


EASA	CERTIFICATION MEMORANDUM
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Subject

Guidance for Rain and Hail Ingestion Testing for Turbine Engines – Short Hail Burst

Log of Issues

Issue	Issue date	Change description
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1. INTRODUCTION

1.1. PURPOSE AND SCOPE

The purpose of **this** Certification Memorandum is to provide specific guidance for showing compliance with CS-E 540 (b):

“The Engine must be designed so that the strike and ingestion of foreign matter that is likely to affect more than one Engine in any one flight will not preclude the continued safe flight and landing of the aircraft as a consequence of a Hazardous Engine Effect or an unacceptable:

- (1) Immediate or subsequent loss of performance;*
- (2) Deterioration of Engine handling characteristics;*
- (3) Exceedance of any Engine operating limitation.”*

This Certification Memorandum describes how to complement the AMC to CS-E 540 (b).

1.2. REFERENCES

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
CS-E 540	Strike an Ingestion of Foreign Matter	CS-E	---	---
CS-E 790	Ingestion of Rain and Hail	CS-E	---	---
---	Aerospace Industries Association (AIA): Inclement Weather Project Group Final Report	---	---	April 14, 2006

1.3. ABBREVIATIONS

The following abbreviations are used in this Certification Memorandum:

Abbreviation	Meaning
AIA	A erospace I ndustries A ssociation
AMC	A cceptable M eans of C ompliance
CM	C ertification M emorandum
CS	C ertification S pecification
EASA	E uropean A viation S afety A gency
HWC	H ail W ater C ontent

1.4. DEFINITIONS

The following definitions are used in this Certification Memorandum:

Definition	Meaning
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2. BACKGROUND

The current AMC to E 540 considers that CS-E 790 for rain and hail may quantify the safety objectives of CS-E 540 (b) with respect to rain and hail ingestion and that this paragraph is intended to be sufficient for demonstrating compliance with CS-E 540 (b). However any unusual finding made during these demonstrations of compliance should be assessed against the safety objectives of CS-E 540 (b) continued safe flight and landing.

CS-E 790 (a)(2) requires that each Engine is capable of acceptable operation throughout its specified operating envelope when subjected to sudden encounters with the certification standard concentrations of rain and hail as defined in Appendix A to CS-E. Acceptable Engine operation precludes, during any 3 minute continuous period in rain and during any 30 second continuous period in hail, the occurrence of flameout, rundown, continued or non-recoverable surge or stall, or loss of acceleration and deceleration capability. It must also be shown after the ingestion that there is no unacceptable mechanical damage, unacceptable power or thrust loss or other adverse Engine anomalies.

Service experience has shown that aircraft have lost all power after flying through hail concentrations that exceeded those test levels used to show compliance with CS-E 790 (a)(2). In one example an aircraft was found to experience a dual engine flameout as a result of an extreme rain and hail encounter and subsequently ditched.

CS-E 790 (a)(2) does not currently address short duration high bursts of hail as identified in the incidents described above and is primarily used to address thermodynamic lag and bleed valve clogging during operation. The incidents described indicate the potential threat from high intensity hail bursts, this is further supported by research performed by the Aerospace Industries Association (AIA, 2006) which found that for encounters shorter than 30 seconds, the hail water content experienced may exceed those levels identified in Appendix A to CS-E. Applicants should therefore consider these findings when demonstrating compliance against CS-E 540 (b).

3. EASA CERTIFICATION POLICY

3.1. EASA POLICY

Applicants are required to show under CS-E 540 (b), that the strike and ingestion of foreign matter including rain and hail that is likely to affect more than one Engine in any one flight will not preclude the continued safe flight and landing of the aircraft as a consequence of a Hazardous Engine Effect or an unacceptable:

- (1) Immediate or subsequent loss of performance;
- (2) Deterioration of Engine handling characteristics;
- (3) Exceedence of any Engine operating limitation.

Experience has shown that the requirements of CS-E 790 and the guidance material contained in AMC E 790 may not address the threats posed by high intensity hail bursts.

Applicants should therefore consider high intensity hail bursts when developing their compliance plans.

This may be achieved by including in their 30 second duration demonstration in CS-E 790, the short burst, high concentration, 13 gm/m³ hail water content (HWC) at 15,000 foot altitude for 5 seconds, as identified in the Aerospace Industries Association study.

