CS-25 Amendment 21 — Change Information

EASA 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: 25/21]' 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 (NPAs) has been used to show the changes:

(a) deleted text is marked with ~~strike through~~;

(b) new or amended text is highlighted in grey;

(c) an ellipsis (…) indicates that the remaining text is unchanged in front of or following the reflected amendment.

BOOK 1

SUBPART B — FLIGHT

<u>Amend CS 25.143 as follows:</u>

CS 25.143 General
(See AMC 25.143)

(a) (See AMC 25.143(a) and (b)) The aeroplane must be safely controllable and manoeuvrable during:~~–~~

(1) ~~T~~take-off;
(2) ~~C~~climb;
(3) ~~L~~level flight;
(4) ~~D~~descent; ~~and~~
(5) ~~Landing~~ approach and go-around; and~~.~~
(6) approach and landing.

(b) (See AMC 25.143(b) and (b)) It must be possible to make a smooth transition from one flight condition to any other flight condition without exceptional piloting skill, alertness, or strength, and without danger of exceeding the aeroplane limit-load factor under any probable operating conditions, including: ~~–~~

(1) The sudden failure of the critical engine~~.~~; (See AMC 25.143(b)(1))

(2) For aeroplanes with three or more engines, the sudden failure of the second critical engine when the aeroplane is in the en route, approach, go-around, or landing configuration and is trimmed with the critical engine inoperative; ~~and~~

(3) Configuration changes, including deployment or retraction of deceleration devices~~.~~; and

(4) Go-around manoeuvres with all engines operating. The assessment must include, in addition to controllability and manoeuvrability aspects, the flight crew workload and the risk of a somatogravic illusion. (See AMC 25.143(b)(4))

<u>Amend CS 25.145 as follows</u>:

CS 25.145 Longitudinal control
(See AMC 25.145)

(a) (See AMC 25.145(a)) It must be possible at any point between the trim speed prescribed in CS 25.103(b)(6) and stall identification (as defined in CS 25.201(d)), to pitch the nose downward so that the acceleration to this selected trim speed is prompt with: –

(1) ~~T~~the aeroplane trimmed at the trim speed prescribed in CS 25.103(b)(6);

(2) ~~T~~the most critical landing gear ~~extended~~ configuration;

(3) ~~T~~the wing-flaps (i) retracted and (ii) extended; and

(4) engine thrust or ~~P~~power (i) off and (ii) at go-around setting ~~maximum continuous power on the engines~~.

(…)

(f) It must be possible to maintain adequate longitudinal and speed control under the following conditions without exceptional piloting skill, alertness, or strength, without danger of exceeding the aeroplane limit-load factor and while maintaining an adequate stall margin throughout the manoeuvre:

(1) Starting with the aeroplane in each approved approach and landing configuration, trimmed longitudinally and with the thrust or power setting per CS 25.161(c)(2), perform a go-around, transition to the next flight phase and level off at the desired altitude:

(i) with all engines operating and the thrust or power controls moved to the go-around power or thrust setting;

(ii) with the configuration changes, as per the approved operating procedures or conventional operating practices; and

(iii) with any practicable combination of Flight Guidance/Autothrust-throttle/Autopilot to be approved, including manual.

(2) Reasonably expected variations in service from the established approach, landing and go-around procedures for the operation of the aeroplane must not result in unsafe flight characteristics during the go-around.

SUBPART C — STRUCTURE

Amend CS 25.562(b) as follows:

CS 25.562 Emergency landing dynamic conditions
(See AMC 25.562)
(…)
(b) ~~With the exception of flight deck crew seats, e~~Each seat type design approved for occupancy must successfully complete dynamic tests or be demonstrated by rational analysis based on dynamic tests of a similar ~~type~~ seat type, in accordance with each of the following emergency landing conditions. The tests must be conducted with an occupant simulated by a 77 kg (170 lb) anthropomorphic test dummy sitting in the normal upright position:

(…)

(2) A change in forward longitudinal velocity (Δv) of not less than 13·4 m/s ~~,~~ (44 ft/s) with the aeroplane's longitudinal axis horizontal and yawed 10 degrees either right or left, whichever would cause the greatest likelihood of the upper torso restraint system (where installed) moving off the occupant's shoulder, and with the wings level. Peak floor deceleration must occur in not more than 0.09 seconds after impact and must reach a minimum of 16 g. With the exception of flight deck crew seats that are mounted in the forward conical area of the fuselage, ~~W~~where floor rails or floor fittings are used to attach the seating devices to the test

fixture, the rails or fittings must be misaligned with respect to the adjacent set of rails or fittings by at least 10 degrees vertically (i.e. out of parallel) with one rolled 10 degrees.

SUBPART E – POWERPLANT

Amend CS 25.975 as follows:

CS 25.975 Fuel tank vents
(See AMC 25.975)

(a) *Fuel tank vents*.

(…)

(5) There may be no point in any vent line where moisture can accumulate with the aeroplane in the ground attitude or the level flight attitude, unless drainage is provided; ~~and~~

(6) No vent or drainage provision may end at any point: **–**

(i) Where the discharge of fuel from the vent outlet would constitute a fire hazard; or

(ii) From which fumes could enter personnel compartments~~.~~; and

(7) Each fuel tank vent system must prevent explosions, for a minimum of 2 minutes and 30 seconds, caused by the propagation of flames from outside the tank through the fuel tank vents into the fuel tank vapour spaces when any fuel tank vent is continuously exposed to flames. (See AMC 25.975(a)(7))

Amend CS 25.1193 as follows:

CS 25.1193 Cowling and nacelle skin

(See AMC 25.1193)

(…)

(e) Each aeroplane must: -

(…)

(4) Be designed and constructed to minimise the likelihood of any in-flight opening or loss of a cowling that could prevent continued safe flight and landing.

(f) The retention system of each removable or openable cowling must:

(1) keep the cowling closed and secured under the operational loads identified in subparagraph (a) of this paragraph following either of the following conditions:

(i) improper fastening of any single latching, locking, or other retention device, or

(ii) the failure of any single latch or hinge.

(2) have readily accessible means to close and secure the cowling that do not require excessive force or manual dexterity; and

(3) have a reliable means for effectively verifying that the cowling is secured prior to each take-off.

SUBPART F – EQUIPMENT

Amend CS 25.1303(a)(3) as follows:

CS 25.1303 Flight and navigation instruments

(See AMC 25.1303)

(a) The following flight and navigation instruments must be installed so that the instruments ~~is~~are visible from each pilot station:

(…)

(3) A magnetic direction indicator ~~(non-stabilised magnetic compass)~~.

(...)

Amend CS 25.1441(b) as follows:

CS 25.1441 Oxygen equipment and supply

(See AMC 25.1441)

(…)

(b) The oxygen system must be free from hazards in itself, in its method of operation, and in its effect upon other components. (See AMC 25.1441(b))

SUBPART G – OPERATING LIMITATIONS AND INFORMATION

Amend CS 25.1535 as follows:

CS 25.1535 ETOPS Design approval

~~To determine~~ For an ~~aircraft~~ aeroplane configuration to be capable of ETOPS, the following ~~must be complied with~~ are required:

(a) Compl~~y~~iance with the requirements of CS-25 considering the maximum flight duration and the longest diversion time for which approval is being sought.

(b) For Early ETOPS, approval of the engine for ETOPS capability in compliance with CS-E 1040.

(~~b~~c) Consideration must have been given to the crew workload and operational implications and the ~~flight~~ crew's and passengers' physiological needs during continued operations with failure effects for the longest diversion time for which approval is being sought.

(~~c~~d) ~~Establish~~ The appropriate capability and limitations must have been established. (See AMC 20-6.)

Amend CS 25.1587 as follows:

CS 25.1587 Performance information

(See AMC 25.1587)

(…)

(c) Each aeroplane flight manual (AFM) must contain the performance information associated with abnormal landing configurations (see AMC 25.1587(c)).

APPENDICES

Amend Appendix Q as follows:

Appendix Q

Additional airworthiness requirements for approval of a Steep Approach Landing (SAL) capability

(See AMC to Appendix Q)

(…)

(SAL) 25.5 Safe operational and flight characteristics

(…)

(b) For conditions (a)(1), (a)(2), and (a)(3):

(1~~i~~) The demonstration must be conducted at the most critical weight and centre of gravity, either with all-engines-operating or with the critical engine inoperative, as appropriate;

(2~~ii~~) The rate of descent must be reduced to 3 feet per second or less before touchdown;

(3~~iii~~) Below a height of 200 ft no action shall be taken to increase power or thrust apart from those small changes which are necessary to maintain an accurate approach;

(4~~iv~~) No nose depression by use of longitudinal control shall be made after initiating the flare other than those small changes necessary to maintain a continuous and consistent flare flight path; and

(5~~v~~) The flare, touchdown and landing may not require exceptional piloting skill or alertness.

(c) For conditions (a)(1) and (a)(3), the flare must not be initiated above the screen height.

(d) For condition (a)(2), it must be possible to achieve an approach path angle 2° steeper than the selected approach path angle in all configurations which exist down to the initiation of the flare, which must not occur above 150 % of the screen height. The flare technique used must be substantially unchanged from that recommended for use at the selected approach path angle.

