, engine mount failure) can be accepted under Part 33, subject to the applicant demonstrating that the shaft failure is Extremely Remote, in order to comply with Safety Analysis requirements of 33.75. In this case, shaft failures resulting in Hazardous Effects may be shown to comply with Part 33, without having met the specific shaft integrity criteria of CS-E 850(b)(2).

For compliance with CS-E 850, an applicant must show that shaft failures are predicted to occur at a rate not in excess of that defined as Remote.

In addition, every shaft failure should either:

- result in non-hazardous effects. This conclusion should be judged readily predictable or supported by test (see also EASA CM-PIFS-003), or
- be considered to be Extremely Remote in accordance with the requirements of CS-E 850(b)(2).

SSD #3 CS-E 515 Critical Parts

CS-E 515 vs. 14 CFR Part 33.70

Engine Critical Parts are identified as a consequence of CS-E 510 and the engine safety assessment. It is recognised in both Part 33 and CS-E that the probability of Primary Failures of certain single elements cannot be sensibly estimated in numerical terms. If the Failure of such elements is likely to result in Hazardous Engine Effects per CS-E 510, reliance must be placed on meeting the prescribed integrity specifications of CS-E 515 in order to support the objective of an Extremely Remote probability of Failure. 33.70 life limited parts rule is in contrast restricted in its application to rotating and major structural components. CS-E does not limit the scope of application in a similar manner, and requires the full consideration of the Critical Parts rule, in the case of hazardous primary failure mechanism.

An SSD is required to ensure parts that are not life limited, but the primary failure of which could cause a hazardous effects, should be subject to CS-E 515 requirements.

SSD #4 CS-E 50 Controls

CS-E 50(g) vs. CFR14 Part 33.28

CS-E 50(g)(1) is exempted in Part 33 (from the requirement to show no hazard from a single failure) in the case of thrust or power command signals, but not in CS-E. This area is considered to be an SSD. There are cases when the thrust/power command signal is also used for shutting down the engine. If this signal is lost, the engine cannot be shut-down, which is hazardous.

SSD #5 CS-E 510 Safety Analysis

CS-E 510, 690(b)(2), 520(d), 60(e), 860 vs. 14 CFR Part 33.75

E 510(c) is included to ensure that 33.75(a)(3) is not be used in place of 33.75(c).

E 510(e)(1) states maintenance actions (for latent failures) that relate to hazardous effects should be published in the ALS of the ICA, 33.75(e)(1) does not specify ALS.

E 520(d), 60(e), 860 are clear regulatory differences, which require no further guidance.

SSD #10 CS-E 740 Endurance Test

CS-E 740(f)(ii) vs. 14 CFR 33.87(a)(7)

33.7 states operating limits are established by the Administrator and 33.87(a)(7) specifies that operating limits must be maintained at at-least 100% during the endurance test. This simple approach therefore appears to make the assumption that by taking the minimum Exhaust/Turbine Gas Temperature (EGT/TGT) demonstrated during the test as the declared Red Line EGT limit, a margin is provided that is sufficient to ensure no service engine will exceed the T41, or Turbine Entry Temperature (TET), that was demonstrated in the test.

E 740(f) specifies that operating limits are based on the mean values demonstrated in the appropriate periods of the endurance test, with adjustments to reduce the value obtained from the average test result to ensure that turbine entry temperatures in flight do not exceed the temperature established in the test. We interpret this to mean that a fleet engine-to-engine scatter [T41(TET) – EGT(TGT)] relationship scatter plus EGT measurement error scatter) value and instrumentation accuracy tolerance value should be subtracted from the average obtained during the test, with consideration also for ambient conditions and engine deterioration effects (which may reduce the declared EGT further) to give the declared Red Line EGT limit.

SSD #12 CS-E 830 & CS-E 870 Maximum Engine Over-speed & Exhaust Gas Over-temperature Test

CS-E 830 and CS-E 870 are used to certify, respectively, the inadvertent use of maximum engine rotational speed and the maximum engine exhaust gas temperature, for periods of up to 20 seconds, without rejection of the engine from service or maintenance action, other than to correct the cause. Compliance to these requirements is optional, i.e. only required when Applicants wish to certify such inadvertent exceedance allowance(s). The amount of testing equates to 15 minutes at the desired conditions, with allowance to split the testing into separate periods of no less than 2.5 minutes each (refer to CS-E for full description of the requirements and associated AMC material).

