CS-25 AMENDMENT 8 - CHANGE INFORMATION

The Agency publishes amendments to Certification Specifications as consolidated documents. These documents are used for establishing the certification basis for applications made after the date of entry into force of the amendment.

Consequently, except for a note "Amdt. No.: 25/8" under the amended paragraph, the consolidated text of CS-25 does not allow readers to see the detailed changes introduced by the new amendment. To allow readers to also see these detailed changes this document has been created. The same format as for publication of Notices of Proposed Amendments has been used to show the changes:

1. text not affected by the new amendment remains the same: unchanged
2. deleted text is shown with a strike through: ~~deleted~~
3. new text is highlighted with grey shading: new
4. ....
   indicates that remaining text is unchanged in front of or following the reflected amendment.
   ....

PREAMBLE

1. Revise Preamble

Reordering of amendment information to approve readability.

Book 1 Airworthiness Code

SUBPART C – STRUCTURE

2. Revise CS 25.361 to read:

**CS 25.361 Engine and auxiliary power unit ~~APU~~ torque
(See AMC 25.361)**

(a) For engine installations:

(1) Each engine mount, pylon and ~~its~~ adjacent supporting airframe structure~~s~~ must be designed for the effects of: ~~engine torque effects combined with~~

(i~~1~~) a limit engine torque corresponding to take-off power/thrust and, if applicable, corresponding propeller speed, acting simultaneously with 75% of the limit loads from flight condition A of CS 25.333 (b);

(ii~~2~~) a limit engine torque corresponding to the maximum continuous power/thrust and, if applicable, corresponding propeller speed, ~~as specified in sub-paragraph (c) of this paragraph~~ acting simultaneously with the limit loads from flight condition A of CS 25.333 (b); and

(iii~~3~~) for turbo-propeller installations only, in addition to the conditions specified in sub-paragraphs (a)(1)(i) and (ii)~~(2) of this paragraph~~, a limit engine torque corresponding to take-off power and propeller speed, multiplied by a factor accounting for propeller control system malfunction, including quick feathering, acting simultaneously with 1g level flight loads. In the absence of a rational analysis, a factor of 1·6 must be used.

~~(b) For turbine engines and auxiliary power unit installations, the limit torque load imposed by sudden stoppage due to malfunction or structural failure (such as a compressor jamming) must be considered in the design of engine and auxiliary power unit mounts and supporting structure. In the absence of better information a sudden stoppage must be assumed to occur in 3 seconds.~~

(2)~~(c)~~ The limit engine torque to be considered under sub-paragraph (1~~a~~) ~~(2) of this paragraph is~~ must be obtained by:

(i) for turbo-propeller installations, multiplying ~~the~~ mean engine torque for the specified power/thrust and speed by a factor of 1·25 ~~for turbo-propeller installations.~~

(ii) for other turbine engines, the limit engine torque must be equal to the maximum accelerating torque for the case considered.

(3) The engine mounts, pylons, and adjacent supporting airframe structure must be designed to withstand 1g level flight loads acting simultaneously with the limit engine torque loads imposed by each of the following conditions to be considered separately:

(i) sudden maximum engine deceleration due to a malfunction or abnormal condition; and

(ii) the maximum acceleration of the engine.

~~(d) When applying CS 25.361 (a) to turbo-jet engines, the limit engine torque must be equal to the maximum accelerating torque for the case considered. (See AMC 25.301 (b).)~~

(b) For auxiliary power unit installations:
The power unit mounts and adjacent supporting airframe structure must be designed to withstand 1g level flight loads acting simultaneously with the limit torque loads imposed by the following conditions to be considered separately:
(1) sudden maximum auxiliary power unit deceleration due to malfunction or abnormal condition or structural failure; and
(2) the maximum acceleration of the auxiliary power unit.

3. Add a new CS 25.362 to read:

CS 25.362 Engine failure loads
(See AMC 25.362.)

(a) For engine mounts, pylons and adjacent supporting airframe structure, an ultimate loading condition must be considered that combines 1g flight loads with the most critical transient dynamic loads and vibrations, as determined by dynamic analysis, resulting from failure of a blade, shaft, bearing or bearing support, or bird strike event. Any permanent deformation from these ultimate load conditions should not prevent continued safe flight and landing.

(b) The ultimate loads developed from the conditions specified in paragraph (a) are to be:
(1) multiplied by a factor of 1.0 when applied to engine mounts and pylons; and
(2) multiplied by a factor of 1.25 when applied to adjacent supporting airframe structure.

SUBPART D - DESIGN AND CONSTRUCTION

4. Revise CS 25.851 to read:

…
CS 25.851 Fire extinguishers
(a) Hand fire extinguishers.
(See AMC 25.851(a))
…
(3) At least one readily accessible hand fire extinguisher must be available for use in each Class A or Class B cargo or baggage compartment and in each Class E or Class F cargo or baggage compartment that is accessible to crewmembers in flight.
….

5. Revise CS 25.855 to read:

CS 25.855 Cargo or baggage compartments
(See AMC to CS 25.855 and 25.857)

….

(b) ~~Class B through Class E cargo or baggage compartments, as defined in CS 25.857, must have a liner, and the liner must be separate from (but may be attached to) the aeroplane structure.~~ The following cargo or baggage compartments, as defined in CS 25.857, must have a liner that is separate from, but may be attached to, the aeroplane structure:

(1) Class B through Class E cargo or baggage compartments; and

(2) Class F cargo or baggage compartments, unless other means of containing the fire and protecting critical systems and structure are provided.

(c) Ceiling and sidewall liner panels of Class C cargo or baggage compartments, and ceiling and sidewall liner panels in Class F cargo or baggage compartments, if installed to meet the requirements of sub-paragraph (b)(2) of this paragraph, must meet the test requirements of Part III of Appendix F or other approved equivalent methods.

….

(h) Flight tests must be conducted to show compliance with the provisions of CS 25.857 concerning –

(1) Compartment accessibility;

(2) The entry of hazardous quantities of smoke or extinguishing agent into compartments occupied by the crew or passengers; and

(3) The dissipation of the extinguishing agent in Class C compartment or, if applicable, in Class F compartment.

6. Revise CS 25.857 to read:

CS 25.857 Cargo Compartment Classification
(See AMC 25.855 and 25.857)

….

(b) *Class B*. ~~(See AMC 25.857(b).)~~ A Class B cargo or baggage compartment is one in which -

(1) There is sufficient access in flight to enable a crewmember ~~to effectively reach any part of the compartment with the contents of a hand fire extinguisher~~, standing at any one access point and without stepping into the compartment, to extinguish a fire occurring in any part of the compartment using a hand fire extinguisher;

….

….

(f) *Class F*. A Class F cargo or baggage compartment is one in which -

(1) There is a separate approved smoke detector or fire detector system to give warning at the pilot or flight engineer station;

(2) There are means to extinguish or control a fire without requiring a crewmember to enter the compartment; and

(3) There are means to exclude hazardous quantities of smoke, flames, or extinguishing agent from any compartment occupied by the crew or passengers.

SUBPART E – POWERPLANT

7. Revise CS 25.901 to read:

CS 25.901 Installation

(a) …

(b) …

(c) The powerplant installation must comply with CS 25.1309, except that the effects of the following need not comply with CS 25.1309(b):

(1) Engine case burn through or rupture;

(2) Uncontained engine rotor failure; and

(3) Propeller debris release.

(See AMC 25.901(c) Safety Assessment of Powerplant Installations and AMC 25-24: Sustained Engine Imbalance)

APPENDICES

8. Amend paragraph (a)(1)(ii) and (a) (2) (iii) in Part I of Appendix F to CS-25 as follows:

Appendix F

Part I – Test Criteria and Procedures for Showing Compliance with CS 25.853, 25.855 or 25.869

(a) *Material test criteria–*

(1)….

….

(ii) Floor covering, textiles (including draperies and upholstery), seat cushions, padding, decorative and non-decorative coated fabrics, leather, trays and galley furnishings, electrical conduit, air ducting, joint and edge covering, liners of Class B and E cargo or baggage compartments, floor panels of Class B, C, ~~D or~~ E or F cargo or baggage compartments, cargo covers and transparencies, moulded and thermoformed parts, air ducting joints, and trim strips (decorative and chafing), that are constructed of materials not covered in sub-paragraph (iv) below, must be self-extinguishing when tested vertically in accordance with the applicable portions of Part I of this Appendix or other approved equivalent means. The average burn length may not exceed 20 cm (8 inches), and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the test specimen may not continue to flame for more than an average of 5 seconds after falling.