(e) All-engines-operating steep approach.

It must be demonstrated that the aeroplane can safely transition from the all-engines-operating steep landing approach to:

(1) the all-engines-operating go-around as per standard procedure; and

(2) the one-engine-inoperative approach climb configuration with one engine having been made inoperative, for the following conditions:

(~~1~~i) te selected steep approach angle

(~~2~~ii) an approach speed of $V_{REF(SAL)}$

(~~3~~iii) the most critical weight and centre of gravity, and

(~~4~~iv) for propeller-powered aeroplanes, the propeller of the inoperative engine shall be at the position it automatically assumes following an engine failure at high power.

(…)

Amend Appendix S as follows:

Appendix S

Airworthiness requirements for non-commercially operated aeroplanes and low-occupancy aeroplanes

(…)

S25.60 Security

Non-commercially operated aeroplanes do not need to comply with the security specifications of CS 25.795(b), (c) and (d).

BOOK 2

AMC – SUBPART B

Amend AMC 25.21(g) as follows:

AMC 25.21(g)
Performance and Handling Characteristics in Icing Conditions

(…)

4.1.1 Operating rules for commercial operation of large aeroplanes (e.g. ~~EU-OPS 1.345~~Part-CAT[1], CAT.OP.MPA.250) require that the aeroplane is free of any significant ice contamination at the beginning of the take-off roll due to application of appropriate ice removal and ice protection procedures during flight preparation on the ground.

(…)

Create AMC 25.143(b)(4) as follows:

AMC 25.143(b)(4)
Go-around Manoeuvres

1. Background

When full thrust or power is applied during a go-around, an excessive level of performance (rate of climb, accelerations) may be reached very quickly, and make it difficult for the flight crew to undertake all the actions required during a go-around, especially in an environment that is constrained (due to Air Traffic Control instructions, operational procedures, etc) and rapidly changing.

This level of performance can also generate acceleration levels (in particular, forward linear accelerations) that could lead to spatial disorientation of the flight crew (e.g. a somatogravic illusion), in particular when combined with reduced visibility conditions and a lack of monitoring of primary flight parameters, such as pitch attitude.

Accidents and incidents have occurred during or after go-arounds where somatogravic illusions have led flight crews to make inappropriate nose-down inputs, leading to an aircraft upset, a loss of control or a deviation from the normal go-around flight path, and in some cases, controlled flight into terrain with catastrophic consequences.

Other accidents resulting in loss of control were due to excessive pitch attitudes combined with the flight crew's inadequate awareness of the situation.

The risk is higher on aeroplanes that have a large operational range of thrust to weight ratios, in particular for twin-engine aeroplanes and those with long-range capabilities.

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[1] Annex IV (Par-CAT) to Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council (OJ L 296, 25.10.2012, p.1-148)

2. Criteria for assessing the go-around manoeuvre risk with respect to somatogravic illusions and the flight crew workload

2.1 Somatogravic illusions

It is considered that the risk of a somatogravic illusion is high when encountering single or combined high values of pitch attitude (nose-up), pitch rate and longitudinal acceleration, associated with a loss of outside visual references.

2.2 Workload

In order to provide sufficient time to the flight crew to manage its tasks, and therefore keep their workload at a reasonable level, longitudinal acceleration and vertical speed may need to be constrained. The assessment of the workload should be performed considering the basic workload functions described in Appendix D of CS-25.

2.3 Risk assessment and mitigation means

There are no scientifically demonstrated aeroplane performance limits to ensure that the risks of somatogravic illusions and excessive workloads remain at acceptable levels. However, it is recommended to ensure that the following criteria are not exceeded during a standard go-around manoeuvre:

— a pitch rate value of 4 degrees per second,

— a pitch attitude of 20 degrees nose-up,

— an energy level corresponding to either:

- a vertical speed of 3 000 ft/min at constant calibrated airspeed,
- a climb gradient of 22 % at constant calibrated airspeed, or
- a level flight longitudinal acceleration capability of 7.8 km/h (4.2 kt) per second.

Note: these boundaries should not affect operational performance, as they are considered to be beyond the operational needs for a standard go-around.

Design mitigation means should be put in place in order to avoid exceeding these criteria and reduce the risk at an acceptable level. These means should:

— provide a robust method to reduce the risk identified, and

— be used during standard go-around procedures.

A reduced go-around (RGA) thrust or power function is considered to be an acceptable means of mitigation (refer to Chapter 4 below).

Alternatively, exceeding any one of the above criteria should be duly justified by the applicant and accepted by EASA.

3. Go-around evaluation

Go-around manoeuvres should be performed during flight testing in order to verify, in addition to the controllability and manoeuvrability aspects, that the flight crew workload and the risk of a somatogravic illusion are maintained at an acceptable level (for an acceptable level of risk of a somatogravic illusion, refer to Chapter 2.3 of this AMC). The go-around manoeuvres should be performed with all engines operating (AEO) and for each approved landing configuration as per the standard AFM go-around procedure:

— with the most unfavourable, and practicable, combination of centre of gravity position and weight approved for landing,
— with any practicable combination of flight guidance/autothrust-throttle/autopilot to be approved, including manual,
— with a level-off altitude 1 000 ft above the go-around initiation altitude.

4. Implementation of a reduced go-around (RGA) thrust or power function

The applicant may provide an RGA thrust or power function for use when the flight crew initiates a go-around. The function should operate with any practicable combination of the flight guidance/autothrust-throttle/autopilot modes to be approved for operation, including manual modes.

This function should limit the engine thrust or power applied and maintain the performance of the aeroplane (in particular, its rate of climb) at a level that:

— is not less than the minimum required performance compatible with the operational needs and the flight crew workload during this phase; and
— reduces the flight crew's risk of suffering a somatogravic illusion.

This thrust or power reduction function may be available either through aircraft system automation or manually.

In any case, acceptable procedure(s) should be available in the aeroplane flight manual (AFM), and the standard go-around procedure should be based on the RGA thrust or power function.

Note: When a reduced go-around thrust or power function is installed, the applicant should still use the most critical thrust or power within the range of available go-around thrust or power when showing compliance with the CS-25 specifications.

4.1 Design target

RGA functions with a design target of a 2 000 ft/min rate of climb capability have been accepted by EASA.

4.2 Cockpit indications and information to the flight crew

In automatic mode, information that thrust or power is reduced in the RGA mode should be indicated to the flight crew.

In manual mode, the thrust level tables should be made available to the flight crew.

4.3 Evaluation

An evaluation of the go-around manoeuvre with the RGA thrust or power function should be conducted following the recommendations of Chapter 3 above.

4.4 Thrust or power mode command

It should be possible for the flight crew, at any time and without any delay, to select and apply the full go-around thrust or power.

The applicant should provide specific procedures for which full thrust or power may be required, such as wind shear alert procedures, TCAS alert procedures, etc.

4.5 Engine failure during go-around with RGA thrust or power

When an engine failure occurs during a go-around performed with active RGA thrust or power, if the required thrust or power from the remaining engine(s) to achieve an adequate performance level cannot be applied automatically, a warning alert to the flight crew is required to prompt them to take the necessary thrust or power recovery action.

The procedure for the recovery of the engine thrust or power setting must be demonstrated to be acceptable in terms of the detection of the situation by the pilot and the required actions in a high-workload environment.

The following items should be evaluated:

— the timeliness of achieving the minimum required performance;

— flight crew awareness (indications, alerting…);

— flight crew actions (commands);

— the flight crew workload in general.

4.6 Performance published in the AFM for RGA thrust or power

The climb performance required by CS 25.119 (in a landing climb, i.e. with all engines operating) should be based on the actual RGA thrust or power available (applied by following the standard AFM procedure). The climb performance required by CS 25.121 (in an approach climb, i.e. with one engine inoperative) should be based on:

— either the RGA thrust or power available, if no thrust or power recovery is implemented,

— or the go-around thrust or power available after the application of the thrust or power recovery action (either automatically, or manually after an alert is triggered).

Amend AMC 25.145(a) as follows:

AMC 25.145(a)
Longitudinal Control – Control Near The Stall

1 CS 25.145(a) requires that there be adequate longitudinal control to promptly pitch the aeroplane nose down from at or near the stall to return to the original trim speed. The intent is to ensure sufficient pitch control for a prompt recovery if the aeroplane is inadvertently slowed to the point of the stall. Although this requirement must be met with engine thrust or power off and at go-around setting ~~maximum continuous power~~, there is no intention to require stall demonstrations at engine thrusts or powers above that specified in CS 25.201(a)(2). Instead of performing a full stall at ~~maximum continuous power~~ go-around thrust or power setting, compliance may be assessed by demonstrating sufficient static longitudinal stability and nose down control margin when the deceleration is ended at least one second past stall warning during a 0.5 m/s^2 (one knot per second) deceleration. The static longitudinal stability during the manoeuvre and the nose down control power remaining at the end of the manoeuvre must be sufficient to assure compliance with the requirement.