There is no equivalent in Part 33 that allows certification of such inadvertent exceedances at the time of initial certification. It is to be noted that CS-E also contains a maximum over-torque paragraph (CS-E 820), to allow, in similar manner to CS-E 830 and CS-E 870, inadvertent torque exceedances up to 20 seconds, without rejection of the engine from service or maintenance action, other than to correct the cause. FAR 33.84 contains a requirement that is fully harmonised with CS-E 820. Since this harmonisation only exists for CS-E 820, and since Applicants' request for inadvertent temperature and speed transients are the subject of additional certification testing per CS-E vs. Part 33, CS-E 830 and CS-E 870 are considered by EASA to constitute a Significant Standard Difference.

SSD #13 CS-E 810 Compressor and Turbine Blade Failure

CS-E 810(a) vs 14 CFR Part 33.94(a)(1)

This difference applies when the engine incorporates integrally bladed rotor discs (blisks). As the airfoils are integral to the disk, there are no retention features between the disk and the airfoils.

Although this difference is applicable to any blisk, it is of particular relevance for a fan blisk. For turbofans it is usually the most critical stage for CS-E 810 / Part 33.94 compliance, as well as the most exposed stage to foreign object damage.

CS-E 810 Compressor and Turbine Blade Failure states (extract):

> *(a) It must be demonstrated that any single compressor or turbine blade will be contained after Failure and that no Hazardous Engine Effect can arise as a result of other Engine damage likely to occur before Engine shut down following a blade Failure.*

AMC E 810 Compressor and Turbine Blade Failure states (extracts):

(2) Containment

> *(b) Test Conditions. Separate tests on each compressor and turbine stage adjudged to be most critical from the point of view of blade containment (account being taken of blade size, material, radius of rotation, Rotational Speed and the relative strength of the adjacent Engine casing under operating temperature and pressure conditions) should be carried out in accordance with the conditions of (i) and (ii).*
>
> > *(i) Number of blades to be detached. One blade should be released at the top of the retention member.*

14 CFR Part 33, paragraph 33.94 Blade containment and rotor unbalance tests states (extract):

(a) Except as provided in paragraph (b) of this section, it must be demonstrated by engine tests that the engine is capable of containing damage without catching fire and without failure of its mounting attachments when operated for at least 15 seconds, unless the resulting engine damage induces a self shutdown, after each of the following events:

> *(1) Failure of the most critical compressor or fan blade while operating at maximum permissible r.p.m. The blade failure must occur at the outermost retention groove or, for integrally-bladed rotor discs, at least 80 percent of the blade must fail.*

While FAA 14 CFR paragraph 33.94 specifies that for blisk "at least 80 percent of the blade must fail", EASA CS-E 810 does not distinguish between bladed disks and blisks, and requires that a "single blade" shall be contained.

EASA considers that application of CS-E 810 (a) means that, in case of a blisk, the airfoil should be released at the inner annulus flow path line of the airfoil section, i.e. at the point where the airfoil section meets the disk hoop continuum. This is consistent with what AMC E 810 (2)(b)(i) provides for a bladed disk.

The applicant will need to show that the blade released at the inner annulus flow path line will be contained after failure, and no Hazardous Engine Effect can arise as a result of other Engine damage.

This demonstration should cover all potential consequences on the Engine, including the effects of rotor unbalance. The conditions laid out in AMC E 810 (2) Containment – including Test Conditions and Conditions after Tests – and, if applicable, (3) Running Following Blade Failure should be considered.

Additionally it is expected that the applicant considers any likely defect in the airfoil, or the disk portion of the blisk exposed to FOD, resulting from strike or ingestion of foreign matter. He should demonstrate that those defects would not propagate and lead to a Hazardous Engine Effect, nor preclude the continued safe flight and landing, in accordance with CS-E 540 (a) and (b).