….

(2)…

….

(iii) A cargo or baggage compartment defined in CS 25.857 as Class B, C, ~~D or~~ E or F must have floor panels constructed of materials which meet the requirements of sub-paragraph (a)(1)(ii) of Part I of this Appendix and which are separated from the aeroplane structure (except for attachments). Such panels must be subjected to the 45-degree angle test. The flame may not penetrate (pass through) the material during application of the flame or subsequent to its removal. The average flame time after removal of the flame source may not exceed 15 seconds, and the average glow time may not exceed 10 seconds.

9. Add the title of Appendix F Part III as follow:

Appendix F

Part III – T Test Method to Determine Flame Penetration Resistance of Cargo Compartment Liners”

10. Correct the appendix H as follow:

Appendix H

[…]
H25.5 Electrical Wiring Interconnection System Instructions for Continued Airworthiness
The applicant must prepare Instructions for ~~T~~Continued Airworthiness applicable to Electrical Wiring Interconnection System as defined in CS 25.1701. (see AMC Appendix H 25.5)

Book 2 Acceptable Means of Compliance

AMC - GENERAL

11. Add a new AMC 25-24 to read as follows:

AMC 25-24
Sustained Engine Imbalance

1. PURPOSE

This AMC sets forth an acceptable means, but not the only means, of demonstrating compliance with the provisions of CS-25 related to the aircraft design for sustained engine rotor imbalance conditions.

2. RELATED CS PARAGRAPHS

a. CS-25:

CS 25.302 “Interaction of systems and structures”
CS 25.571 “Damage tolerance and fatigue evaluation of structure”
CS 25.629 “Aeroelastic stability requirements”
CS 25.901 “Installation”
CS 25.903 “Engines”

b. CS-E:

CS-E 520 “Strength”
CS-E 525 “Continued Rotation”
CS-E 810 “Compressor and Turbine Blade Failure”
CS-E 850 “Compressor, Fan and Turbine Shafts”

3. DEFINITIONS. Some new terms have been defined for the imbalance condition in order to present criteria in a precise and consistent manner. In addition, some terms are employed

from other fields and may not be in general use as defined below. The following definitions apply in this AMC:

a. Airborne Vibration Monitor (AVM). A device used for monitoring the operational engine vibration levels that are unrelated to the failure conditions considered by this AMC.

b. Design Service Goal (DSG). The design service goal is a period of time (in flight cycles/hours) established by the applicant at the time of design and/or certification and used in showing compliance with CS 25.571.

c. Diversion Flight. The segment of the flight between the point where deviation from the planned route is initiated in order to land at an en route alternate airport and the point of such landing.

d. Ground Vibration Test (GVT). Ground resonance tests of the aeroplane normally conducted in compliance with CS 25.629.

e. Imbalance Design Fraction (IDF). The ratio of the design imbalance to the imbalance (including all collateral damage) resulting from release of a single turbine, compressor, or fan blade at the maximum rotational speed to be approved, in accordance with CS-E 810.

f. Low Pressure (LP) Rotor. The rotating system, which includes the low pressure turbine and compressor components and a connecting shaft.

g. Well Phase. The flight hours accumulated on an aeroplane or component before the failure event.

4. BACKGROUND

a. Requirements. CS 25.901(c) requires the powerplant installation to comply with CS 25.1309. In addition, CS 25.903(c) requires means of stopping the rotation of an engine where continued rotation could jeopardise the safety of the aeroplane, and CS 25.903(d) requires that design precautions be taken to minimise the hazards to the aeroplane in the event of an engine rotor failure. CS-E 520(c)(2) requires that data shall be established and provided for the purpose of enabling each aircraft constructor to ascertain the forces that could be imposed on the aircraft structure and systems as a consequence of out-of-balance running and during any continued rotation with rotor unbalance after shutdown of the engine following the occurrence of blade failure, as demonstrated in compliance with CS-E 810, or a shaft, bearing or bearing support, if this results in higher loads.

b. Blade Failure. The failure of a fan blade and the subsequent damage to other rotating parts of the fan and engine may induce significant structural loads and vibration throughout the airframe that may damage the nacelles, equipment necessary for continued safe flight and landing, engine mounts, and airframe primary structure. Also, the effect of flight deck vibration on displays and equipment is of significance to the crew's ability to make critical decisions regarding the shut down of the damaged engine and their ability to carry out other operations during the remainder of the flight. The vibratory loads resulting from the failure of a fan blade have traditionally been regarded as insignificant relative to other portions of the design load spectrum for the aeroplane. However, the progression to larger fan diameters and fewer blades with larger chords has changed the significance of engine structural failures that result in an imbalanced rotating assembly. This condition is further exacerbated by the fact that fans will continue to windmill in the imbalance condition following engine shut down.

c. Bearing/Bearing Support Failure. Service experience has shown that failures of bearings/bearing supports have also resulted in sustained high vibratory loads.

d. Imbalance Conditions. There are two sustained imbalance conditions that may affect safe flight: the windmilling condition and a separate high power condition.

(1) Windmilling Condition. The windmilling condition results after the engine is shut down but continues to rotate under aerodynamic forces. The windmilling imbalance condition results from bearing/bearing support failure or loss of a fan blade along with collateral damage. This condition may last until the aeroplane completes its diversion flight, which could be several hours.

(2) High Power Condition. The high power imbalance condition occurs immediately after blade failure but before the engine is shut down or otherwise spools down. This condition addresses losing less than a full fan blade which may not be sufficient to cause the engine to spool down on its own. This condition may last from several seconds to a few minutes. In some cases it has hampered the crew's ability to read instruments that may have aided in determining which engine was damaged.

e. The information provided in this AMC is derived from the recommendations in the report “Engine Windmilling Imbalance Loads - Final Report,” dated July 1, 1997, which is appended to this NPA for information.

f. The criteria presented in this AMC are based on a statistical analysis of 25 years of service history of high by-pass ratio engines with fan diameters of 1.52 metres (60 inches) or greater. Although the study was limited to these larger engines, the criteria and methodology are also acceptable for use on smaller engines.

5. EVALUATION OF THE WINDMILLING IMBALANCE CONDITIONS

a. Objective. It should be shown by a combination of tests and analyses that after:
i) partial or complete loss of an engine fan blade, or
ii) after bearing/bearing support failure, or
iii) any other failure condition that could result in higher induced vibrations
including collateral damage, the aeroplane is capable of continued safe flight and landing.

b. Evaluation. The evaluation should show that during continued operation at windmilling engine rotational speeds, the induced vibrations will not cause damage that would jeopardise continued safe flight and landing. The degree of flight deck vibration[1] should not prevent the flight crew from operating the aeroplane in a safe manner. This includes the ability to read and accomplish checklist procedures.

This evaluation should consider:

(1) The damage to airframe primary structure including, but not limited to, engine

[1] ‘ An acceptable level of cockpit vibration in terms of vibration frequency, acceleration magnitude, exposure time and direction may be found in ISO 2631/1 “International Standard, Evaluation of Human Exposure to Whole-Body Vibration, Part I: General Requirements”, 1985.

mounts and flight control surfaces,

(2) The damage to nacelle components, and

(3) The effects on equipment necessary for continued safe flight and landing (including connectors) mounted on the engine or airframe.

c. Blade Loss Imbalance Conditions

(1) Windmilling Blade Loss Conditions. The duration of the windmilling event should cover the expected diversion time of the aeroplane. An evaluation of service experience indicates that the probability of the combination of a 1.0 IDF and a 60 minute diversion is on the order of 10^{-7} to 10^{-8} while the probability of the combination of a 1.0 IDF and a 180 minute diversion is 10^{-9} or less. Therefore, with an IDF of 1.0, it would not be necessary to consider diversion times greater than 180 minutes. In addition, the 180 minute diversion should be evaluated using nominal and realistic flight conditions and parameters. The following two separate conditions with an IDF of 1.0 are prescribed for application of the subsequent criteria which are developed consistent with the probability of occurrence:

(a) A 60 minute diversion flight.