2 The aeroplane should be trimmed at the speed for each configuration as prescribed in CS 25.103(b)(6). The aeroplane should then be decelerated at 0.5 m/s^2 (1 knot per second) with wings level. For tests at idle thrust or power, it should be demonstrated that the nose can be pitched down from any speed between the trim speed and the stall. Typically, the most critical point is at the stall when in stall buffet. The rate of speed increase during the recovery should be adequate to promptly return to the trim point. Data from the stall characteristics test can be used to evaluate this capability at the stall. For tests at ~~maximum continuous power~~ go-around thrust or power setting, the manoeuvre need not be continued for more than one second beyond the onset of stall warning. However, the static longitudinal stability characteristics during the manoeuvre and the nose down control power remaining at the end of the manoeuvre must be sufficient to assure that a prompt recovery to the trim speed could be attained if the aeroplane is slowed to the point of stall.

3 For aeroplanes with an automatic pitch trim function (either in manual control or automatic mode), the nose-up pitch trim travel should be limited before or at stall warning activation (or stall buffet onset, or before reaching the angle-of-attack (AOA) limit if a high AOA limiting function is installed), in order to prevent an excessive nose-up pitch trim position and ensure that it is possible to command a prompt pitch down of the aeroplane to recover control.

The applicant should demonstrate this feature during flight testing or by using a validated simulator.

Note 1: the behaviour of the automatic pitch trim function in degraded flight control laws should be evaluated under CS 25.1309 and CS 25.671.

Note 2: the applicant may account for certain flight phases where this limit is not appropriate, and provide a rationale that supports these exceptions to EASA for consideration.

Create AMC 25.145(f) as follows:

AMC 25.145(f)
Longitudinal control – go-around

1. CS 25.145(f)(1) requires there to be adequate longitudinal control to promptly pitch the aeroplane (nose down and up) and adequate speed control in order to follow or maintain the targeted trajectory during the complete manoeuvre from any approved approach and landing configuration to a go-around, transition to the next flight phase and level off at the desired altitude.

The objective is to assess, in particular, the combined effects of a thrust or power application and a nose-up trim pitching moment.

The applicant should perform the evaluation throughout the range of thrust-to-weight ratios to be certified. This range should include, in particular, the highest thrust-to-weight ratio for the all-engines-operating condition, with the aeroplane at its minimum landing weight, all engines operating and the thrust or power at the go-around setting.

The evaluation should show adequate:

— pitch control (i.e. no risk of excessive pitch rate or attitude, maintaining an adequate stall margin throughout the manoeuvre, no excessive overshoot of the level-off altitude), and
— speed control (i.e. no risk of speed instability or exceedance of V_{FE} with the wing-flaps extended and V_{LE} with the landing gear extended).

Refer also to AMC No. 1 to CS 25.1329, Section 14.1.3.3, which provides guidance related to the demonstration of the flight guidance system go-around mode.

2. The applicant shall evaluate reasonably expected variations in service from the established approach, landing and go-around procedures and ensure that they do not result in unsafe flight characteristics during a go-around.

It is expected that these variations may include:

a) non-stabilised speed conditions prior to the initiation of a go-around (e.g. approach speed - 5 kt), and
b) adverse pitch trim positions:
    i) in manual mode with a manual pitch trim, a pitch trim positioned for the approach or landing configuration, and kept at this position during the go-around phase; and
    ii) in autopilot or manual mode with an automatic pitch trim function: the most adverse position that can be sustained by the autopilot or automatic pitch trim function, limited to the available protecting/limiting features or alert (if credit can be taken for it).

The applicant should perform these demonstrations by conducting go-around manoeuvres in flight or during simulator test programmes.

Amend AMC 25.201(d) as follows:

AMC 25.201(d)
Stall Demonstration

1 The behaviour of the aeroplane includes the behaviour as affected by the normal functioning of any systems with which the aeroplane is equipped, including devices intended to alter the stalling characteristics of the aeroplane.

2 Unless the design of the automatic flight control system of the aeroplane protects against such an event, the stalling characteristics and adequacy of stall warning, when the aeroplane is stalled under the control of the automatic flight control system, should be investigated. (See also CS 25.1329(~~f~~ h).)

AMC – SUBPART E

Create AMC 25.975(a)(7) as follows:

AMC 25.975(a)(7)

Fuel tank vent fire protection

1. Purpose

This AMC provides guidance and acceptable means of compliance with CS 25.975(a)(7) and the related specifications for the prevention of fuel tank explosions caused by the ignition of vapours outside fuel tank vents.

2. References

2.1. Related certification specifications:

— CS 25.863 Flammable fluid fire protection

— CS 25.867 Fire protection: other components

— CS 25.901 Installation (paragraphs (b)(2) and (c))

— CS 25.954 Fuel system lightning protection

— CS 25.963 Fuel tanks: general (paragraphs (d) and (e)(2))

— CS 25.981 Fuel tank ignition prevention.

2.2. Technical publications

— Hill, Richard and George R. Johnson, Investigation of Aircraft Fuel Tank Explosions and Nitrogen Inerting Requirements During Ground Fires, FAA Technical Report No. FAA-RD-75-119. Washington, D.C.: U.S. Department of Transportation, 1975

— FAA Technical Report ADS-18, National Technical Information Service (NTIS), Lightning Protection Measures for Aircraft Fuel Systems. Springfield, VA: U.S. Department of Commerce, 1964

— Military Standard, Environmental Engineering Considerations and Laboratory Test Methods, MIL-STD-810G w/Change1, Method 511.6 Procedure II. Philadelphia, PA: U.S. Department of Defense, 2014

— RTCA, Inc., Environmental Conditions and Test Procedures for Airborne Equipment, RTCA/DO-160G. Washington DC: RTCA, Inc., 2010

— Coordinating Research Council, Inc., Handbook of Aviation Fuel Properties. Atlanta, GA: CRC, Inc., 2004

— Kuchta, Joseph M., Summary of Ignition Properties of Jet Fuels and Other Aircraft Combustible Fluids, Technical Report AFAPL-TR-75-70. Springfield, VA: U.S. Department of Commerce, 1975

3. Definitions

— **Autogenous Ignition (Auto-Ignition) Temperature (AIT).** The minimum temperature at which an optimised flammable vapour and air mixture will spontaneously ignite when heated to a uniform temperature in a normal atmosphere without an external source of ignition, such as a flame or spark.

— **Flammability Limit.** The highest and lowest concentration of fuel-in-air-by-volume per cent that will sustain combustion. A fuel-to-air mixture below the lower limit is too lean to burn, while a mixture above the upper limit is too rich to burn. The flammability limit varies with altitude and temperature and is typically presented on a temperature-versus-altitude plot.

— **Flash Point.** The minimum temperature at which a flammable liquid will produce flammable vapour at sea level ambient pressure.

— **Flame Holding.** The ability of a flame arrestor to halt the propagation of a flame front through a passage.

— **Ignition Source.** A source of sufficient energy to initiate combustion of a fuel-air mixture. Hot surfaces that can exceed the auto-ignition temperature of the flammable vapour under consideration are considered to be ignition sources. Electrical arcs, electrical sparks, and friction sparks are also considered to be ignition sources if sufficient energy is released to initiate combustion.

— **Stoichiometric Ratio.** The ratio of fuel to air corresponding to the condition in which the available amounts of fuel and oxygen completely react with each other, thereby resulting in combustion products that contain neither fuel nor oxygen.

4. Acceptable means of compliance

Acceptable means of compliance with CS 25.975(a)(7) include:

— flame arrestors in the fuel tank vents that prevent flame propagation into the fuel tank (see paragraph 5 of this AMC);

— fuel tank inerting systems that exceed the basic requirements of CS 25.981 and prevent fuel tank explosions* (see paragraph 7.1 of this AMC);

— fuel tank pressurisation systems or features of the system that result in a closed vent system and that are effective in preventing a fuel tank explosion during all operating conditions (e.g. taxiing, take-off, landing, refuelling, etc.) and post-crash fire conditions (see paragraph 7.2 of this AMC); and

— fuel tank or vent system fire suppression systems that prevent a fuel tank explosion with a fire present at the fuel tank vent outlet for the required 2 minutes and 30 seconds (see paragraph 7.3 of this AMC).

* Fuel tank inerting systems that meet CS 25.981 would not necessarily be adequate for demonstrating compliance with CS 25.975 because CS 25.981 does not require the fuel tank ullage to be fully inert at all times. If inerting is used as the means of compliance with CS 25.975, the inerting system must be effective in preventing flame that is present at the vent outlet from propagating to the fuel tank. The applicant should show this during normal operating conditions, all foreseeable ground fire conditions (e.g. from refuelling, refuelling overflow, etc.), and post-crash ground fire conditions.

5. Flame arrestors

5.1. This paragraph describes the use of flame arrestors as a means of meeting the 2-minute and 30-second time requirements defined in CS 25.975(a)(7). The guidance is based on evaluating the flame arrestor performance during critical case conditions anticipated to occur when fire is adjacent to the fuel tank vent outlet. The flame arrestor should meet the performance described in this AMC during post-crash ground fires or other fire scenarios such as those resulting from fuel leakage due to fuel tank damage or fuel spilled during refuelling mishaps.