Applicants can assess engine operation against this elevated threat, either integrated within the current 30-second test point or separately using test or analysis. Applicants may also propose alternatives to assess similar short-term, high concentration threats.

This policy is complementary to the existing guidance material of AMC E 790 and in particular AMC E 790 (a)(2).

3.2. WHO THIS CERTIFICATION MEMORANDUM AFFECTS

Applicants to an engine Type Certificate that need to show compliance with CS-E 540.

Applicants to a change to an engine Type Certificate, when this change affects compliance with CS-E 540.

4. REMARKS

1. Suggestions for amendment(s) to this EASA Certification Memorandum should be referred to the Certification Policy and Planning Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu or fax +49 (0)221 89990 4459.
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APPENDIX A – SHORT TERM HAIL CONCENTRATION

The HWC defined by CS-E 790 (a)(2) includes consideration for the duration of the storm encounter. On this basis, the maximum HWC level of 10 gm/m³ specified in Appendix A to CS-E is consistent with the 30-second test demonstration requirement of the rule.

Consideration for this encounter period is intended to confirm that the effects of thermodynamic lag and ice blockage of engine bleed systems are accounted for during engine certification. The relationship between maximum HWC and storm encounter duration is provided in figure 1 below for the range of storm penetration speed used to establish the 30-second duration requirements.

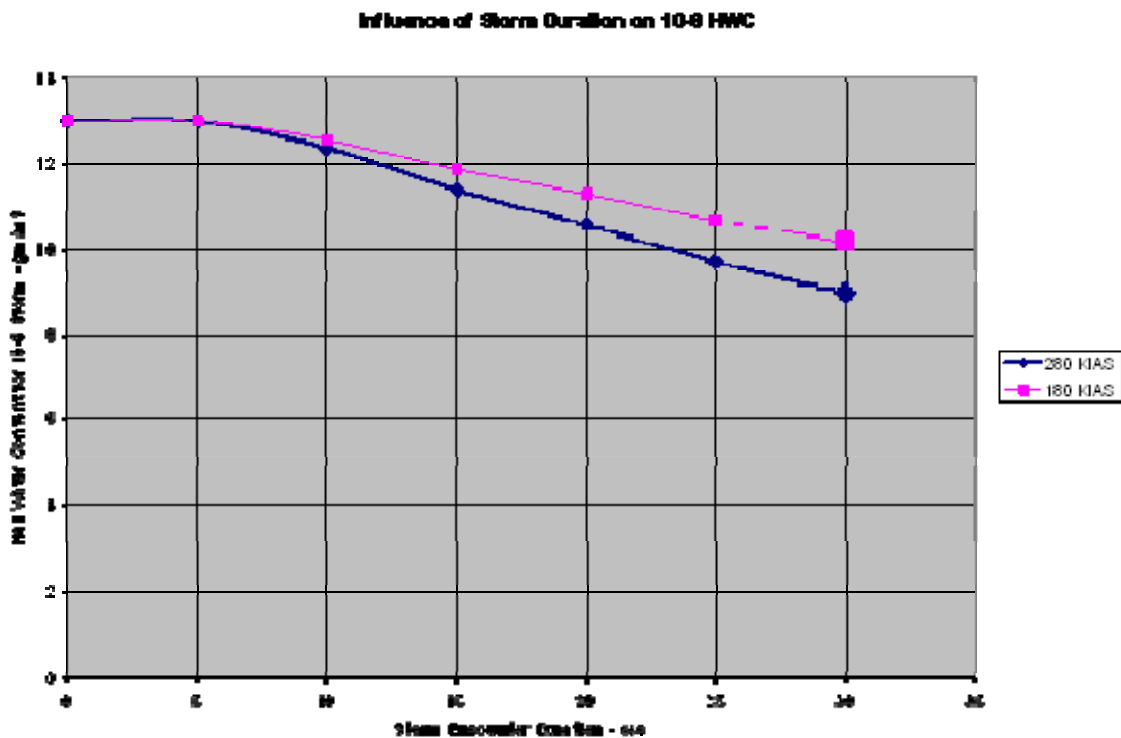


Figure 1 Maximum HWC Threat Relation to Storm Encounter Duration

As shown, encounters shorter than 30 seconds may exceed 10 gm/m³, and is influenced by the Operating Manual storm penetration speed guidelines for the engine installation.