Proposed Equivalent Safety Finding to CS 25.858(a)

Applicable to B777F

Introductory note:

The hereby presented Equivalent Safety Finding has been classified as an important ESF and as such shall be subject to public consultation, in accordance with EASA Management Board decision 02/04 dated 30 March 2004, 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."

Statement of Issue

The Boeing Commercial Airplane Group (BCAG) has applied for an Amended Type Certificate from the European Aviation Safety Agency (EASA) to convert B777-200LR model aircraft into a freighter including a Class E cargo compartment in the main deck.

Applicable EASA regulation CS 25.855 (i) requires that:
“it must be shown that no inadvertent operation of smoke or fire detectors in any compartment would occur as a result of fire contained in any other compartment, either during or after extinguishment, unless the extinguishing system floods each such compartment simultaneously.”

Boeing has previously indicated that, similarly to other existing configurations, because of potential smoke leakage from the main deck, the smoke detection capability in the lower lobe cargo compartments will be inhibited during a main deck fire event in order to maintain compliance with CS 25.855(i).

However, the intent of CS 25.858(a) is to provide a smoke or fire warning indication to the flight crew within one minute after the start of a fire. According to CS 25.857(c), the forward and aft lower cargo Class C compartments require an approved smoke or fire detection system. During the time the smoke detection capability is inhibited, the forward and aft lower lobe cargo compartments will not strictly comply with the requirements of applicable CS 25.858(a):

“The detection system must provide a visual indication to the flight crew within one minute after the start of a fire”.

B777F - Equivalent Safety Finding to CS 25.858(a)

Boeing Design Proposal:

The 777 Freighter (777F) is a twin-engine airplane and is a derivative of the 777 major model. Based on the 777-200LR passenger airplane, the 777 Freighter is designed for long range express and general market freight operation. The 777F Cargo Fire Detection System is comprised of a smoke detection system for the main deck and lower lobe cargo compartments, with an alternate technology sensor as a backup in each detector..

The 777F Cargo Smoke Detection System (CSDS) controller software is designed so that the CSD Controller will inhibit either the forward or aft lower lobe Class C cargo compartment smoke indications from being transmitted to the flight crew whenever the main deck Class E cargo fire alarm has been set.
During the period of time that the lower lobe cargo smoke detection capability is inhibited, the backup sensors remain active: the CSDS controller will still set an alarm if the alternate sensors reach their alarm threshold. But unlike the smoke sensors, the alternate sensors are not expected to detect a fire within one minute in all foreseeable cases due to the technology being utilized.

Regardless of inhibition, all of the smoke detectors will continue to transmit their smoke level readings, alternate sensor data, and all other associated readings (such as internal faults to the detector) to the CSDS controller.

Boeing Justification:

As in past experience during Freighter certification flight testing for Class E main deck smoke penetration, smoke is expected to migrate into both the forward and aft lower lobe cargo compartments and cause inadvertent lower lobe cargo fire warnings unless the fire detection system design prevents this.
Boeing attributes the smoke migration into the lower lobe cargo compartments during main deck smoke penetration tests to the depressurized condition of the airplane combined with the high sensitivity of the cargo smoke detection system (CSDS) and the high quantity of smoke generated in the main deck cargo compartment during the test. Boeing expects several airflow paths in the lower lobe cargo compartments which influence the smoke migration from the main deck cargo compartment will exist when the airplane is depressurized.

If a forward or aft lower lobe cargo fire warning were to occur after a main deck cargo fire warning, the flight crew would not know if the second cargo fire warning is due to an actual lower lobe cargo fire or a false cargo fire warning due to smoke migration into either of the lower lobe cargo compartments. The flight crew's response to a lower lobe Class C cargo fire warning, which is likely to be a false warning, would result in a higher degree of crew workload and an increased risk of crew errors.

Therefore, Boeing proposes to implement a design which will inhibit lower lobe Class C smoke detection capability but retain an alternate lower cargo fire detection capability while the airplane is in a main deck Class E cargo fire mode.

Boeing Safety Equivalency Demonstration:

Boeing considers that the airplane design and applicable Airplane Flight Manual (AFM) procedures provide the following three compensating factors that provide an equivalent level of safety.

The first compensating factor is the very low probability of a lower lobe cargo fire occurring after a main deck cargo fire has occurred. The controlled main deck cargo fire is unlikely to spread into the lower lobe compartments. The fire will be reduced to a smoldering state by the Class E fire procedure. The residual heat of a main deck fire would be concentrated in the main deck crown. Laboratory tests have indicated that the temperature near the test chamber floor remain relatively low during simulated fire tests. In addition, cargo compartment fires are improbable events. The cargo fire data show that the combination of main deck cargo fire and an independent lower lobe cargo fire on the same flight is much less than extremely improbable. This extremely low probability has been relied upon in developing the cargo fire protection system architecture in previous JAA approved certification projects.

The second compensating factor for this approach is the airplane environment during the time that the lower lobe cargo smoke detection capability is inhibited. While the airplane is in the Class E cargo fire mode, all ventilation airflow, to or within, the main deck and aft lower lobe cargo compartments are shut off. Some air which is exhausted to the forward lower cargo compartment bilge area during the normal Class E main deck fire procedure will be shut down if an alternate sensor alarm is received from the forward cargo smoke/fire detectors. Prior to the alarm, this air primarily circulates below the cargo floor and cargo container/pallet bases, and leaks out under the sloping sidewall liners. It therefore does not present a significant threat of accelerating a fire to unacceptable levels prior to the alternate sensor alarm indication. This air is routed to another part of the airplane if an alternate sensor alarm is received. The AFM cargo fire procedures for the main deck Class E cargo compartment result in the airplane being depressurized to a cabin altitude higher than 20,000 feet. Fire growth in a compartment with a reduced partial pressure of oxygen at this altitude, and without ventilation airflow, is negligible. This airplane environment further reduces the probability of a subsequent lower lobe cargo fire after a main deck cargo fire by reducing the amount of oxygen available to sustain or propagate a cargo fire.

The third compensating factor is the design of the cargo smoke detectors as mentioned above. The 777F cargo smoke detectors also have alternate technology sensors that are fully monitored by the cargo smoke detector controller. As discussed above, the alternate sensors function independently of the smoke detector sensors, and they can also provide a fire warning indication to the flight crew. The alternate sensors will be qualified by lab test. Although the alternate sensors will not be certified to meet the one minute response requirement per CS 25.858(a), they will be able to provide the capability to detect an actively burning lower cargo fire at a temperature that is well below the temperature the cargo liners are certified to withstand for five minutes per CS Part 25 Appendix F part 3 requirements. Any potentially threatening lower lobe fire would be annunciate by the alternate sensors before any risk to airplane systems or structure occurred.