5.2. Flame arrestors that meet the standards defined in this AMC may not be effective in preventing the propagation of fires that may occur following lightning strikes near the fuel tank vent outlet. The ignition of fuel vapours near the vent outlet caused by lightning results in a high-speed pressure wave that can travel through the flame arrestor without sufficient time for the heat transfer necessary for the flame arrestor to quench the flame front. Instead, fuel tank vent lightning protection may be addressed as discussed in AMC 25.954 'Fuel System Lightning Protection', which is based on locating vents outside the lightning strike zones of the aeroplane. While aeroplane manufacturers have used flame arrestors to address lightning protection in several instances, they needed dedicated testing that addressed the unique design features to demonstrate the effectiveness of the installation. The guidance in this AMC is intended to address compliance with CS 25.975(a)(7) and is not intended to be used as guidance for showing compliance with the lightning protection requirements in CS 25.954.

5.3. The installation of flame arrestors in the aeroplane fuel vent system will affect the performance of the fuel tank vent system. The applicant should account for factors such as the introduction of a flow restriction and the associated increase in the pressure drop during refuelling system failure conditions, as well as the impact of environmental conditions such as icing and lightning, when requesting approval of the fuel tank installation. Means of compliance for these considerations are not addressed in this AMC. General fuel system guidance is provided in AMC 25.963 and AMC 25.981.

5.4. Previous results from flame arrestor performance tests indicated that the critical condition for evaluating the effectiveness of the flame arrestor occurs when the flame front contacts the surface of the flame arrestor, which results in heating of the flame arrestor. As the flame arrestor is heated, the ability of the flame arrestor to absorb energy may be reduced, resulting in its inability to quench the flame. Once this occurs, the flame will then pass through the flame arrestor, resulting in flashback. It is important to realise that flashback through heated flame arrestor channels, which normally quench flames, should not be confused with auto-ignition or hot surface ignition. Flashback will occur when the rate of heat loss to the channel wall is insufficient to quench the flame. In this case, the wall acts as an inadequate heat sink and not as an ignition source. The flame retains sufficient heat energy to pass to the upstream side of the flame arrestor.

5.5. Flame propagation past the flame arrestor may also occur due to the ignition of flammable vapours by hot surfaces. The time it takes for the assembly surfaces on the internal side of the flame arrestor, including the line and housing, to be heated to a temperature higher than the AIT of the flammable vapour mixture could be the limiting factor in establishing the effectiveness of the flame arrestor assembly. The ignition of combustible mixtures by hot surfaces (auto-ignition) involves different phenomena from the phenomena involved in flashback as discussed in paragraph 5.4 of this AMC. For auto-ignition to occur, a portion of the combustible gas must dwell near a hot surface long enough for the amount of chemical heat produced to become greater than the heat dissipated to the surroundings. The maximum dwell time (commonly termed the 'ignition lag') is a function of the heat transfer characteristics of the gas and the heat source, as well as the kinetics of the combustion process. For this reason, the surface area and the shape of the hot surface, and the flow field around the heat source, are critical factors in determining whether ignition will occur.

5.6. The test conditions defined in this AMC are intended to evaluate the effectiveness of flame arrestors during two conditions. The first condition is the ignition, by an external source, of flammable vapours at the fuel tank vent outlet. The flame arrestor should be effective in stopping the initial propagation of flames. The second condition is a continuous flow of vapour exiting the fuel vent. The flame arrestor should hold the flames without passing the flames to the upstream portion of the vent system. The applicant should determine the critical test conditions following a review and analysis of the particular flame arrestor installation and its characteristics.

5.7. The conditions under which the flame arrestor should be effective include those where flammable fluid vapours are exiting the fuel tank at flow rates that vary from no flow, which typically occurs during normal ground operations, to high-flow conditions, which typically occur during refuelling or when the fuel tank is heated due to a ground fire following an accident.

5.8. The applicant should conduct an analysis to determine the pass/fail criteria for the aeroplane-specific flame arrestor installation. The analysis should include consideration of hot surface ignition when determining whether the flame arrestor assembly meets the explosion prevention requirement of 2 minutes and 30 seconds. The maximum surface temperatures of the flame arrestor installation and the flame arrestor should be established when meeting the requirement. The applicant should consider the velocity of the flammable fluid vapour on the surface of the flame arrestor and the duct sidewall upstream (tank) side of the flame arrestor. Provided that a uniform vapour velocity is present (i.e. there are no areas of stagnation), a heat source whose temperature exceeds the AITs quoted for static conditions (typically 230 °C/450 °F) will not cause ignition in the flame arrestor installation. Data in the Handbook of Aviation Fuels Properties (see Chapter 2.2 of this AMC) show the relationships between vapour velocities and AITs. Test results from developmental testing of flame arrestors installed in fuel vent lines have shown that ignition will not occur if the temperature of the centre of the flame arrestor remains below 370 C/700 °F. However, this temperature limit may not be appropriate for other surfaces in the flame arrestor installation where a uniform flammable vapour flow is not present. The applicant should analyse the flame arrestor design to determine the critical locations and fuel vapour flow conditions that result in the highest surface temperatures, and run an adequate number of test conditions to validate the analysis.

6. Demonstrating compliance using flame arrestors

6.1. The performance of a flame arrestor is influenced by installation effects that may cause variations in critical parameters such as the speed of the flame front and the temperatures of the surfaces. The applicant should account for such installation effects in demonstrating compliance. The applicant may choose to show compliance with CS 25.975(a)(7) by testing a complete, conformed production installation of the flame arrestor (including the upstream and downstream ducting). Alternatively, the applicant may request EASA approval to use other tests and analysis of the flame arrestor and the installation as a means of compliance.

6.2. The applicant may propose to use flame arrestor elements from a supplier. The supplier may have previously qualified an element to flame propagation requirements without consideration of the design of the aeroplane into which the flame arrestor will be installed. The applicant should conduct tests to show that they have accounted for any effects of the installation, including flame front speeds and duct sidewall temperatures. The fuel types for these tests differ, and should be established as discussed in paragraph 6.3.1.3 of this AMC prior to conducting any testing.

6.3. Flame arrestor installation test.

6.3.1. Test Set-up.

Figure A-1 shows a schematic of the test set-up. The test set-up involves mounting the flame arrestor element in a tube configuration that is representative of the aeroplane installation. The speed of the flame front that travels down the fuel vent system tubing toward the flame arrestor is a critical factor in the performance of the flame arrestor in preventing flame propagation. The flame front will accelerate down the tubing, so higher velocities will occur if the flame arrestor is located farther away from the fuel tank vent outlet. Therefore, the shape and diameter of the tubing and its length from the fuel tank vent inlet to the flame arrestor should be representative of the production configuration, unless the flame arrestor element was previously found to comply in an installation in which the speed of the flame reaching the flame arrestor was higher. In addition, the orientation of the flame arrestor in the fixture is a critical parameter for the compliance demonstration. For instance, a flame arrestor installation that faces downward, so a ground fire impinges on its face, will have a shorter duration flame-holding capability than a flame arrestor that is mounted horizontally.

6.3.1.1. Test fixture features.

The applicant should consider the following features in designing the flame arrestor test fixture:

1. Orient the element to simulate the actual aeroplane installation.
2. Cut viewing sections into the pipe upstream and downstream of the flame arrestor element and cover them with transparent material to provide visual access to the element.
3. Locate igniters upstream and downstream of the element.
4. Locate thermocouples in the duct to measure the incoming flammable mixture temperature and the vapour temperatures downstream of the flame arrestor element.
5. Install thermocouples on the surface of the centre of the flame arrestor element's upstream face and on the surface of the upstream side of the duct.
6. Incorporate a pressure-relief feature in the upstream portion of the system to relieve explosive pressures when ignition of the upstream flammable fluid vapour occurs.

7. Mix air that is at a temperature higher than the boiling point of the fuel being used (see paragraph 6.3.1.3 of this AMC) with fuel, and introduce it at the inlet of the tube.
8. Vary fuel–air ratios by adjusting the respective fuel-vapour and air-supply rates.

6.3.1.2. Test equipment.

The test equipment should include:

1. The test article, including the flame arrestor and the downstream section of the vent system assembly that meets production specifications.
2. A section of ducting that is representative of the production flame arrestor installation.
3. A means of generating a supply of fuel vapour at preselected fuel-to-vapour air ratios and various flow rates.
4. A window for observing upstream and downstream conditions during the test. This should allow to determine the location of the flame front relative to the flame arrestor.
5. A means to measure temperatures on the upstream duct surfaces and the flame arrestor.
6. A means to measure fuel vapour mixture temperatures both upstream and downstream of the flame arrestor.
7. A means to relieve explosive pressure upstream of the flame arrestor.
8. Ignition sources for igniting the explosive mixture upstream and downstream of the flame arrestor.

