Consultation Paper Special Condition UK.SC.E.0001 Issue 1

SUBJECT :	Cabin Evacuation - Protection from Fuel Tank Explosion due to External Fuel Fed Ground Fire.
REQUIREMENTS incl. Amdt.:	CS 25.863, CS 25.867, CS 25.856(b), CS 25.994, CS25.981(a)(1)(2) and 25.1309(a) at Amendment 23; CS25.963(e)(2) at Amendment 14; CS25.975(a)(7) at Amendment 21, and; CS 25.803(a) at Amendment 15
ASSOCIATED IM/MoC[1]:	Yes ☒ / No ☐
ADVISORY MATERIAL:	AMC 25.863(a), AMC 25.963(e), AMC 25.975(a)(7), AMC 25.856 / FAA AC25.856-2A

Contents

[1] Associated Interpretative Material and/or Means of Compliance may be published for awareness only and they are not subject to public consultation.

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Deadline for comments: 27 December 2024

Introductory Note

The UK CAA is undertaking the validation of a major change to type design on a large aeroplane that was certificated by EASA after the end of 2020, the certification basis of which incorporated the following Special Condition (SC) that was published by the EASA after the end of 2020. In accordance with UK CAA Design and Certification procedures, such SCs 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.

All interested persons may submit their comments on this Special Condition Proposal online, Special Condition UK.SC.E.0001 Consultation. The consultation period will close on 27 December 2024.

The final decision shall be published by the UK CAA.

Acronyms and Abbreviations

AC	Aircraft
CAA	Civil Aviation Authority
CEH	Complex Electronic Hardware
CS	Certification Specification
DEV	Deviation
EASA	European Union Aviation Safety Agency
EU	European Union
FAA	Federal Aviation Administration
Reg	Regulation
SC	Special Condition
TC	Type Certificate
UK	United Kingdom of Great Britain and Northern Ireland

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Identification of Issue

The UK CAA received an application for validation of a major change to type design on a large aeroplane.

1) The design change introduces a conformal fuselage structural fuel tank[2] to the aeroplane, also called rear centre tank (RCT) located behind the main landing gear wheel bay, in the lower section of the fuselage, partially replacing the aft cargo compartment.

   The integration of a conformal fuselage structural fuel tank located below the cabin floor presents challenges in terms of occupants' protection against the risks of external fire burnthrough, fuel vapour ignition and fuel tank explosion as well as challenges to ensure crashworthiness of this fuel tank.

   The protection against external fire burnthrough was addressed through a dedicated Special Condition subject to consultation by EASA which closed in February 2021 and was adopted by CAA in February 2024:

   https://www.easa.europa.eu/document-library/product-certification-consultations/final-specialcondition-ref-sc-d25856-01

   https://consultations.caa.co.uk/airworthiness-policy-team/part-21-aircraft-airworthiness-special-conditions/

   The crashworthiness of the fuel tank design was addressed through a dedicated Special Condition subject to consultation by EASA which closed in January 2023 and will be addressed by a dedicated Special Condition that CAA is consulting upon separately.

   https://www.easa.europa.eu/en/document-library/product-certification-consultations/final-special-condition-ref-sc-e25963-01

   https://consultations.caa.co.uk/

   The protection against the fuel vapour ignition and fuel tank explosion was addressed through a dedicated Special Condition subject to consultation by EASA which closed in July 2022 and which is subject of this consultation by CAA.

   https://www.easa.europa.eu/en/document-library/product-certification-consultations/final-special-condition-ref-sc-e25963-01

   This present Special Condition therefore addresses only the risk of fuel ignition and fuel tank explosion.

[2] A conformal fuselage structural fuel tank is a fuel tank, that carries aircraft loads and shares some boundaries with the fuselage skin.

The experience gathered with large aeroplanes carrying more than 19 passengers, equipped with classical wing fuel tanks (incl. centre wing fuel tanks) and auxiliary tanks located in cargo compartments, is considered satisfactory in terms of protection of the cabin occupants during post-crash evacuation from the risk of fuel tank explosion generated by an external fuel fed ground fire. However, the proposed RCT installation, because of its design and location, is considered as an unusual or novel design feature for this category of aeroplanes with regards to this risk.

2) CS 25 at amendment 23, includes several specifications that address the risk of fuel vapours ignition. However, none of them adequately covers the risk of ignition in a RCT as introduced on this aeroplane in case of external fuel fed ground fire:

- *CS 25.856(b) For aeroplanes with a passenger capacity of 20 or greater, thermal/acoustic insulation materials (including the means of fastening the materials to the fuselage) installed in the lower half of the aeroplane fuselage must meet the flame penetration resistance test requirements of Part VII of Appendix F to CS-25, or other approved equivalent test requirements. This requirement does not apply to thermal/acoustic insulation installations that the Agency finds would not contribute to fire penetration resistance.*
- *CS 25.863 considers the minimisation of the probability of ignition and resultant hazards due to the ignition of flammable fluids or vapours that might escape from a fluid system.*
- *CS 25.867 considers the fire protection in specific zones around the nacelle.*
- *CS 25.963(e)(2) requires the Fuel Tank Access Covers to "have the capacity to withstand the heat associated with fire at least as well as an access cover made from aluminium alloy in dimensions appropriate for the purpose for which they are to be used except that the access covers need not be more resistant to fire than an access cover made from the base fuel tank structural material." This rule was created following an accident where a fuel tank access panel failed from impact damage causing a fuel leak from a perforated wing tank and generated an external fuel fed ground fire.*
- *CS 25.975(a)(7) specifies that fuel tank vent systems must prevent explosions, for a minimum of 2 minutes and 30 seconds, in case of external ground fire.*
- *CS 25.981(a)(1) and (2) require demonstrating that no aircraft systems operation, failure, malfunction may cause an increase of temperature inside the fuel tank beyond a temperature that has a safe margin below the lowest expected auto-ignition temperature of the fuel.*