(b) If the maximum diversion time established for the aeroplane exceeds 60 minutes, a diversion flight of a duration equal to the maximum diversion time, but not exceeding 180 minutes.

(2) Aeroplane Flight Loads and Phases

(a) Loads on the aeroplane components should be determined by dynamic analysis. At the start of the windmill event, the aeroplane is assumed to be in level flight with a typical payload and realistic fuel loading. The speeds, altitudes, and flap configurations considered may be established according to the Aeroplane Flight Manual (AFM) procedures. The analysis should take into account unsteady aerodynamic characteristics and all significant structural degrees of freedom including rigid body modes. The vibration loads should be determined for the significant phases of the diversion profiles described in paragraphs 5c(1)(a) and (b) above.

(b) The significant phases are:
1 The initial phase during which the pilot establishes a cruise condition;
2 The cruise phase;
3 The descent phase; and
4 The approach to landing phase.

(c) The flight phases may be further divided to account for variation in aerodynamic and other parameters. The calculated loads parameters should include the accelerations needed to define the vibration environment for the systems and flight deck evaluations. A range of windmilling frequencies to account for variation in engine damage and ambient temperature should be considered.

(3) Strength Criteria

(a) The primary airframe structure should be designed to withstand the flight and windmilling vibration load combinations defined in paragraphs 1, 2, and 3 below.

1 The peak vibration loads for the flight phases in paragraphs 5c(2)(b)1 and 3 above, combined with appropriate 1g flight loads. These loads should be considered limit loads, and a factor of safety of 1.375 should be applied to obtain ultimate load.

2 The peak vibration loads for the approach to landing phase in paragraph 5c(2)(b)4 above, combined with appropriate loads resulting from a positive symmetrical balanced manoeuvring load factor of 1.15g. These loads should be considered as limit loads, and a factor of safety of 1.375 should be applied to obtain ultimate load.

3 The vibration loads for the cruise phase in paragraph 5c(2)(b)2 above, combined with appropriate 1g flight loads and 70 percent of the flight manoeuvre loads up to the maximum likely operational speed of the aeroplane. These loads are considered to be ultimate loads.

4 The vibration loads for the cruise phase in paragraph 5c(2)(b)2 above, combined with appropriate 1g flight loads and 40 percent of the limit gust velocity of CS 25.341 as specified at V_C (design cruising speed) up to the maximum likely operational speed of the aeroplane. These loads are considered to be ultimate loads.

(b) In selecting material strength properties for the static strength analyses, the requirements of CS 25.613 apply.

(4) Assessment of Structural Endurance

(a) Criteria for fatigue and damage tolerance evaluations of primary structure are summarised in Table 1 below. Both of the conditions described in paragraphs 5c(1)(a) and (b) above should be evaluated. Different levels of structural endurance capability are provided for these conditions. The criteria for the condition in paragraph 5c(1)(b) are set to ensure at least a 50 percent probability of preventing a structural component failure. The criteria for the condition in paragraph 5c(1)(a) are set to ensure at least a 95 percent probability of preventing a structural component failure. These criteria are consistent with the probability of occurrences for these events discussed in paragraph 5(c)(1) above.

(b) For multiple load path and crack arrest “fail-safe” structure, either a fatigue analysis per paragraph 1 below, or damage tolerance analysis per paragraph 2 below, may be performed to demonstrate structural endurance capability. For all other structure, the structural endurance capability should be demonstrated using only the damage tolerance approach of paragraph 2 below. The definitions of multiple load path and crack arrest "fail-safe" structure are the same as defined for use in showing compliance with CS 25.571, "Damage tolerance and fatigue evaluation of structure."

1 Fatigue Analysis. Where a fatigue analysis is used for substantiation of multiple load path “fail-safe” structure, the total fatigue damage accrued during the well phase and the windmilling phase should be considered. The analysis should be conducted considering the following:

(aa) For the well phase, the fatigue damage should be calculated using an approved load spectrum (such as used in satisfying the requirements of CS 25.571) for the durations specified in Table 1. Average material properties may be used.

(bb) For the windmilling phase, fatigue damage should be calculated for the diversion profiles using a diversion profile consistent with the AFM recommended operations, accounting for transient exposure to peak vibrations, as well as the more sustained exposures to vibrations. Average material properties may be used.

(cc) For each component, the accumulated fatigue damage specified in Table 1 should be shown to be less than or equal to the fatigue damage to failure of the component.

2 Damage Tolerance Analysis. Where a damage tolerance approach is used to establish the structural endurance, the aeroplane should be shown to have adequate residual strength during the specified diversion time. The extent of damage for residual strength should be established, considering growth from an initial flaw assumed present since the aeroplane was manufactured. Total flaw growth will be that occurring during the well phase, followed by growth during the windmilling phase. The analysis should be conducted considering the following:

(aa) The size of the initial flaw should be equivalent to a manufacturing quality flaw associated with a 95 percent probability of existence with 95 percent confidence (95/95).

(bb) For the well phase, crack growth should be calculated starting from the initial flaw defined in paragraph 5c(4)(b)2(aa) above, using an approved load spectrum (such as used in satisfying the requirements of CS 25.571) for the duration specified in Table 1. Average material properties may be used.

(cc) For the windmilling phase, crack growth should be calculated for the diversion profile starting from the crack length calculated in paragraph 5c(4)(b)2(bb) above. The diversion profile should be consistent with the AFM recommended operation accounting for transient exposure to peak vibrations as well as the more sustained exposures to vibrations. Average material properties may be used.

(dd) The residual strength for the structure with damage equal to the crack length calculated in paragraph 5c(4)(b)2(cc) above should be shown capable of sustaining the combined loading conditions defined in paragraph 5c(3)(a) above with a factor of safety of 1.0.

TABLE 1 - Fatigue and Damage Tolerance

	Condition	Paragraph 5c(1)(a)	Paragraph 5c(1)(b)
	Imbalance Design Fraction (IDF)	1.0	1.0
	Diversion time	A 60-minute diversion	The maximum expected diversion[6]
Fatigue Analysis[1,2] (average material properties)	Well phase	Damage for 1 DSG	Damage for 1 DSG
	Windmilling phase	Damage due to 60 minute diversion under a 1.0 IDF imbalance condition.	Damage due to the maximum expected diversion time[6] under a 1.0 IDF imbalance condition

	Criteria	Demonstrate no failure[7] under twice the total damage due to the well phase and the windmilling phase.	Demonstrate no failure[7] under the total damage (unfactored) due to the well phase and the windmilling phase.
Damage Tolerance[1,2] (average material properties)	Well phase	Manufacturing quality flaw[5] (MQF) grown for 1 DSG	Manufacturing quality flaw[5] (MQF) grown for 1/2 DSG
	Windmilling phase[3,4]	Additional crack growth for 60 minute diversion with an IDF = 1.0	Additional crack growth for the maximum diversion[6] with an IDF = 1.0
	Criteria	Positive margin of safety with residual strength loads specified in 5c(3)(a) for the final crack length	Positive margin of safety with residual strength loads specified in 5c(3)(a) for the final crack length

Notes:

1 *The analysis method that may be used is described in paragraph 5 (Evaluation of the Windmilling Imbalance Conditions) of this AMC.*

2 *Load spectrum to be used for the analysis is the same load spectrum qualified for use in showing compliance with CS 25.571, augmented with windmilling loads as appropriate.*

3 *Windmilling phase is to be demonstrated following application of the well phase spectrum loads.*

4 *The initial flaw for damage tolerance analysis of the windmilling phase need not be greater than the flaw size determined as the detectable flaw size plus growth under well phase spectrum loads for one inspection period for mandated inspections.*

5 *MQF is the manufacturing quality flaw associated with 95/95 probability of existence. (Reference - 'Verification of Methods For Damage Tolerance Evaluation of Aircraft Structures to FAA Requirements', Tom Swift FAA, 12th International Committee on Aeronautical Fatigue, 25 May 1983, Figures 42, and 43.)*

6 *Maximum diversion time for condition 5c(1)(b) is the maximum diversion time established for the aeroplane, but need not exceed 180 minutes. This condition should only be investigated if the diversion time established for the aeroplane exceeds 60 minutes.*

7 *The allowable cycles to failure may be used in the damage calculations.*

(5) Systems Integrity

(a) It should be shown that systems required for continued safe flight and landing after a blade-out event will withstand the vibratory environment defined for the windmilling conditions and diversion times described above. For this evaluation, the aeroplane is assumed to be dispatched in its normal configuration and condition. Additional conditions associated with the Master Minimum Equipment List (MMEL) need not be considered in combination with the blade-out event.