6.3.1.3. Fuel type.

6.3.1.3.1. The applicant should establish the critical fuel type for the test based on a review of the approved fuels for the aeroplane model. The applicant should use fuels in the test that have representative characteristics of the critical fuel approved for use in the aeroplane. The use of hexane as a representative fuel for kerosene fuels such as Jet A and TS-1 has been found to be acceptable. Hexane (C_6H_{14}) is readily available and easily manipulated in the gaseous state, so it is typically a fuel of choice. The AIT for hexane of 223 °C/433 °F closely simulates that of Jet A kerosene fuel, which has an AIT of 224 C/ 435 °F, and JP-4 which has an AIT of 229 °C/445 °F.

Note: The applicant should not use fuels with higher AITs than these, such as propane, for the flame arrestor element test because ignition on the back side of the flame arrestor would not be adequately evaluated.

6.3.1.3.2. Table A-1 summarises the properties of hexane and provides an example of the method for calculating the stoichiometric relationship of hexane needed for the test.

6.3.1.3.3. The applicant may use propane for testing of a flame arrestor installation if the AIT is not a critical parameter for the test. For example, testing of a simulated production flame arrestor installation to validate that temperatures of portions of the installation within the fuel tank remain below the maximum permitted fuel tank surface temperature (typically 200 °C/400 °F) would be acceptable, provided that the applicant or supplier has previously shown that the flame arrestor element meets the flame-holding requirements.

6.3.1.3.4. Table A-3 summarises the properties of propane as provided in FAA Technical Report ADS-18, Lightning Protection Measures for Aircraft Fuel Systems (see Chapter 2.2 of this AMC), and provides an example of the method for calculating the stoichiometric ratio of propane.

6.3.1.4. Thermocouples.

The applicant should use bare junction 1/16- to 1/8-inch metal-sheathed, ceramic-packed, chromel-alumel thermocouples with nominal 22 to 30 AWG (American wire gage) size conductors or equivalent. The applicant should not use air-aspirated, shielded thermocouples. Experience has shown that 1/16-inch thermocouples may provide more accurate calibration than 1/8-inch thermocouples; the 1/16-inch thermocouples are therefore recommended.

6.3.1.5. Test specimen.

The test specimen should be a production component that conforms to the type design intended for certification.

6.3.2. Test conditions.

Two types of tests are typically needed to demonstrate compliance: one for flame propagation prevention in a static vent vapour flow condition, and one for flame holding in a continuous vapour flow condition. These conditions provide a conservative demonstration of fuel tank vent fire protection capability with respect to delaying flame front propagation through the fuel vent flame arrestor installation during ground fire conditions.

6.3.2.1. Flame propagation test (static).

This test demonstrates the element's flame-arresting performance in a static condition at the critical fuel mixture condition of 1.15 ± 0.05 stoichiometric. This mixture is based on FAA-sponsored tests done by Atlantic Research, documented in the Lightning Protection Measures for Aircraft Fuel Systems report. The report shows curves of the flame arrestor equilibrium temperature for various air–flow ratios as a function of the per cent stoichiometric fuel–air ratio (see Figure A-2 in this AMC). These curves maximise at about 1.10 to 1.20 stoichiometric. The curves indicate that higher temperatures occur at lower flow rates.

6.3.2.1.1. Establish the mixed flow.

Close the fuel and air valves. Ignite the mixture downstream of the element. Verify that flames did not propagate through the flame arrestor by observing it through the viewing window. Verify that the upstream mixture is combustible by energising the upstream igniter and observing the ignition of the upstream mixture. The applicant should repeat this test a minimum of 5 times at this mixture, as is done with explosion proof testing.

6.3.2.1.2. Flame front velocity.

The velocity of the flame front as it reaches the flame arrestor can significantly influence the effectiveness of the flame arrestor in preventing flame propagation. The flame front velocity increases as the flame travels down a vent line containing flammable vapours. The velocity of the flame front is installation-dependent and influenced by the length and diameter of the vent line, and by flow losses between the ignition source and the flame arrestor. The test configuration should include consideration of these critical features. If an applicant proposes to use a previously approved flame arrestor element in a new installation with a different length or diameter of the vent line than previously tested, the applicant should account for these installation differences in the compliance demonstration. The applicant may need to conduct a separate test to demonstrate that the flame arrestor is effective in the installed configuration.

6.3.2.2. Flame-holding test.

The purpose of this test is to show that a flame present at the fuel tank vent outlet, when a continuous flow of flammable vapour is exiting the vent, will not propagate into the fuel tank. The test conditions for this test are based on test results documented in the Lightning Protection Measures for Aircraft Fuel Systems report that resulted in the highest flame arrestor temperature. Run this test at a 1.15 stoichiometric fuel–air ratio. The flammable vapour flow rate that achieves a velocity of 0.75 to 1.0 feet per second (ft/s) across the flame arrestor is the range where flame arrestor failure occurred in the shortest time during development testing.

Adjust the flow to achieve a velocity of 0.75 ft/s (+ 0.25, – 0 ft/s) across the flame arrestor and ignite it downstream of the flame arrestor.

Determine and establish the location of the flame front by viewing it through the viewing window.

Determine the position of the flame front and adjust the vapour flow rate such that the flame front contacts the downstream flame arrestor face, resulting in the greatest rate of heating of the flame arrestor surface.

Take care to maintain the flammable vapour flow rate at a constant value throughout the test so as to maintain the correct fuel-to-air ratio.

6.3.2.2.1. Flame arrestor element maximum surface temperatures.

Monitor the temperature at the upstream centre of the flame arrestor during the flame-holding test; it is required to stay below 370 °C/700 °F for the first 2 minutes and 30 seconds after the ignition. Data from developmental testing show that the temperature of the centre of the upstream flame arrestor face at which failure (i.e. propagation of the flame) occurred was typically above 370 °C/700 °F, which is well above the AIT of JP-4 fuel vapour of 229 °C/445 °F, as established during no-flow conditions. The upstream flame arrestor temperature can go well above the AIT without causing upstream ignition because of the high local velocity of the vapour. For this reason, hexane, with an AIT of 223 °C/433 °F, should be used for the test of the flame arrestor element.

6.3.2.2.2. Flame arrestor installation and vent system maximum surface temperatures.

The compliance demonstration must show that flames present at the vent outlet do not propagate into the fuel tank during the first 2 minutes and 30 seconds after ignition. If the flame arrestor installation or any vent system components that are exposed to the flame are installed in locations where the ignition of flammable vapours could result in the propagation of the fire into the fuel tank, the applicant must show that ignition of the fuel vapours does not occur. This may require the installation of additional surface temperature instrumentation as part of the compliance demonstration test. The applicant should establish temperature limits for any components of the vent or flame arrestor assembly that are located in spaces where flammable vapours may be present, based on the location of the components in relation to the fuel tank. AMC 25.981 provides guidance for establishing a maximum allowable surface temperature within the fuel tank (the tank walls, baffles, or any components) that provides a safe margin, under all normal or failure conditions, that is at least 30 °C/50 °F below the lowest expected AIT of the approved fuels. The AIT of fuels will vary because of a variety of factors (e.g. ambient pressure, dwell time, fuel type, etc.). The AIT accepted by EASA without further substantiation for kerosene fuels, such as Jet A, under static sea level conditions, is 232 °C/450 °F. This results in a maximum allowable surface temperature of

200 °C/400 °F for an affected surface of a fuel tank component. Higher surface temperature limits in flammable fluid leakage zones may be allowed in certain cases where the applicant can substantiate that the higher temperature limits are acceptable. The applicant should monitor and record surface temperatures for any components where the analysis-established limits were required, and should show that the surface temperatures remain below the established limits.

6.3.3. Pass/fail criteria.

6.3.3.1. The flame arrestor installation should meet the following performance criteria, as described in paragraph 6.3.2 of this AMC:

— It should pass the static propagation test;

— It should have a minimum flame-holding time of 2 minutes and 30 seconds;

— Installation-dependent maximum surface temperature limits should be established for any flame arrestor and vent system components located in fuel tanks or flammable fluid leakage zones that are determined to be potential sources that could propagate the flame from the external vent to the fuel tank.

6.3.3.2. After completing the flame arrestor tests noted above, the applicant should carefully examine the integrity of the structure of the flame arrestor. Suppliers have constructed flame arrestors from one flat and one corrugated stainless steel sheet that are rolled up and placed into a flanged casing. This construction produces a series of small passages. Structural integrity of the coiled sheet metal is maintained by either rods that cross at the front and rear faces of the coil or by brazing or welding of the coiled sheet metal at various points around the surface. Flame arrestors have failed the test when the flame passed across the flame arrestor because structural integrity was lost during the test due to failures of welds or brazed joints. Damage to components of the flame arrestor assembly is acceptable if the flame arrestor installation prevents flame propagation during the test, and the maintenance requirements specify that the flame arrestor must be repaired or replaced following an event where the flame arrestor was exposed to flame.

6.3.4. Related qualification and installation considerations.

This paragraph does not contain an all-inclusive list of applicable qualification considerations. The tests should show that each component performs its intended function within the environment where it is installed. The applicant should establish design-specific qualification requirements in addition to the items listed in this paragraph.

6.3.4.1. Vibration.

Test the flame arrestor in a vibration environment representative of the installation.

