Equivalent Safety Finding on CS 25.981 :
Fuel Tank Ignition Prevention – Hot Surface Ignition Temperature

Applicable to Boeing 737-7, 737-8 and 737-9

Introductory Note:

The hereby presented Equivalent Safety Finding has been classified as an important Equivalent Safety Finding and as such shall be subject to public consultation, in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) of which states:

"*2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

Exceptionally, the consultation period of this Equivalent Safety Finding will be limited to two weeks. This derogation to the above quoted Decision is based on the fact that this ESF consultation process needs to be concluded as soon as possible not to endanger the conclusion of the certification process.

Statement of Issue:

CS 25.981 Fuel tank ignition prevention (and associated AMC 25.981) requires :

(a) No ignition source may be present at each point in the fuel tank or fuel tank system where catastrophic failure could occur due to ignition of fuel or vapours. This must be shown by:

(1) Determining the highest temperature allowing a safe margin below the lowest expected auto-ignition temperature of the fuel in the fuel tanks.

(2) Demonstrating that no temperature at each place inside each fuel tank where fuel ignition is possible will exceed the temperature determined under sub-paragraph (a)(1) of this paragraph. This must be verified under all probable operating, failure, and malfunction conditions of each component whose operation, failure, or malfunction could increase the temperature inside the tank.

(3) Demonstrating that an ignition source does not result from each single failure and from all combinations of failures not shown to be Extremely Improbable as per 25.1309. (See AMC 25.981(a))

CS 25.863 Flammable fluid fire protection (and associated AMC 25.863) requires:

(a) In each area where flammable fluids or vapours might escape by leakage of a fluid system, there must be means to minimise the probability of ignition of the fluids and vapours, and the resultant hazards if ignition does occur. (See AMC 25.863 (a).)

(b) …

Boeing has proposed for certification of the Boeing 737-7, 737-8, and 737-9 (737 MAX) airplane models, powered with CFM LEAP-1B engines, to use a maximum surface temperature for the fuel tanks that is above the limits provided in the guidances AMC 25.981(a), “Ignition precautions” and AMC 25.863(a) “flammable fluid fire protection”.

Boeing has requested the use of 500 °F (260°C) as an acceptable Hot Surface Ignition Temperature (HSIT) in order to address failures of the bleed air system that could cause temperatures of the internal surface of the fuel tanks to exceed 200 °C.

The potential failure scenario involves a bleed air leak in the bleed air duct system (largely inherited from the 737NG) that could create an ignition source in the fuel tank.

The 400°F / 200°C value is derived from jet fuel Auto Ignition Temperature (considered at 450°F) with margins (50°F) and had been extensively and commonly used for years in the compliance demonstrations for fire and fuel tank explosion risk problematics. This temperature had been used as well for maximum allowable hot surface temperature without further substantiation.

The Boeing proposal is reducing the safety margins and deviates from well established practices that are in place since the fuel tank ignition mitigations were introduced as a result of the TWA 800 accident (1998) investigation. The subsequent SFAR88, INT/POL25/12, FAR/CS 25.981 and their ACs / AMCs revisions have been consistently refering to a fuel ignition temperature of 400°F/200°C based on fuel Auto Ignition Temperature (AIT).

EASA is in the opinion that a Means of Compliance approach does not balance the reduction of safety margins. Similarly to the FAA policy, having issued the Equivalent Level Of Safety P-19, EASA has elaborated the conditions to grant an Equivalent Safety Finding for which Boeing shall demontsrate that the use of this fuel HSIT temperature is providing the same level of safety as the commonly used fuel AIT.

Equivalent Safety Finding to CS 25.981 :
Fuel Tank Ignition Prevention – Hot Surface Ignition Temperature

Applicable to Boeing 737-7, B737-8 and 737-9

Applicant Proposal:

To demontsrate that the use of the fuel Hot Surface Ignition Temperature at 500 °F (260°C) is providing the same level of safety as the commonly used fuel AIT (400°F / 200°C), Boeing is proposing the following substantiation:

- There are no normal operating conditions that produce fuel tank inner surface temperatures above 400°F.

- There is a very specific transient single failure condition that can temporarily produce localized fuel tank inner wall temperature above 400°F (specifically up to 434°F which is still below the AIT of 450°F), as described below:

    - A failure of a bleed air duct routed in the wing leading edge or in the ECS pack bay that –

        1) Is failed in a location that directs the escaping air directly towards the fuel tank, i.e. duct failure has to be approximately within a 90 degree cone facing the fuel tank.

2) Grows slowly to a hole size greater than 2 inches in diameter but not fast enough or large enough to cause the bleed system to close the engine bleed supply due to under pressure, over pressure or over temperature limits.

3) The flight crew response to accomplish and resolve a flight deck duct leak indication is assumed to be a maximum of 15 minutes. The leak would need to progress to greater than 2 inches in diameter in less than 15 minutes in order to result in a fuel tank inner wall temperature above 400°F or else the crew response would shut down the engine bleed. If the event was a duct burst (an explosive release of pressure), the automatic under pressure protection design feature of the bleed system will shut down the engine bleed.

- The analysis conservatively assumed no liquid fuel in the fuel tank (fuel would act as a heat sink).

- Although it is unlikely that the bleed duct will fail in a specific location, with a specific hole size and with a slow crew reaction to the duct leak indication, Boeing has analyzed localized heating of the tank wall and compared to a hot surface ignition temperature of 500°F (550°F with a 50°F margin) to ensure there is adequate margin for this unlikely set of circumstances that have to exist for this failure condition.

Safety Equivalency Demonstration:

In order to justify that the 737MAX fuel tank/system design complies with the fuel tank safety regulations (CS 25.981), it shall be demonstrated that :

- The temperature excursion remains below the fuel AIT;

- The excursion is limited over time

- The worst resulting excursive temperature will not, under nominal conditions neither under single failure nor any combination of failures not extremely improbable, result in a temperature higher than the lowest fuel hot surface ignition temperature minus a 50°F margin.

    - The substantiation of the higher than 200°C hot surface temperature includes a detailed design specific analysis that considers the following factors:
        - Zonal flammable vapor temperatures.
        - The size and geometry of component surfaces that would be at temperatures above 400 °F / 200°C. Enclosed spaces can create a stagnation area in combination with increased surface area (e.g., corners in structural walls or other closely spaced hot surfaces). The analysis must be supported by test data that can be shown to be applicable to the design specific geometry.
        - Proximity of higher temperature component surfaces to fuel tank surfaces.
        - Ventilation in the area where the component surface temperature will be higher under normal, failure, and malfunction conditions. Stagnation zones that may be present in the area being assessed, such that natural convection or vapor velocity from ventilation cannot be assumed.
        - Peak temperatures and failures or malfunctions necessary for surface temperature to reach proposed higher temperature limits.

- The proposed temperature is showing a safe margins versus the maximum allowable hot surface temperatures for the given flammable vapors (i.e fuel, hydraulic fluids, others)
- Surface Material & Material Roughness Effects
- Effect of Fuel Additives
- Effects of various ignition conditions vs fuel phase, ignition immersed in fuel liquid, ignition in ullage part, ignition of sloshed fuel (drops released on surface).