(b) The initial flight environmental conditions are assumed to be night, instrument meteorological conditions (IMC) en route to nearest alternate airport, and approach landing minimum of 300 feet and 3/4 mile or runway visual range (RVR) 4000m or better.

(6) Flight crew Response. For the windmilling condition described above, the degree of flight deck vibration shall not inhibit the flight crew's ability to continue to operate the aeroplane in a safe manner during all phases of flight.

d. Bearing/Bearing Support Failure. To evaluate these conditions, the low pressure (LP) rotor system should be analysed with each bearing removed, one at a time, with the initial imbalance consistent with the airborne vibration monitor (AVM) advisory level. The analysis should include the maximum operating LP rotor speed (assumed bearing failure speed), spool down, and windmilling speed regions. The effect of gravity, inlet steady air load, and significant rotor to stator rubs and gaps should be included. If the analysis or experience indicates that secondary damage such as additional mass loss, secondary bearing overload, permanent shaft deformation, or other structural changes affecting the system dynamics occur during the event, the model should be revised to account for these additional effects. The objective of the analyses is to show that the loads and vibrations produced by the bearing/bearing support failure event are less than those produced by the blade loss event across the same frequency range.

An alternative means of compliance is to conduct an assessment of the design by analogy with previous engines to demonstrate this type of failure is unlikely to occur. Previous engines should be of similar design and have accumulated a significant amount of flight hours with no adverse service experience.

e. Other failure conditions. If any other engine structural failure conditions applicable to the specific engine design, e.g. failure of a shaft, could result in more severe induced vibrations than the blade loss or bearing/bearing support failure condition, they should be evaluated.

6. ANALYSIS METHODOLOGY

a. Objective of the Methodology. The aeroplane response analysis for engine windmilling imbalance is a structural dynamic problem. The objective of the methodology is to develop acceptable analytical tools for conducting dynamic investigations of imbalance events. The goal of the windmilling analyses is to produce loads and accelerations suitable for structural, systems, and flight deck evaluations.

b. Scope of the Analysis. The analysis of the aeroplane and engine configuration should be sufficiently detailed to determine the windmilling loads and accelerations on the aeroplane. For aeroplane configurations where the windmilling loads and accelerations are shown not to be significant, the extent and depth of the analysis may be reduced accordingly.

c. Results of the Analysis. The windmilling analyses should provide loads and accelerations for all parts of the primary structure. The evaluation of equipment and human factors may require additional analyses or tests. For example, the analysis may need to produce floor vibration levels, and the human factors evaluation may require a test (or analysis) to subject the seat and the human subject to floor vibration.

7. MATHEMATICAL MODELLING

a. Components of the Integrated Dynamic Model. Aeroplane dynamic responses should be calculated with a complete integrated airframe and propulsion analytical model. The model should provide representative connections at the engine-to-pylon interfaces, as well as all interfaces between components (e.g., inlet-to-engine and engine-to-thrust reverser). The model should be to a similar level of detail to that used for certification flutter and dynamic gust analyses, except that it should also be capable of representing asymmetric responses. The model should be representative of the aeroplane to the highest windmilling frequency expected. The model consists of the following components:

(1) Airframe structural model,
(2) Propulsion structural model (including the engine model representing the engine type-design),
(3) Control system model,
(4) Aerodynamic model, and
(5) Forcing function and gyroscopic effects.

The airframe and engine manufacturers should mutually agree upon the definition of the integrated structural model, based on test and experience.

b. Airframe Structural Model. An airframe structural model is necessary in order to calculate the response at any point on the airframe due to the rotating imbalance of a windmilling engine. The airframe structural model should include the mass, stiffness, and damping of the complete airframe. A lumped mass and finite element beam representation is considered adequate to model the airframe. This type of modelling represents each airframe component, such as fuselage, empennage, and wings, as distributed lumped masses rigidly connected to weightless beams that incorporate the stiffness properties of the component. A full aeroplane model capable of representing asymmetric responses is necessary for the windmilling imbalance analyses. Appropriate detail should be included to ensure fidelity of the model at windmilling frequencies. A more detailed finite element model of the airframe may also be acceptable. Structural damping used in the windmilling analysis may be based on Ground Vibration Test (GVT) measured damping.

c. Propulsion Structural Model

(1) Engine manufacturers construct various types of dynamic models to determine loads and to perform dynamic analyses on the engine rotating components, its static structures and mounts. Dynamic engine models can range from a centreline two-dimensional (2D) model, to a centreline model with appropriate three-dimensional (3D) features such as mount and pylon, up to a full 3D finite element model (3D FEM). Any of these models can be run for either transient or steady state conditions.

(2) Propulsion structural models typically include the engine and all major components of the propulsion system, such as the nacelle intake, fan cowl doors, thrust reverser, common nozzle assembly, all structural casings, frames, bearing housings, rotors, and a representative pylon. Gyroscopic effects are included. The models provide for representative connections at the engine-to-pylon interfaces as well as all interfaces between components (e.g., inlet-to-engine and engine-to-thrust reverser). The engine that is generating the imbalance forces should be modelled in this level of detail, while the undamaged engines

that are operating normally need only to be modelled to represent their sympathetic response to the aeroplane windmilling condition.

(3) Features modelled specifically for blade loss windmilling analysis typically include fan imbalance, component failure and wear, rubs (blade to casing, and intershaft), and resulting stiffness changes. Manufacturers whose engines fail the rotor support structure by design during the blade loss event should also evaluate the effect of the loss of support on engine structural response during windmilling.

(4) Features that should be modelled specifically for bearing/bearing support failure windmilling events include the effects of gravity, inlet steady air loads, rotor to stator structure friction and gaps, and rotor eccentricity. Secondary damage should be accounted for, such as additional mass loss, overload of other bearings, permanent shaft deformation, or other structural changes affecting the system dynamics, occurring during rundown from maximum LP rotor speed and subsequent windmilling.

d. Control System Model. The automatic flight control system should be included in the analysis unless it can be shown to have an insignificant effect on the aeroplane response due to engine imbalance.

e. Aerodynamic Model. The aerodynamic forces can have a significant effect on the structural response characteristics of the airframe. While analysis with no aerodynamic forces may be conservative at most frequencies, this is not always the case. Therefore, a validated aerodynamic model should be used. The use of unsteady three-dimensional panel theory methods for incompressible or compressible flow, as appropriate, is recommended for modelling of the windmilling event. Interaction between aerodynamic surfaces and main surface aerodynamic loading due to control surface deflection should be considered where significant. The level of detail of the aerodynamic model should be supported by tests or previous experience with applications to similar configurations. Main and control surface aerodynamic derivatives should be adjusted by weighting factors in the aeroelastic response solutions. The weighting factors for steady flow (k=0) are usually obtained by comparing wind tunnel test results with theoretical data.

f. Forcing Function and Gyroscopic Forces. Engine gyroscopic forces and imbalance forcing function inputs should be considered. The imbalance forcing function should be calibrated to the results of the test performed under CS-E 810.

8. VALIDATION.

a. Range of Validation. The analytical model should be valid to the highest windmilling frequency expected.

b. Aeroplane Structural Dynamic Model. The measured ground vibration tests (GVT) normally conducted for compliance with CS 25.629 may be used to validate the analytical model throughout the windmilling range. These tests consist of a complete airframe and propulsion configuration subjected to vibratory forces imparted by electro-dynamic shakers.

(1) Although the forces applied in the ground vibration test are small compared to the windmilling forces, these tests yield reliable linear dynamic characteristics (structural modes) of the airframe and propulsion system combination. Furthermore, the windmilling forces are far less than would be required to induce non-linear behaviour of the structural

material (i.e. yielding). Therefore, a structural dynamic model that is validated by ground vibration test is considered appropriate for the windmilling analysis.

(2) The ground vibration test of the aeroplane may not necessarily provide sufficient information to assure that the transfer of the windmilling imbalance loads from the engine is accounted for correctly. The load transfer characteristics of the engine to airframe interface via the pylon should be validated by test and analysis correlation. In particular, the effect of the point of application of the load on the dynamic characteristics of the integrated model should be investigated in the ground vibration test by using multiple shaker locations.