- *CS 25-994 Fuel system components in an engine nacelle or in the fuselage must be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway under each of the conditions prescribed in CS 25.721(b).*

The inerting of the fuselage tank, while introduced in the frame of compliance with CS 25.981(b), is primarily focussed at protecting the fuel tank against internal design failure modes that could ignite fuel vapours. Moreover, the agreed compliance means of the inerting system is based on a statistical objective following a Monte-Carlo analysis per CS-25 Appendix N. This strategy cannot be assumed to meet the safety objective of protection against external ground fire hazards.

However, Flammability Reduction Systems or Ignition Mitigation Means can be considered provided their performance could be demonstrated to prevent ignition of RCT fuel vapours by an external ground fire. In accordance with 21.B.75(a)(1) of Annex Part-21 to Regulation (EU) 748/2012 for novel or unusual design features, there is the need to address the threat of RCT fuel vapour ignition in case of external fuel fed ground fire.

Considering all the above, the following Special Condition is proposed to complement CS-25 Amdt. 23 certification specifications:

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Special Condition UK.SC.E.0001

Cabin Evacuation - Protection from Conformal Fuselage Structural Fuel Tank Explosion due to External Fuel Fed Ground Fire

In order to protect cabin occupants during evacuation, from the risk of fuselage tank explosion triggered by an external fuel fed ground fire[3], the large aeroplane design must prevent ignition of fuel tank vapour (due to hot surface) from occurring inside the conformal fuselage structural fuel tank.

The corresponding demonstration must consider sufficient time to allow a safe evacuation of all occupants after an event leading to an external fuel fed ground fire.

Definition

A conformal fuselage structural fuel tank is a fuel tank, that shares some boundaries with the fuselage skin.

[3] External fuel fed ground fire: An external fuel fed ground fire or external fuel fed pool fire will be referred to ‘external ground fire’ later in the IM and MoC part for sake of brevity.

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Interpretative Material to Special Condition UK.SC.E.0001

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Fuel Vapours ignition conditions for a fuel tank explosion.

The risk of explosion due to an external ground fire arises from fuel vapours within the tank coming into contact with the heated tank surface (hot surface ignition risk). The applicant may use a time to reach 204 °C (400 °F) on the inner side of the tank wall as the criteria for determining the ignition condition. This 204 °C (400 °F) temperature value is accepted by EASA as the maximum surface temperature inside fuel tanks for kerosene type fuels without further substantiation (reference to AMC 25.981(a)). A transient excursion for not more than 2 minutes above 204 °C (400 °F) but remaining below the accepted auto-ignition temperature of 232 °C (450 °F) for kerosene type fuels is also accepted, in accordance with AMC 25.981 §3.5.3 conditions. A higher surface temperature threshold and/or longer excursion time may be used but will need to be substantiated.

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Means Of Compliance to Special Condition UK.SC.E.0001

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1 - Time duration for fuel vapours ignition prevention

In order to comply with the Special Condition requirement, the applicant should demonstrate that the conditions allowing the ignition of the conformal fuselage structural tank fuel vapours are not reached during at least 5 minutes of exposure to the external ground fire.

2 - Baseline minimum time to vapour ignition

The above minimum time of 5 minutes is derived from the CS 25.856(b) objective for fire burnthrough prevention. It is deemed adequate to allow safe evacuation of occupants.

The applicant should consider the same safety objective for the emergency evacuation for all external ground fire generated hazards. Therefore, this time duration is also used as the baseline standard for fuselage tank fuel vapours ignition protection.

3 - Evaluation conditions for the conformal fuselage structural fuel tank

The demonstration should be based on tests or analysis supported by tests. The test or analysis supported by test should consider critical fuel loads for the risk of explosion. The test or analysis supported by test should include the most critical design sections or parts of the fuel tank for the fuel vapour ignition conditions.

4 - External fuel fed Ground Fire Flame definition

The time needed to reach the fuel vapour ignition conditions on the inner surface of the fuselage structural fuel tank wall should be established using a representative flame characterizing external ground fire conditions.

CS 25 Appendix F, Part VII specifies a test method to determine the burnthrough resistance of thermal/acoustic insulation materials. This includes the specifications for a test burner representing, during material burnthrough tests, an external ground fire impacting the fuselage.

For the demonstration of compliance of a conformal fuselage tank with the present Special Condition, the applicant may either use a burner complying with the Appendix F, Part VII specifications, or a burner providing the same flame characteristics.