



Initial Airworthiness

Equivalent Safety Findings (ESF)

Equivalent Safety Finding – Degraded flight instrument external probe heating system



Consultation Paper Equivalent Safety Finding UK.ESF.F.0001 Issue 1

Proposed: Final

Deadline for comments: 25 December 2024

SUBJECT: Degraded flight instrument external probe heating system

REQUIREMENTS incl. Amdt.: CS 25.1326(b)(2) at Amdt. 21

ASSOCIATED IM/MoC: Yes / No

ADVISORY MATERIAL: AMC 25.1326

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Introductory Note

The following equivalent safety finding has been raised by the UK CAA in accordance with the provisions of point 21.A.15 of Part-21 (Annex I to UK Regulation (EU) No 748/2012).

In accordance with the UK CAA Design and Certification procedures, such Equivalent Safety Findings shall be assessed by the authority and be subject to a period of public consultation of not less than 2 weeks except if they have been previously agreed and published by the UK CAA.

Interested persons submitted their comments on this Equivalent Safety Finding Proposal online: Equivalent Safety Finding UK.ESF.F.0001 Consultation. The consultation period closed on 25 December 2024.

The final decision shall be published by the UK CAA and is contained in this Final Consultation Paper.

Acronyms and Abbreviations

ADS	Air Data System
ADSP	Air Data Smart Probe
AFM	Aircraft Flight Manual
AMC	Acceptable Means of Compliance
AOA	Angle of Attack
CAA	Civil Aviation Authority
CAS	Crew Alerting System
CMR	Certification Maintenance Requirements
CS	Certification Specification
DFCS	Digital Flight Control System
ESF	Equivalent Safety Finding
EU	European Union
ICA	Instructions for Continued Airworthiness
TAT	Total Air Temperature
UK	United Kingdom of Great Britain and Northern Ireland

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Identification of Issue

A Large Aeroplane (CS-25) is equipped with Air Data System Probes (ADSP), Total Air Temperature (TAT) probes and Angle Of Attack (AOA) vanes. Those probes are equipped with heating systems that require compliance with CS 25.1326(b)(2) at Amdt 21 "Flight instrument external probes heating systems alert".

CS 25.1326(b)(2) reads as follows:

"If a flight instrument external probe heating system is installed, an alert must be provided to the flight crew when the flight instrument external probe heating system is not operating or not functioning normally. The alert must comply with the following requirements:

[...]

(b) The alert provided must be triggered if either of the following conditions exists:

[...]

(2) The flight instrument external probe heating system is switched 'on' and is not functioning normally."

CS 25.1326(b)(2) requires the indication of heating system failure by providing an alert as soon as the failure occurs and irrespective whether the aircraft is flying or not in icing conditions. The intent of the requirement is to provide the pilot with the necessary alerts of either total loss of, or degraded, anti-icing performance of the external probes.

The design of ADSP and TAT probe does not provide a direct indication to alert the pilot for all kind of heater failures leading to a degradation¹ of their anti-ice capability leading to potentially hazardous or catastrophic consequences; therefore, it does not literally meet the requirement CS 25.1326(b)(2).

Nevertheless, the Applicant proposes an ESF to CS 25.1326(b)(2) based on the detection of degraded anti-icing performance, through monitoring of the possible erroneous air data - potentially caused by a malfunction of a probe heating system - from one or more probes. The mitigation is proposed through a combination of alerts and AFM procedures and is supplemented by scheduled maintenance tasks to detect latent failures at individual probe heating system level. This meets the intent of the requirement, since it provides adequate alerts based on ADS outputs comparison to enable the crew decision-making process. The scheduled maintenance tasks are added to compensate the fact that the monitoring capabilities will only allow detection of degraded probe heating system performance when encountering (severe enough) icing conditions.

This ESF to CS 25.1326(b)(2) is limited to ADSP and TAT probes only².

¹ Complete failure of the anti-ice capability of each flight external probe is detected and annunciated to the flight crew.

² AoA vanes are excluded from the scope of this request for ESF as a degradation of their heater performance do not require flight crew awareness and response to mitigate the consequences of the failure(s) during flight.