(3) Structural damping values obtained in the ground vibration tests are considered conservative for application to windmilling dynamic response analysis. Application of higher values of damping consistent with the larger amplitudes associated with windmilling analysis should be justified.

c. Aerodynamic Model. The dynamic behaviour of the whole aeroplane in air at the structural frequency range associated with windmilling is normally validated by the flight flutter tests performed under CS 25.629.

d. Engine Model. The engine model covering the engine type-design will normally be validated by the Engine manufacturer under CS-E 520(c)(2) by correlation against blade-off test data obtained in showing compliance with CS-E 810. This is aimed at ensuring that the model accurately predicts initial blade release event loads, any rundown resonant response behaviour, frequencies, potential structural failure sequences, and general engine movements and displacements. In addition, if the Failure of a shaft, bearing or bearing support, results in higher forces being developed, such Failures and their resulting consequences should also be accurately represented.

9. HIGH POWER IMBALANCE CONDITION.

An imbalance condition equivalent to 50 percent of one blade at cruise rotor speed considered to last for 20 seconds may be assumed unless it is shown that the engine will respond automatically and spool down in a shorter period. It should be shown that attitude, airspeed, and altimeter indications will withstand the vibratory environment of the high power condition and operate accurately in that environment. Adequate cues should be available to determine which engine is damaged. Strength and structural endurance need not be considered for this condition.

AMC - SUBPART C –

12. Minor formatting changes to improve readability

13. Add AMC 25.361 to read as follows:

AMC 25.361
Engine and auxiliary power unit torque

CS 25.361(a)(1) is applicable to all engine installations, including turbo-fans, turbo-jets and turbo-propellers, except CS 25.361(a)(1)(iii) which applies only to turbo-propeller installations.

CS 25.361(a)(2)(i) - “Mean engine torque” refers to the value of the torque, for the specified condition, with any dynamic oscillations removed.

CS 25.361 (a)(3)(i) - Examples are; high power compressor surges, blade tip rub during manoeuvres, small and medium bird encounters, or combinations of these events.

CS 25.361(a)(3)(ii) and (b)(2) - As an example, the term “maximum acceleration” is taken to be that torque seen by the engine mounts under a runaway of the fuel metering unit up to its maximum flow stop.

14. Add AMC 25.362 to read as follows:

AMC 25.362
Engine Failure Loads

1. **PURPOSE**. This AMC describes an acceptable means for showing compliance with the requirements of CS 25.362 “Engine failure loads”. These means are intended to provide guidance to supplement the engineering and operational judgement that must form the basis of any compliance findings relative to the design of engine mounts, pylons and adjacent supporting airframe structure, for loads developed from the engine failure conditions described in CS 25.362.

2. **RELATED CS PARAGRAPHS.**

a. CS-25:

CS 25.361 “Engine and auxiliary power unit torque”
CS 25.901 “Powerplant installation”

b. CS-E:

CS-E 520 “Strength”
CS-E 800 “Bird strike and ingestion”
CS-E 810 “Compressor and turbine blade failure”
CS-E 850 “Compressor, Fan and Turbine Shafts”

3. **DEFINITIONS**. Some new terms have been defined for the transient engine failure conditions in order to present criteria in a precise and consistent manner in the following pages. In addition, some terms are employed from other fields and may not necessarily be in general use. For the purposes of this AMC, the following definitions should be used.

a. Adjacent supporting airframe structure: Those parts of the primary airframe that are directly affected by loads arising within the engine.

b. Ground Vibration Test: Ground resonance tests of the aeroplane normally conducted for compliance with CS 25.629, “Aeroelastic stability requirements.”

c. Transient failure loads: Those loads occurring from the time of the engine structural failure, up to the time at which the engine stops rotating or achieves a steady windmilling rotational speed.

d. Windmilling engine rotational speed: The speed at which the rotating shaft systems of an unpowered engine will rotate due to the flow of air into the engine as a result of the forward motion of the aeroplane.

4. **BACKGROUND**.

a. Requirements. CS 25.362 ("Engine failure loads") requires that the engine mounts, pylons, and adjacent supporting airframe structure be designed to withstand 1g flight loads combined with the transient dynamic loads resulting from each engine structural failure condition. The aim being to ensure that the aeroplane is capable of continued safe flight and landing after sudden engine stoppage or engine structural failure, including ensuing damage to other parts of the engine.

b. Engine failure loads. Turbine engines have experienced failure conditions that have resulted in sudden engine deceleration and, in some cases, seizures. These failure conditions are usually caused by internal structural failures or ingestion of foreign objects, such as birds or ice. Whatever the source, these conditions may produce significant structural loads on the engine, engine mounts, pylon, and adjacent supporting airframe structure. With the development of larger high-bypass ratio turbine engines, it became apparent that engine seizure torque loads alone did not adequately define the full loading imposed on the engine mounts, pylons, and adjacent supporting airframe structure. The progression to high-bypass ratio turbine engines of larger diameter and fewer blades with larger chords has increased the magnitude of the transient loads that can be produced during and following engine failures. Consequently, it is considered necessary that the applicant performs a dynamic analysis to ensure that representative loads are determined during and immediately following an engine failure event.

A dynamic model of the aircraft and engine configuration should be sufficiently detailed to characterise the transient loads for the engine mounts, pylons, and adjacent supporting airframe structure during the failure event and subsequent run down.

c. Engine structural failure conditions. Of all the applicable engine structural failure conditions, design and test experience have shown that the loss of a fan blade is likely to produce the most severe loads on the engine and airframe. Therefore, CS 25.362 requires that the transient dynamic loads from these blade failure conditions be considered when evaluating structural integrity of the engine mounts, pylons and adjacent supporting airframe structure. However, service history shows examples of other severe engine structural failures where the engine thrust-producing capability was lost, and the engine experienced extensive internal damage. For each specific engine design, the applicant should consider whether these types of failures are applicable, and if they present a more critical load condition than blade loss. In accordance with CS-E 520(c)(2), other structural failure conditions that should be considered in this respect are:

- failure of a shaft, or
- failure or loss of any bearing/bearing support, or
- a bird ingestion.

5. **EVALUATION OF TRANSIENT FAILURE CONDITIONS**

a. Evaluation. The applicant's evaluation should show that, from the moment of engine structural failure and during spool-down to the time of windmilling engine rotational speed, the engine-induced loads and vibrations will not cause failure of the engine mounts, pylon, and adjacent supporting airframe structure. (*Note*: The effects of continued rotation (windmilling) are described in AMC 25-24).

Major engine structural failure events are considered as ultimate load conditions, since they occur at a sufficiently infrequent rate. For design of the engine mounts and pylon, the ultimate loads may be taken without any additional multiplying factors. At the same time, protection of the basic airframe is assured by using a multiplying factor of 1.25 on those ultimate loads for the design of the adjacent supporting airframe structure.

b. Blade loss condition. The loads on the engine mounts, pylon, and adjacent supporting airframe structure should be determined by dynamic analysis. The analysis should take into account all significant structural degrees of freedom. The transient engine loads should be determined for the blade failure condition and rotor speed approved per CS-E, and over the full range of blade release angles to allow determination of the critical loads for all affected components.

The loads to be applied to the pylon and airframe are normally determined by the applicant based on the integrated model, which includes the validated engine model supplied by the engine manufacturer.

The calculation of transient dynamic loads should consider:

- the effects of the engine mounting station on the aeroplane (i.e., right side, left side, inboard position, etc.); and
- the most critical aeroplane mass distribution (i.e., fuel loading for wing-mounted engines and payload distribution for fuselage-mounted engines).

For calculation of the combined ultimate airframe loads, the 1g component should be associated with typical flight conditions.

c. Other failure conditions. As identified in paragraph 4(c) above, if any other engine structural failure conditions, applicable to the specific engine design, could result in higher loads being developed than the blade loss condition, they should be evaluated by dynamic analysis to a similar standard and using similar considerations to those described in paragraph 5.b., above.