6.3.4.2. Icing.

Installation of a flame arrestor will probably introduce a point in the vent system where icing is likely. The applicant should account for this effect in the vent system design by either installing pressure-relief provisions that protect the tank from excessive pressure differentials, or by showing that icing or clogging of the flame arrestor with ice is not possible.

6.3.4.3. Fuel tank bottom pressures.

In many cases, applicants have established the size of fuel tank vent systems, and the associated fuel tank refuelling rates, based on the bottom pressure of the fuel tank after failure of the refuelling system shut-off system and the resulting fuel overflow of the tank through the vent system. However, installation of a flame arrestor or modifications to the vent system may result in increased tank bottom pressures. Therefore, if an applicant adds a flame arrestor to a fuel vent, or modifies an existing flame arrestor, the applicant should evaluate the effects of these changes on the tank bottom pressure, and adjust the refuelling rates to maintain the fuel tank bottom pressures within the limits that were established by the fuel tank structural analysis.

6.3.4.4. Lightning.

The applicant must show that the fuel tank vent system installation complies with CS 25.954. AMC 25.954 provides guidance in meeting those requirements. FAA Technical Report ADS-18 (see paragraph 2.2 of this AMC) provides factors that the applicant should consider when developing features to protect fuel tank vents from lightning.

7. Demonstrating compliance using fuel tank inerting, fuel tank pressurisation, and fire suppression systems

7.1. Fuel tank inerting.

An applicant’s use of fuel tank inerting systems to show compliance with CS 25.975(a)(7) requires them to demonstrate that the design prevents fuel tank explosions during all operating conditions (e.g. taxiing, take-off, landing, refuelling, etc.) and post-crash fire scenarios. To comply with CS 25.981, inerting systems are not required to inert the fuel tanks during all operating conditions. Therefore, if an applicant proposes an inerting system as the means of compliance with CS 25.975(a)(7), the system would need to have additional capability to prevent fuel tank explosions during all operating conditions. For example, inerting systems found compliant with CS 25.981 typically allow the fuel tanks to become flammable during refuelling operations, and when the inerting system is inoperative. The applicant would need to address these conditions in order to ensure that the system continues to meet the requirements of CS 25.975(a)(7).

7.2. Fuel tank pressurisation systems.

Fuel tank pressurisation systems or features of the system that result in a ‘closed’ vent system may become inoperative during an accident or the subsequent post-crash fire scenario. If the applicant proposes fuel tank inerting or pressurisation as the means of compliance with CS 25.975(a)(7), the applicant must show that these means are effective in preventing a fuel tank explosion during all operating conditions (e.g. taxiing, take-off, landing, refuelling, etc.) and post-crash fire conditions.

7.3. Fire suppression systems.

Fuel tank or vent system fire suppression systems are typically activated by a light sensor, and they discharge a fire-suppressant agent that is only effective for a short time. Demonstrating compliance using this technology would require the applicant to show its effectiveness in preventing a fuel tank explosion with a fire present at the fuel tank vent outlet for a minimum of 2 minutes and 30 seconds.

Appendix A. Example of Calculation for Fuel-to-Air Ratio

Table A-1. Combustion Properties of Hexane

Property	Value
Heat of combustion, BTU/lb.	19 200
Molecular weight	86.17
Limits of inflammability in air (% by volume) per cent: Lower Upper	 1.2 7.4
Flash point	– 22 °C/– 7 °F
Boiling point	69 °C/156 °F
Auto-ignition temperature (AIT)	223 °C/433 °F
Vapour pressure at 21 °C/70 °F (Pa/psia)	17 237/2.5

Note: The equation for the combustion of hexane and oxygen is written as:

$2\ C_6\ H_{14} + 19\ O_2 = 14\ H_2O + 12\ CO_2$

For every 2 moles of hexane consumed, 19 moles of oxygen are required for complete combustion with no residual oxygen. Thus, 172.34 g of hexane require 19 × 32.00 = 608 g of oxygen or 2 627.48 g of air, which is 23.14 per cent by weight oxygen. Hence, the ratio of the weight of air to the weight of hexane required for stoichiometric burning (i.e. complete combustion of hexane with no excess oxygen) is 15.24.

A 1.15 fraction of stoichiometric mixture of air and hexane has an air-to-fuel weight ratio of:

$$\frac{2627.48}{1.15 \times 172.37} = 13.2$$

Table A-2. Fuel-to-Air Mixtures for Flame Arrestor Tests

Condition	JP-4 Per cent by Volume	JP-4 Fuel–Air Mass Ratio	Hexane Per cent by Volume	Hexane Fuel–Air Mass Ratio
Lean limit	0.90	0.035	1.3	0.04
Between lean limit and stoichiometric	1.10	0.045	1.7	0.05
Stoichiometric	1.58	0.065	2.2	0.0658
1.15 Stoichiometric	1.82	0.074	2.5	0.07567
Between stoichiometric and rich limit	3.0	0.15	6.3	0.2
Rich limit	6.16	0.23	8.0	0.26

Table A-3. Combustion Properties of Propane

Property	Value
Heat of combustion (298 °K), kcal/g-mole	530.6
Flammability limits in air (% by volume), per cent: Lower Upper	 2.2 9.5
Flame temperature (stoichiometric in air, STP)	1 925 °C/3 497 °F
Quenching diameter,* cm/in	0.28/0.11
Minimum spark ignition energy,* millijoules	0.027
Critical velocity gradient for flashback,* sec^{-1}	600
Laminar flame speed,* cm-sec	40

*Applicable to 1.1 stoichiometric propane-to-air at standard temperature and pressure (STP).

Note: The equation for the combustion of propane and oxygen is written as:

$C_3H_8 + 5\ O_2 = 4\ H_2O + 3\ CO_2$

For every mole of propane consumed, 5 moles of oxygen are required for complete combustion with no residual oxygen. Thus, 44.09 g of propane require 5 × 32.00 = 160 g of oxygen or 691.44 g of air, which is 23.14 per cent by weight oxygen. Hence, the weight of air to weight of propane required for stoichiometric burning (i.e. complete combustion of propane with no excess oxygen) is 15.7. A 1.15 fraction of stoichiometric mixture of air and propane has an air-to-fuel weight ratio of:

$$\frac{691.44}{1.15 \times 44.09} = 13.7$$

Figure A-1. Fuel Tank Vent Flame Arrestor Test Schematic

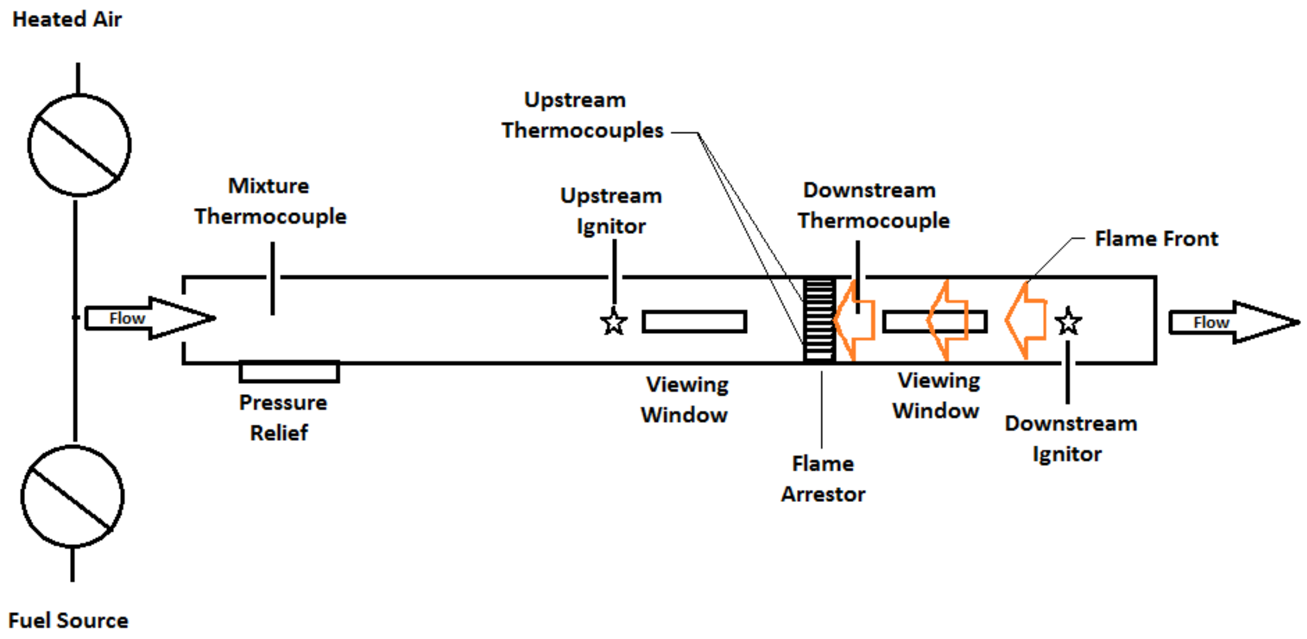
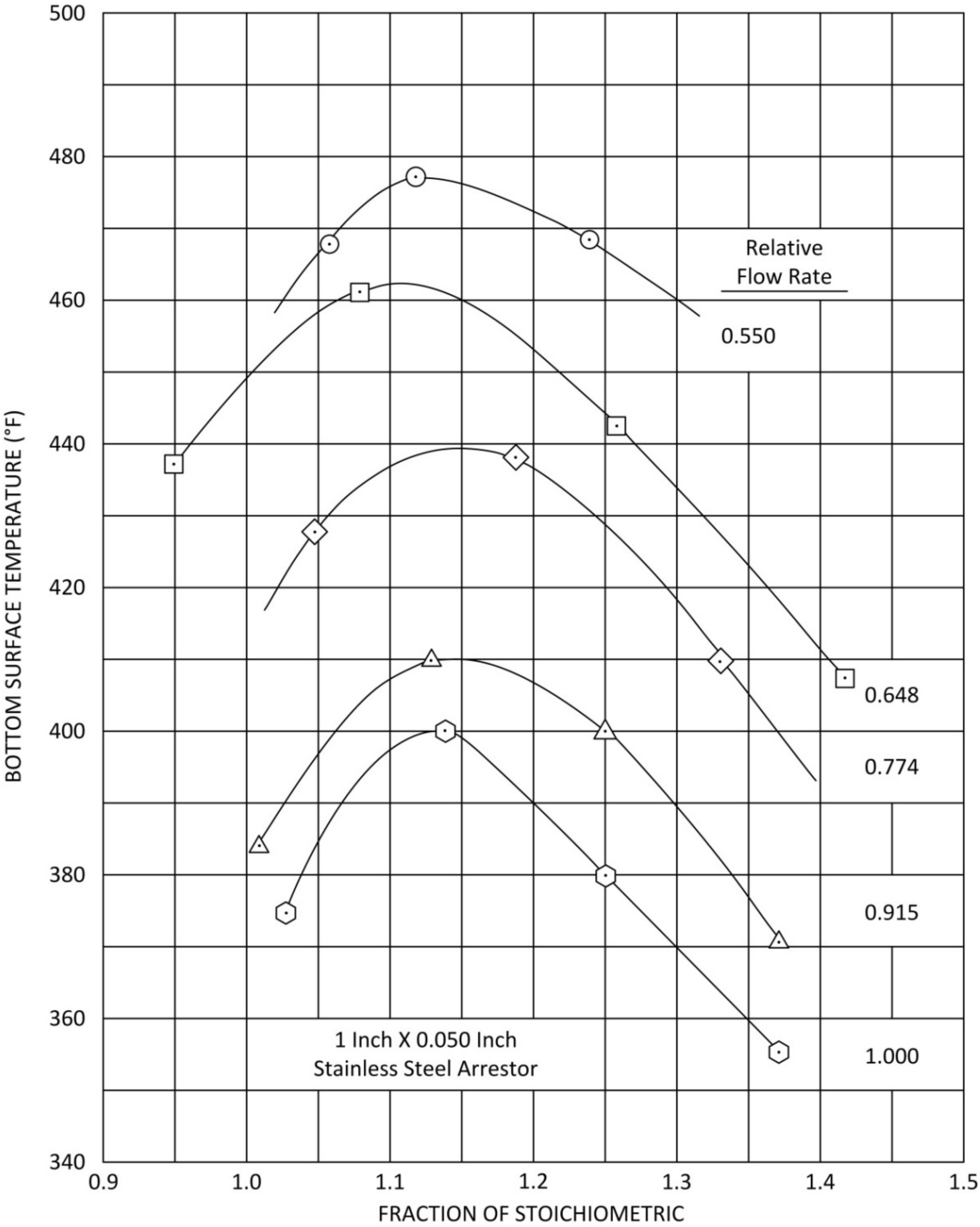


Figure A-2. Flame Arrestor Surface Temperature at Various Flow Rates and Stoichiometric Mixture Ratios*



* FAA Technical Report ADS-18, Lightning Protection Measures for Aircraft Fuel Systems (see paragraph 2.2 of this AMC).

Create AMC 25.1193(e)(4) and (f) as follows:

AMC 25.1193(e)(4) and (f)

Engine cowling retention

a. Purpose and scope

CS 25.1193(e)(4) requires design precautions to be taken to minimise the risk of any in-flight opening or loss of an engine cowling that could prevent continued safe flight and landing. CS 25.1193(f) requires the retention system of each removable or openable cowling to have a means, which is demonstrated to be reliable and effective, to verify that the cowling is closed and latched prior to each take-off.

Reported occurrences of engine cowling separations revealed that features like latch handles hanging down, cowling gaps, and detection capabilities offered by walk-arounds and/or checks at the completion stage of maintenance activities, had not been reliable or effective in preventing aeroplanes from taking off with unclosed/unlatched cowlings.

For turbofan engines, these occurrences have concerned fan cowls only. Thrust reverser cowls have shown satisfactory in-service experience with regard to the risk of a cowling separation. Therefore, specifications CS 25.1193(e)(4) and (f) are intended to be applicable to engine fan cowls only.

All dispatch configurations, as permitted by the master minimum equipment list (MMEL) and the configuration deviation list (CDL), should be considered when showing compliance with CS 25.1193(e)(4) and (f).

b. Selection of appropriate design features

The following guidelines are provided to help the applicant in selecting design features appropriate to the engine/nacelle characteristics, and in showing compliance with CS 25.1193(e)(4) and (f).

Human factors

In determining the most appropriate design feature, or combination of design features, to cope with the human-factor aspects that contribute to the risk of an aeroplane being released with unclosed or unlatched cowlings, attention should be placed on the following aspects of cowling latched/unlatched indications:

— Their verification by personnel should not necessitate unusual physical effort (e.g. bending down or kneeling on the ground);

— Their verification by personnel should take into account the variability in the physical capabilities of personnel;

— The provision of these indications should take into account a possible lack of diligence of personnel in conducting walk-arounds and in completing their maintenance activities;

— The combination of indications should draw the attention of personnel without ambiguity (e.g. by paint effects) and should not be rendered ineffective by lighting conditions (night/day), weather conditions, or the operational environment.

Design considerations

The following considerations should be taken into account when selecting design features to mitigate the risk of a cowling separation:

— A wing-mounted engine/nacelle presents a higher risk than a rear-mounted engine/nacelle, therefore it requires more noticeable cowling latched/unlatched indications and/or a combination of them;

— An engine/nacelle with a small ground clearance presents a higher risk than one with a large ground clearance, therefore it requires more noticeable indications and/or a combination of them;

— A hanging heavy/large piece or part on an engine/nacelle with a large ground clearance may draw the attention of personnel;

— A unique indication on the lower part of an engine/nacelle that has a small ground clearance may not be sufficient to draw attention to it;

— The noticeability of a forced gap between the fan cowl and the surrounding structure may be adversely affected by its environment, such as the ambient lighting conditions, external painting or the condition of the surrounding structure, and may not be individually sufficient to draw attention to it;

— A flashing light in an open gap or outside the nacelle skin may draw the attention of personnel. In such cases, the reliability of the flashing light should be investigated and substantiated, taking into account the effects of the engine/nacelle environment;

— A mechanical flag on the outside of the nacelle skin may draw the attention of personnel;

— A latch which is locked by a key equipped with a red flag may draw the attention of personnel, however a duplicate key without a flag could be used, and therefore the use of a flag may not be sufficient;

— A design with a remote indication (i.e. on the flight deck) of the unlatched/unclosed fan cowl condition may effectively draw the attention of the flight crew.

Other guidelines

Furthermore, the following guidelines related to the use of some of the design features should be taken into account by the applicant:

— Procedural control measures may not always be followed as a result of the pressure to dispatch the aeroplane, and because of routine issues;

— Improper Instructions for Continuing Airworthiness may be issued, which may lead to:

- Improper rigging of the cowls and the associated latches;

- Poor maintenance of design features intended to prevent aeroplane dispatch with unlatched cowlings, such as bright paint fading over time (or becoming soaked with the dirt accumulated at the bottom of the nacelle), hold-open cowl devices not performing their intended function, etc.;

— Some nacelle painting can defeat the design precautions:

- Red or orange nacelle colours may negate the visibility of red/dayglow latches;
- A dark nacelle colour may reduce the noticeability of gaps.

— Specific tools may be improperly defined and maintained (e.g. keys required to open cowls, normally fitted with a red flag, being used without a flag).

In order to address the human factors that contribute to the risk, it might be necessary to conduct an in-service and practical evaluation of the proposed design.

AMC – SUBPART F

Create AMC 25.1303(a)(3) as follows:

AMC 25.1303(a)(3)

Direction indicators

In this AMC, 'primary direction indicator' refers to the direction indicator required by CS 25.1303(b)(6) and 'standby direction indicator' to the one required by CS 25.1303(a)(3).