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This provides compensating factors allowing to reach an equivalent level of safety per point 21.B.80(a)2 of Part-21 (Annex I to UK Regulation (EU) No 748/2012).

Considering all the above, the following Equivalent Safety Finding to CS 25.1326(b)(2) at Amdt 21 is defined, which is agreed by UK CAA.

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UK.ESF.F.0001 Equivalent Safety Finding: ADS degraded flight instrument external probe heating system

1. APPLICABILITY

This ESF is applicable to CS-25 Large Aeroplanes.

1.1 AFFECTED CS

CS 25.1326(b)(2) at Amdt 21. Flight instrument external probes heating systems alert

2. COMPENSATING FACTORS

The ADSP and TAT probe heating system, although not literally compliant with CS 25.1326(b)(2) for certain failure modes leading to degraded anti-icing performance, may be installed and safely operated within the aircraft flight envelope provided that the below compensating factors are complied with.

a. For ADSP

1. The failure of one ADSP heater having an effect on operational capability or safety shall be detected, based on the following logics
 - If the degraded heating leads to small bias below the DFCS monitoring threshold, there is no effect on operational capability or safety and the aircraft will pursue the flight safely and so as per AMC 25.1326, there is no need to provide alert to the crew.
 - If the degraded heating leads to bias higher than the DFCS monitoring threshold (erroneous data), the DFCS monitoring system allows to detect the erroneous ADS data and trigger a root cause for dispatch purpose and possibly a caution CAS message "ADS x: FAIL".
2. The DFCS shall embed sufficient monitoring capabilities that enable 2 ADS erroneous data not to have higher than hazardous consequences and may trigger a caution CAS message "ADS x+y: FAIL" (e.g., subsequent failures) or a warning CAS message "ADS: ALL UNRELIABLE" (e.g., simultaneous failures).
3. In case of 3 or more ADS erroneous data there shall be sufficient monitoring capabilities that may trigger a warning CAS message "ADS: ALL UNRELIABLE".
4. the Instructions for Continued Airworthiness (ICA) shall include:
 - maintenance tasks checking the probe heating system following the generic ADS fault messages triggered to avoid latent failures remaining in the system.
 - a scheduled maintenance task (through a Certification Maintenance Requirement (CMR)) aimed at checking the ADSP heater in order to detect potential latent failures modes degrading the anti-icing/de-icing capability. The CMR interval shall adequately compensate the duration of operation with the latent failure(s).

Notes:

With those CAS messages, pilots would be aware of a failure of the ADS but would not be informed of the origin of the failure.

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The AFM procedures associated to CAS message “ADS x(+y): FAIL” and “ADS x(+y): PROBE HEAT FAIL” require the same pilot actions: reversion to the valid ADS/IRS source or disregard of ADS driven parameters in SFD, as applicable.

The AFM procedure associated to CAS “ADS: ALL UNRELIABLE” does not require different pilot action whether it is an ADS failure or an ADSP heater failure that drives this CAS message.

b. For TAT Probes

1. The failure of one TAT heater – leading to 2 erroneous temperature data - having an effect on operational capability or safety shall be detected. The crew is aware of erroneous TAT thanks to the caution CAS message “ADS: TAT MISCOMPARE”.
2. In case of 3 or more erroneous temperature data, there shall be sufficient monitoring capabilities that may trigger a caution CAS message “ADS: TAT MISCOMPARE” leading the crew to leave icing conditions which is considered as major.
3. the Instructions for Continued Airworthiness (ICA) shall include:
 - maintenance tasks checking the probe heating system following the generic TAT fault messages triggered to avoid latent failures remaining in the system
 - a scheduled maintenance task (through a Certification Maintenance Requirement (CMR)) aimed at checking the TAT heater in order to detect potential latent failures modes degrading the anti-icing/de-icing capability. The CMR interval shall adequately compensate the duration of operation with the latent failure(s).

Note: In case of triggering of the CAS message “ADS: TAT MISCOMPARE”, the procedure differs from “ADS x+y: TAT HEAT FAIL” and the pilot is required to avoid or leave the icing conditions and increase speed and landing distance.