6. **ANALYSIS METHODOLOGY**.

a. Objective of the methodology. The objective of the analysis methodology is to develop acceptable analytical tools for conducting investigations of dynamic engine structural failure events. The goal of the analysis is to produce loads and accelerations suitable for evaluations of structural integrity. However, where required for compliance with CS 25.901 ("Powerplant installation"), loads and accelerations may also need to be produced for evaluating the continued function of aircraft systems, including those related to the engine installation that are essential for immediate flight safety (for example, fire bottles and fuel shut off valves).

b. Scope of the analysis. The analysis of the aircraft and engine configuration should be sufficiently detailed to determine the transient and steady-state loads for the engine mounts, pylon, and adjacent supporting airframe structure during the engine failure event and subsequent run-down.

7. MATHEMATICAL MODELLING AND VALIDATION

a. Components of the integrated dynamics model. The applicant should calculate airframe dynamic responses with an integrated model of the engine, engine mounts, pylon, and adjacent supporting airframe structure. The model should provide representative connections at the engine-to-pylon interfaces, as well as all interfaces between components (e.g., inlet-to-engine and engine-to-thrust reverser). The integrated dynamic model used for engine structural failure analyses should be representative of the aeroplane to the highest frequency needed to accurately represent the transient response. The integrated dynamic model consists of the following components that must be validated:

- Airframe structural model.
- Propulsion structural model (including the engine model representing the engine type-design).

b. Airframe Structural Model and Validation

(1) An analytical model of the airframe is necessary in order to calculate the airframe responses due to the transient forces produced by the engine failure event. The airframe manufacturers currently use reduced lumped mass finite element analytical models of the airframe for certification of aeroelastic stability (flutter) and dynamic loads. A typical model consists of relatively few lumped masses connected by weightless beams. A full aeroplane model is not usually necessary for the engine failure analysis, and it is normally not necessary to consider the whole aircraft response, the effects of automatic flight control systems, or unsteady aerodynamics.

(2) A lumped mass beam model of the airframe, similar to that normally used for flutter analysis, is acceptable for frequency response analyses due to engine structural failure conditions. However, additional detail may be needed to ensure adequate fidelity for the engine structural failure frequency range. In particular, the engine structural failure analysis requires calculating the response of the airframe at higher frequencies than are usually needed to obtain accurate results for the other loads analyses, such as dynamic gust and landing impact. The applicant should use finite element models as necessary. As far as possible, the ground vibration tests normally conducted for compliance with CS 25.629 (“Aeroelastic stability requirements”) should be used to validate the analytical model.

(3) Structural dynamic models include damping properties, as well as representations of mass and stiffness distributions. In the absence of better information, it will normally be acceptable to assume a value of 0.03 (i.e., 1.5% equivalent critical viscous damping) for all flexible modes. Structural damping may be increased over the 0.03 value to be consistent with the high structural response levels caused by extreme failure loads, provided it is justified.

c. Propulsion Structural Model and Validation

For propulsion structural model and validation, see AMC 25-24.

AMC - SUBPART D -

15. Correct AMC 25.703 as follows:

AMC 25.703 Take-off configuration Warning Systems

…

5. DISCUSSION

a. Regulatory Basis

(1) CS 25.703, "Takeoff warning system," requires that a take-off configuration warning system be installed in large aeroplanes. This requirement was introduced with JAR25 Amendment 5 effective 1.1.79. On the FAR side, this was added to FAR Part 25 by Amendment 25-42 effective on March 1, 1978. CS 25.703 requires that a takeoff warning system be installed and provide an aural warning to the flight crew during the initial portion of the take off roll, whenever the aeroplane is not in a configuration which would allow a safe takeoff.
The intent of this rule is to require that the takeoff configuration warning system cover (a) only those configurations of the required systems which would be unsafe, and (b) the effects of system failures resulting in wrong surface or system functions if there is not a separate and adequate warning already provided. According to the preamble of FAR Part 25 Amendment 25-42, the takeoff warning system should serve as "backup for the checklist, particularly in unusual situations, e.g., where the checklist is interrupted or the takeoff delayed." Conditions for which warnings are required include wing flaps or leading edge devices not within the approved range of takeoff positions, and wing spoilers (except lateral control spoilers meeting the requirements of CS 25.671), speed brakes, parking brakes, or longitudinal trim devices in a position that would not allow a safe takeoff. Consideration should also be given to adding rudder trim and aileron (roll) trim if these devices can be placed in a position that would not allow a safe takeoff.

(2) Prior to ~~CS~~ JAR-25 Amendment 5 and FAR Part 25 Amendment 25-42, there was no requirement for a takeoff configuration warning system to be installed in large aeroplanes….”

16. Correct AMC 25.735 as follows:

AMC 25.735 Brakes and Braking Systems Certification Tests and Analysis

[…]

2. RELATED REGULATORY MATERIAL AND COMPLEMENTARY DOCUMENTS

a. Related EASA Certification Specifications

Part-21 and CS-25 paragraphs (and their associated AMC material where applicable) that prescribe requirements related to the design substantiation and certification of brakes and braking systems include:

21A.303 Compliance with applicable requirements
CS 25.101 General
CS 25.109 Accelerate-stop distance
CS 25.125 Landing
CS 25.301 Loads

CS 25.303 Factor of safety
CS 25.729 Retracting mechanism
CS 25.733 Tyres
CS 25.1301 Function and installation
CS 25.1309 Equipment, systems and installations
CS 25.1322 Warning, caution and advisory lights
CS 25.1501 General: Systems and Equipment Limitations
~~CS 25.1524 Systems and equipment limitations~~
CS 25.1541 Markings and Placards: General
CS 25.1591 Supplementary performance information
…"

17. Correct AMC 25.783 as follows:

AMC 25.783 Fuselage doors

…

5. DISCUSSION OF THE CURRENT REQUIREMENTS.

…

CS 25.783(b) Opening by persons
There must be means to safeguard each door against opening during flight due to inadvertent action by persons.
The door should have inherent design features that achieve this objective. It is not considered acceptable to rely solely on cabin pressure to prevent inadvertent opening of doors during flight, because there have been instances where doors have opened during unpressurised flight, such as during landing. Therefore all doors should incorporate features to prevent the door from being opened
inadvertently by persons on board.

In addition, for each door that could be a hazard, design precautions must be taken to minimise the possibility for a person to open a door intentionally during flight. If these precautions include the use of auxiliary devices, those devices and their controlling systems must be designed so that:

(i) no single failure will prevent more than one exit from being opened, and

(ii) failures that would prevent opening of any exit after landing are improbable

…"

18. Amend AMC 25.857 as follows:

AMC 25.855 and 25.857
~~Cargo Compartment Classification~~ Cargo or baggage compartments

1. PURPOSE

This Acceptable Means of Compliance (AMC) sets forth an acceptable means, but not the only means, of demonstrating compliance with the provisions of the airworthiness standards for Class B and Class F cargo compartments for large aeroplanes. This AMC provides a rational method for demonstrating that the requirements of the related paragraphs of CS-25 are met and that fires occurring in the compartments can be controlled to ensure that they do not present a hazard to the aeroplane or its occupants. Like all AMC material, this AMC is not, in itself, mandatory and does not constitute a requirement. Terms used in this AMC, such as "shall" and "must," are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used.

2. RELATED DOCUMENTS

a. Certification Specifications.

CS 25.851 Fire extinguishers
CS 25.855 Cargo or baggage compartments
CS 25.857 Cargo compartment classification
CS 25.858 Cargo compartment fire detection systems

b. FAA Advisory Circulars (AC).

~~Relevant part of the FAA Advisory Circular~~ The following FAA Advisory Circulars are accepted by the Agency as providing acceptable means of compliance with CS 25.857:

AC 25-17, Transport Airplane Cabin Interiors Crashworthiness Handbook~~, dated 15/7/91~~ (relevant parts addressing the applicable FAR Part 25/CS-25 paragraphs)
AC 25-9A, Smoke Detection, Penetration, and Evacuation Tests and related Flight Manual Emergency Procedures~~, dated 6/1/94~~
AC 25-18, Transport Category Airplanes Modified for Cargo Service~~, dated 6/1/94~~
~~are accepted by the Agency as providing acceptable means of compliance with CS 25.857~~.
AC 20-42C, Hand Fire Extinguishers for use in Aircraft
AC 25-22, Certification of Transport Airplane Mechanical Systems

FAA Order 8150.4, Certification of Cargo Containers with Self-Contained Temperature Control Systems (Active ULDs)

3. BACKGROUND

CS 25.857(b) and 25.857(f) provide standards for certification of two classes of cargo compartments, Class B and Class F.

