EASA	CERTIFICATION MEMORANDUM
	**EASA CM No.: EASA CM – PIFS – 005 Issue: 01** **Issue Date: 31st of July 2012** **Issued by: Propulsion section** **Approved by: Head of Products Certification Department** **Regulatory Requirement(s): CS-E 790**

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Subject

Guidance for Rain and Hail Ingestion Testing for Turbine Engines – Ice Accretion

Log of Issues

Issue	Issue date	Change description
01	31.07.2012	First issue.

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1. INTRODUCTION

1.1. PURPOSE AND SCOPE

CS-E 790 Ingestion of Rain and Hail, requires that the ingestion of large hailstones (0.8 to 0.9 specific gravity) at the maximum true air speed, for altitudes up to 4500 metres, associated with a representative aircraft operating in rough air, with the Engine at Maximum Continuous power/ thrust, must not cause unacceptable mechanical damage or unacceptable power or thrust loss after the ingestion, or require the Engine to be shut down.

In addition to complying with the above requirements and except as provided for Engines for Rotorcraft, it must also be shown 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.

This Certification Memorandum provides additional guidance related to the development of ice accretion within the engine as a consequence of operation in hail.

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 790	Ingestion of Rain and Hail	CS-E	---	---

1.3. ABBREVIATIONS

The following abbreviations are used in this Certification Memorandum:

Abbreviation	Meaning
AMC	**A**cceptable **M**eans of **C**ompliance
CS	**C**ertification **S**pecification
EASA	**E**uropean **A**viation **S**afety **A**gency

1.4. DEFINITIONS

The following definitions are used in this Certification Memorandum:

Definition	Meaning
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2. BACKGROUND

Recent hail certification testing has identified that ice accretion may occur within the engine as a consequence of operation in hail. Ice accretion within the engine can result in operability problems, downstream engine damage, and possibly power loss from engine flameout.

The risk of hail causing ice accretion within the engine should therefore be considered by applicants during hail certification testing. This phenomenon would not be revealed when the engine is tested with water only.

3. EASA CERTIFICATION POLICY

3.1. EASA POLICY

If an applicant proposes using excess water in lieu of an actual hail ingestion test, the applicant should address the issue of inter-compressor bleed clogging and also the possibility of ice accretion within the compression system (e.g. low pressure compressor stator vanes).

Accretion within the engine resulting from ingesting the certification standard hail content of Appendix A to CS-E should not result in unacceptable engine damage or adverse operability, including flameout, rundown, or continued or non-recoverable surge or stall.

3.1.1. Hail Water Content and Ice Accretion

When conducting hail ingestion tests at sea level in compliance with CS-E 790 and Appendix A to CS-E, applicants should consider an adjustment to the hail water content to account for the higher air density at sea level compared with altitude flight conditions (see AMC E 790 (a)(2) paragraph (5)(c)). On this basis, the maximum hail water content specified in Appendix A of CS-E is amplified by a factor, (the specific amplification factor depends upon the critical flight condition and the sea level test conditions). This amplification is intended to validate the engine's ability to tolerate the operability effects (e.g. reduced stall margin, increased fuel flow requirements, and degraded combustion flameout margin) associated with hail ingestion by providing the same water-to-air ratio within the engine core at sea level that is experienced during an in-flight hail encounter.

However, ice accretion within the engine compressor depends on the absolute hail water content level rather than the water-to-air ratio within the engine. It is therefore possible, that the pressure altitude density effect on hail water content for the sea level test may result in ice accretion within the engine that would not occur in flight. Note that flight airspeed effects should still be applied to the engine test simulation.

If certification testing reveals an issue with ice accretion during the CS-E 790 testing with amplified hail water content, the manufacturer may need to repeat the testing at the levels identified in Appendix A to CS-E to evaluate the true ice accretion threat. Alternatively, the manufacturer may choose to run an initial test at those levels identified in Appendix A to CS-E to demonstrate the engines capability with respect to ice accretion before performing the higher hail water content operability test.

3.2. WHO THIS CERTIFICATION MEMORANDUM AFFECTS

Applicants to an engine Type Certificate that need to show compliance with CS-E 790.

Applicants to a change to an engine Type Certificate, when this change affects compliance with CS-E 790.

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.
2. For any question concerning the technical content of this EASA Certification Memorandum, please contact:

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