A Class B cargo compartment is configured in a manner that allows a crewmember to extinguish or control any fire likely to occur in the compartment using a hand fire extinguisher. While the person combating the fire must have access to the compartment, it must not be necessary for that person to physically enter the compartment to extinguish the fire (see CS 25.857 (b)(1)). The contents of the compartment may be reached by hand or with the contents of a hand extinguisher while standing in the entry door.

A Class F cargo compartment is similar to a Class C compartment in that there are means to extinguish or control the fire without any requirement to enter the compartment.

Both Class B and Class F cargo compartments have fire or smoke detection systems to alert the crew to the presence of the fire.

4. COMPARTMENT CLASSIFICATION

All cargo compartments must be properly classified in accordance with CS 25.857 and meet the requirements of CS 25.857 pertaining to the particular class involved (see CS 25.855 (a)).

In order to establish appropriate requirements for fire protection, a system for classification of cargo or baggage compartments was developed and adopted for large aeroplanes.

Classes A, B, and C were initially established; Classes D, E, and F were added later. Class D has been eliminated from the CS-25 specifications (by Amdt 3). The classification is based on the means by which a fire can be detected and the means available to control the fire.

a. A Class A compartment (see CS 25.857(a)) is one that is located so close to the station of a crewmember that the crewmember would discover the presence of a fire immediately. In addition, each part of the compartment is easily accessible so that the crewmember could quickly extinguish a fire with a portable fire extinguisher. A Class A compartment is not required to have a liner.

b. A Class B compartment (see CS 25.857(b)) is one that is more remote than a Class A compartment and must, therefore, incorporate a fire or smoke detection system to give warning at the pilot or flight engineer station. Because a fire would not be detected and extinguished as quickly as in a Class A compartment, a Class B compartment must have a liner in accordance with CS 25.855 (b). In flight, a crewmember must have sufficient access to a Class B compartment to reach any part of the compartment by hand or with the contents of a hand extinguisher when standing at any one access point, without stepping into the compartment. There are means to ensure that, while the access provisions are being used, no hazardous quantity of smoke, flames, or extinguishing agent will enter areas occupied by the crew or passengers.

c. A Class C compartment (see CS 25.857(c)) differs from a Class B compartment in that it is not required to be accessible in flight and must, therefore, have a built-in fire extinguishing system to suppress or control any fire. A Class C compartment must have a liner and a fire or smoke detection system in accordance with CS 25.855 (b) and CS 25.857(c)(1). There must also be means to exclude hazardous quantities of extinguishant and products of combustion from occupied areas (see CS 25.857(c)(3)).

d. A Class E compartment (see CS 25.857(e)) is found on an all-cargo aeroplane. Typically, a Class E compartment is the entire cabin of an all-cargo aeroplane; however, other compartments of such aeroplanes may be also classified as Class E compartments. Shutting off the ventilating airflow to or within the compartment controls a fire in a Class E compartment. A Class E compartment must have a liner (see CS 25.855 (b)) and a fire or smoke detection system installed in accordance with CS 25.857(e)(2). It is not required to have a built-in fire suppression system.

e. A Class F compartment (see CS 25.857 (f)) is one in which there are means to control or extinguish a fire without requiring a crewmember to enter the compartment. Allowing access by a crewmember in the presence of a fire warning is not envisioned. Class F compartments that include a built-in fire extinguisher/suppression system or require the use of acceptable fire containment covers (FCCs) would meet these requirements. The Class F compartment must have a fire or smoke detection system installed in accordance with CS 25.857(f)(1). Unless there are other means of containing the fire and protecting critical systems and structure, a Class F compartment must have a liner meeting the requirements of part III of Appendix F , or other approved equivalent methods (see CS 25.855 (b)).

It is not envisaged that lower deck cargo compartments be approved as Class F cargo compartments. The Class F cargo compartment was introduced as a practicable and safe alternative to the previous practice of providing large Class B cargo compartments. These latter compartments were limited to the main deck for accessibility reasons. Lower deck cargo compartments in aircraft carrying passengers need to comply with the Class C cargo compartment requirements of CS25.857(c).

5. FIRE PROTECTION FEATURES

Based on the class of the compartment, fire protection features must be provided. The fire protection features must be shown to meet the standards established by the original type certification basis for the aeroplane or later CS-25 standards. These features may include liners, fire or smoke detection systems, hand fire extinguishers, and built-in fire suppression systems.

a. Liners

The primary purpose of a liner is to prevent a fire originating in a cargo compartment from spreading to other parts of the aeroplane before it can be brought under control. For Class B compartments, it is assumed that the fire will be quickly extinguished. Therefore, the liner does not need to be qualified to the requirements of Part III of Appendix F. For Class F cargo compartments, the fire might have grown larger prior to being suppressed, and therefore, better protection is needed to prevent damage to surrounding systems and structure. However, the liner does not need to serve as the compartment seal. It should be noted, however, that the liner is frequently used to perform the secondary functions of containing discharged extinguishing agent and controlling the flow of oxygen into the compartment. If other means, such as compartment walls, are not capable of performing those functions, the liner must be sufficiently airtight to perform them.

The liner must have sufficient fire integrity to prevent flames from burning through the liner before the fire can be brought under control and the heat from the fire is sufficiently dissipated. As stated in Part III of Appendix F, in addition to the basic liner material, the term "liner" includes any design feature, such as a joint or fastener that would affect the capability of the liner to safely contain a fire.

b. Access

(1) Class B. Class B compartments must provide sufficient accessibility to enable a crewmember to reach any part of the compartment by hand or with the contents of a hand extinguisher without physically entering the compartment. This requirement, by its nature, tends to limit the size and shape of the compartment. Additionally, the access provisions should be sufficiently large to enable the crewmember to determine visually that a fire has been extinguished. Access is also a function of how the compartment is configured rather than just dimension and/or volume. In determining access, it would not be acceptable for there to be a need to pull baggage or cargo on to the floor of the passenger compartment to gain access

to the seat of the fire. Such action may introduce a safety hazard to the passengers.

"To reach any part of the compartment" means that the crewmember should be able to open the door or hatch and, standing in the opening, reach by hand anywhere in the compartment where cargo or baggage can be located. The extension of the crewmember's reach through the use of fire extinguisher wands, etc., should not be considered in determining reach.

Based on the estimated reach of a 95 percentile male, the outline of any compartment, viewed from above, should fit within a vertical cylinder of radius 132 cm (52 inches) measured from the centreline of the access door or hatch (see Figure 1). This dimension assumes the above male can reach a one foot square box located anywhere within the compartment. Access by a smaller crewmember to reach the same area within the compartment could require that the crewmember move laterally within the access door or hatch opening, while not physically entering the compartment.

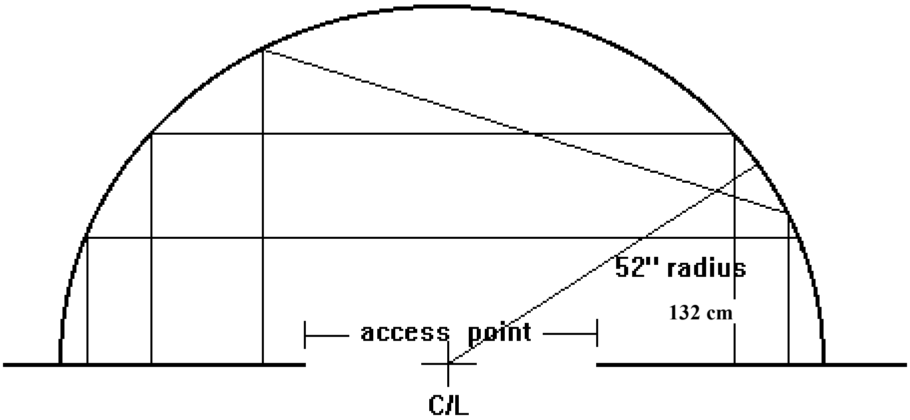

Figure 1
Example of possible cargo compartment shapes within 132 cm (52 inches) reach from access point centreline.

(2) *Class F.* In the case of a Class F compartment, a means should be provided to control or extinguish a fire without a crewmember entering the compartment.

One means is to design the compartment to Class C requirements but not include a built-in fire suppression system. One suppression method might be to utilize a plumbing and nozzle distribution system within the compartment that would provide acceptable suppression capability throughout the volume of the compartment. The source for such a system could be hand fire extinguishers, which interface with the distribution system through a suitable interface nozzle. This reduces the complexity and costs associated with a built-in suppression system and could be suitable for smaller compartments. For certification purposes, the extinguishing agent concentration should be measured in flight, following aeroplane flight manual (AFM) procedures, and the length of protection time afforded by the system should be recorded. This time of protection should be used to establish AFM limitations for cargo or baggage compartment fire protection times. The operator, for route planning, could then use these times. For Halon 1301 fire extinguishing agent, a minimum five percent concentration by volume at all points in the compartment is considered adequate for initial knock-down of a fire, and a three percent concentration by volume at all points in the compartment is considered the minimum for controlling a fire after it is knocked down. This option requires the use of a liner as stated in CS 25.855 (b).

Another means of providing fire protection in a Class F compartment might be the use of cargo containers or fire containment covers (FCCs) shown to be capable of containing a fire. Some FCCs have already been developed and are typically constructed of woven fibreglass-based materials that will pass the oil burner test requirements of Part III of Appendix F.

This is in line with the revised CS 25.855 which for a Class F cargo or baggage compartment not using FCCs requires a ceiling and sidewall liner constructed of materials that meet the requirements of Part III of Appendix F and be separated from the aeroplane structure (except for attachments), while the floor panels must comply with Part I of Appendix F.

Similarly, if FCCs are proposed as a means of compliance for the new Class F compartment, it is likely that in order to meet the intent they must also meet these standards (i.e. Part III of Appendix F for the sides and top and Part I of Appendix F for the bottom). However, based on full scale qualification testing there is evidence that alternative materials, not fully in compliance with Part III of Appendix F, might also be acceptable for FCC side and top portions, as long as they are successfully tested and meet the intent of the rule.

It is recommended that the Agency be contacted for concurrence when FCC or Container qualification is envisaged in order to address the relevant test method.

Unless evidence can be presented to support a different design, if FCCs are used as a means of compliance, they should completely surround all cargo, including underneath the cargo, except for obviously non-flammable items, such as metal stock, machinery, and non-flammable fluids without flammable packaging. Because the fire is controlled or extinguished within the isolated compartment, but is separated from the actual cargo compartment boundaries, the cargo compartment liner requirements of CS 25.855(c) would not apply. However, the effects of the heat generated by the contained/covered fire should be evaluated to ensure that adjacent systems and structure are not adversely affected. For certification purposes, test data with the actual design configuration and possible fire sources would have to be provided. The temperature and heat load time history measurements at various locations above, around and below the FCC are needed to ensure the continued safe function of adjacent systems and structure. The time history data should be used to establish the length of protection time afforded by the system and subsequent AFM limitations for cargo or baggage compartment fire protection times. The operator would then use these times for route planning purposes.

Class F cargo compartment designs which rely on fire containment, e.g. fire hardened containers/pallets and/or FCCs (placed over palletised loads or non-fire hardened containers) should be considered in regards to the possibility of incorrect usage.
All practicable means to prevent the carriage of cargo in standard containers or pallets (if special pallets are required) and/or the omission of FCCs should be incorporated. Means may include, but not be limited to, physical features at the container/pallet to cargo compartment floor interface or operational procedures such as requiring aircraft crew verification of cargo loading before every flight or a suitable detection system that would warn the crew in the event a non authorized cargo configuration has been loaded.

c. Extinguishing Agent.

In order to effectively extinguish or control a fire in a Class B or F cargo or baggage compartment, sufficient fire extinguishing agent must be allocated. Guidance on this topic has been contained in FAA AC 20-42C. This guidance material is accepted by the Agency as addressing how to implement the provisions of CS 25.851(a) that require that at least one hand fire extinguisher be located in the pilot compartment, at least one readily accessible hand fire extinguisher be available for use in each Class A or Class B cargo/baggage compartment and in each accessible Class E or Class F cargo/baggage compartment, and one or more hand fire extinguishers be located in the passenger compartment for aeroplanes with a passenger seating capacity of 7 or more.

d. Fire Control.

"To control a fire" (CS 25.857(f)(2)) implies that the fire does not grow to a state where damage to the aeroplane or harm to the passengers or crew occurs during the time for which the fire protection system is demonstrated to be effective (ie, from the time a fire is detected to the time when an emergency evacuation from the aeroplane can be completed). This in turn implies that critical aeroplane systems and structure are not adversely affected and the temperature and air contaminants in areas occupied by passengers and crew do not reach hazardous levels.

(1) Adequate protection should be provided for cockpit voice and flight data recorder and wiring, windows, primary flight controls (unless it can be shown that a fire cannot cause jamming or loss of control), and other systems and equipment within the compartment that are required for safe flight and landing.

(2) Regardless of a compartment's classification, it must be demonstrated that hazardous quantities of smoke, flames, extinguishing agent, or noxious gases do not enter any compartment occupied by passengers or crewmembers. FAA Advisory Circular 25-9A, Smoke Detection, Penetration, and Evacuation Tests and Related Flight Manual Emergency Procedures, provides guidance concerning smoke penetration testing.

(3) If an aeroplane has one or more Class B cargo compartments, portable protective breathing equipment must be provided for the appropriate crewmembers in accordance with CS 25.1439.

(4) Additional protective breathing equipment or breathing gas supply, and additional fire extinguishers, may be required for Class B cargo compartment operation to ensure that the fire can be controlled for the time the aeroplane is expected to be in the air after onset of a fire.

6. <u>PROCEDURES AND LIMITATIONS</u>

a. To ensure that the contents of Class B and F compartments are either accessible or located such as to allow firefighting, any cargo or baggage loading limitations and any operational limitations or procedures provided must be identified with placards in the compartment. The loading and operational limitations must also be addressed in the appropriate weight and balance or loading document.

b. Any operational limitations or procedures necessary to ensure the effectiveness of the fire protection system for Class B and Class F cargo and baggage compartments should be clearly defined in the AFM. This should include such items as any changes to the ventilation system to prevent the entrance of smoke or gases into occupied areas, use of hand fire extinguishers, use of protective breathing equipment, use of protective clothing, and use of the FCCs. The certification engineers should work closely with the Agency to ensure that additional training necessary for crewmembers assigned to combat fires is adequately addressed.

c. Any time limit for a cargo or baggage compartment fire protection system, or other conditions or procedures related to combating a fire in a compartment, should be clearly defined in the AFM.

7. AFM CONSIDERATIONS.

a. Crewmember(s) designated to combat a fire in a Class B compartment will need special training. Fires occurring in luggage are difficult to extinguish completely and rekindling may occur. Crewmembers designated to combat fires in Class B compartments should be trained to check periodically to ensure that a fire has not grown back to hazardous proportions.

b. Aeroplane flight manuals should contain instructions to land at the nearest suitable airport following smoke/fire detection, unless it can be positively determined that the fire is extinguished.

c. Any limitations regarding occupancy of Class B and Class F compartments during flight, or during takeoff and landing, should be defined in the AFM.

d. Any loading restrictions associated with access to cargo or baggage or special containers should be clearly identified in the AFM. This would include, but not be limited to, placement of luggage in a Class B compartment or identification of special containers or covers associated with fire protection in a Class F compartment. If covers are used in conjunction with a Class F cargo compartment, they should be easy to install and sufficiently durable to withstand in-service conditions.

AMC – SUBPART E

19. Delete existing AMC 25.981:

…

“~~AMC 25.981 Fuel Tank Temperature~~

~~FAA Advisory Circular 25.981-1A, Guidelines For Substantiating Compliance With The Fuel Tank Temperature Requirements, dated 20/01/71, is accepted by the Agency as providing acceptable means of compliance with CS 25.981.~~”

AMC – SUBPART F

20. Correct AMC 25.1309 to read as follows:

AMC 25.1309 System Design and Analysis
…
6. BACKGROUND
…
b. Fail-Safe Design Concept.

The ~~Part~~ CS-25 airworthiness standards are based on, and incorporate, the objectives and principles or techniques of the fail-safe design concept, which considers the effects of failures and combinations of failures in defining a safe design."