When designing and installing a standby direction indicator, the applicant should follow the guidelines below:

(a) Independence between the primary direction indicator and the standby direction indicator should be established in all foreseeable operating conditions. Failure conditions and subsequent switching to the backup source of direction should be carefully considered;

(b) The reliability of the standby direction indicator should be commensurate with the identified hazard level. Consideration should be given to CS 25.1333(b) and AMC 25-11, Chapter 4, Table 6;

(c) Additional availability assessments should be provided:

(1) Direction indications should be available immediately following the loss of the primary direction source without additional crew member action, and after any single failure or combination of failures. Consideration should be given to CS 25.1333(b);

(2) Direction indications should not be adversely affected following a loss of normal electrical power. Consideration should be given to CS 25.1351(d);

(3) Operation during and after exposure to a high-intensity radiated field (HIRF) environment should be demonstrated. Consideration should be given to CS 25.1317(a);

(4) Operation after exposure to indirect effects of lightning should be established. Consideration should be given to CS 25.1316(a).

Create AMC 25.1305(c)(5) as follows:

AMC 25.1305(c)(5)

Powerplant ice protection system functioning indication

In addition to an indication of the functioning of each nacelle ice protection system, an indication of the functioning of each engine ice protection system should be provided under the following conditions:

1. If the engine ice protection system requires a flight crew action to operate it (i.e. the system is manual), and

2. If the engine ice protection system does not require a flight crew action to operate it (i.e. the system is automatic, or it functions permanently), unless all of the following conditions are met:

— The engine thrust/torque and aeroplane performance are not significantly affected by the engine ice protection system switching on/off;

— There is no significant effect of the engine ice protection system switching on/off on the flight deck instruments, controls (such as the throttle lever) and the flight deck environment (such as noise);

— The engine ice protection system failures are indicated to the flight crew; and

— The indication of the functioning of the engine ice protection system is not used to indicate to the flight crew that the aircraft is operating in an icing environment, requiring, for example, the flight crew to apply an AFM procedure to protect the engine against the effects of the icing environment.

Amend AMC 25.1324 as follows:

AMC 25.1324

Flight instrument external probes

(…)

9. Mode of Operation

(…)

b. De-icing test:

During this test, the icing protection of the probe (typically resistance heating) should be 'off' until 0.5 inch of ice has accumulated on the probe. For ice crystal tests in de-icing mode, since no accretion is usually observed, an ~~agreed~~ 'off' time duration should be agreed before the test. In the past, a ~~one~~1-minute time duration without heating power has been accepted. This mode need not be tested if, in all operational scenarios (including all dispatch cases), the probe heating systems are activated automatically at aircraft power 'On' and cannot be switched to manual operation later during the flight. Furthermore, in assessing whether or not this mode needs to be tested, any failure conditions that are not demonstrated to be extremely improbable, and that may lead to probe heating supply interruptions, should be considered.

Amend AMC 25.1327 as follows:

AMC 25.1327
Direction indicator
(…)
~~5. For standby compass instruments, the accuracy of the magnetic heading indications after correction should be better or equal to 10°.~~
(…)

Create AMC 25.1441(b) as follows:

AMC 25.1441(b)

Risk assessment related to oxygen fire hazards in gaseous oxygen systems

1. Purpose

This AMC provides guidance material and acceptable means of compliance for demonstrating compliance with CS 25.1441(b), which requires an oxygen system to be free from hazards in itself, in its method of operation, and in its effect upon other components.

This AMC applies to centralised, decentralised or portable oxygen systems. Those systems may be installed in an occupied compartment or in a remote inaccessible area.

2. Related certification specifications

CS 25.869(c) Fire protection: systems — Oxygen equipment and lines
CS 25.1301 Function and installation
CS 25.1309 Equipment, systems and installations
CS 25.1441(b) Oxygen equipment and supply
CS 25.1453 Protection of oxygen equipment from rupture

3. Installation

CS 25.869(c) specifies that oxygen system equipment and lines must:

(1) not be located in any designated fire zone;

(2) be protected from heat that may be generated in, or may escape from, any designated fire zone; and

(3) be installed so that escaping oxygen cannot cause the ignition of grease, fluid, or vapour accumulations that are present in normal operation or as a result of a failure or malfunction of any system.

In addition, the following analysis and precautions should be considered.

3.1. External ignition sources

An analysis should be performed to identify all possible external ignition sources and their mechanisms. If an ignition source exists in the vicinity of the oxygen system installation, it should be demonstrated that in normal operation or in conditions that result from a failure or malfunction of any system, the risk of ignition is minimised and that all design precautions have been taken to minimise this risk.

3.2. Contamination

The compartments in which oxygen system components are installed should provide adequate protection against potential contamination by liquids, lubricants (grease, etc.), dust, etc.

3.3. Ventilation

The compartments in which oxygen system components are installed should be ventilated in such a way that, if a leak occurred or oxygen was discharged directly into the compartment (not overboard) from any protective device or pressure-limiting device, the likelihood of ignition of the oxygen-enriched environment would be minimised. The applicant should substantiate that the ventilation rate of the compartment is adequate. Analytically determined ventilation rates should be validated by flight test results or their equivalent.

CS 25.1453(f) provides additional specifications related to ventilation.

This paragraph does not apply to portable oxygen systems, such as systems used to provide first-aid oxygen to passengers or supplemental oxygen for cabin crew mobility, usually stowed in overhead bins, provided that it is confirmed that the shut-off means mounted on the oxygen container is always closed when the system is stowed and not used.

3.4. Routing

The installation of the system should be such that components and pipelines are:

— adequately separated from electrical and fluid systems;
— routed so as to minimise joints and sharp bends;
— clear of moving controls and other mechanisms.

CS 25.1453(b) provides additional specifications related to oxygen pressure sources and the installation of tubing.

4. Oxygen hazards analysis (OHA)

The applicant should demonstrate that the oxygen systems and their components are designed so that the occurrence of an uncontrolled oxygen fire at the aircraft level is extremely improbable and does not result from a single failure.

To assess the consequences of system/component failures, the applicant should conduct an oxygen hazards analysis (OHA) in either a qualitative or a quantitative manner, and include the conclusions of the OHA in the oxygen systems system safety analysis (SSA).

The applicant should provide an OHA with a detailed assessment of the potential ignition and combustion mechanisms. In the OHA, the applicant should do the following:

4.1. Equipment failures

The applicant should use a detailed failure modes and effects analysis (FMEA) at the component level as the input for the OHA. The OHA should not include quality/production issues or human errors during assembly in.

The applicant should take into account all single failures, and any failure combinations that are not shown to be extremely improbable.

4.2. Operating conditions

The applicant should consider the worst-case operating conditions, including any failures determined from paragraph 4.1 that are not shown to be extremely improbable.

4.3. Components and materials

The analysis should cover all component designations and the materials of construction, including compounds and non-metallic material.

Most materials ignite at lower temperatures in an oxygen-enriched environment than in air. The applicant should therefore establish the auto-ignition temperature assuming a 100 % oxygen-enriched environment, and evaluate the materials used to determine whether they are flammable under the conditions specified in paragraph 4.2.

4.4. Ignition mechanisms

The assessment should address the identification of the possible internal ignition mechanisms. As a minimum, the following mechanisms should be assessed:

— adiabatic compression (pneumatic impact) (see Note 1 below)

— frictional heating
— mechanical impact
— particle impact
— fresh metal exposure
— static discharge
— electric arc
— chemical reaction
— resonance.

The applicant should evaluate each ignition mechanism under the conditions specified in paragraph 4.2 to determine whether it exists in the component and in the system considered.

Note 1: in calculating the temperature elevation due to oxygen compression, the applicant should use the transient peak pressures measured under paragraph 5.2, unless other values are duly demonstrated.

4.5. Kindling chain

The applicant should evaluate the ability of a fire to propagate and burn through a component, i.e. the kindling chain. The ignition and burning of a single component may produce sufficient heat to ignite the surrounding materials, leading to a burn-through of the component.

Therefore, if any of the ignition mechanisms assessed under paragraph 4.4 exists, the applicant should conduct an analysis to assess the kindling chain, based on the ability of the materials of construction to contain a fire.

5. Design considerations

5.1. High-pressure shut-off

As required by CS 25.1453(c), the applicant must keep to a minimum the parts of the system that are subjected to high-pressure oxygen, and must locate those parts so they are remote from occupied compartments to the extent that is practicable.

High-pressure shut-off valves should be designed to open and close slowly enough so as to avoid the possible risk of fire or explosion.

5.2. Pressure-limiting devices (e.g. relief valves)

As required by CS 25.1453(e), the applicant must design the pressure-limiting devices (e.g. relief valves), which protect parts of the system from excessive pressure, so that in the event of a malfunction of the normal pressure-controlling means (e.g. a pressure-reducing valve), they prevent the pressure from exceeding the applicable maximum working pressure multiplied by 1.33.

In addition, the performance of pressure-limiting devices should be tested on a complete system under the conditions specified in paragraph 4.2, but limited to failures that are not shown to be extremely improbable.

For testing purposes, oxygen can be replaced by an inert gas (e.g. nitrogen). However, the relationship between the pressure and the temperature would not be simulated by the inert gas and should be analysed separately. The transient pressure level (TPL) should be measured at various locations, and each component of the oxygen system exposed to the TPL should be demonstrated to sustain the pressure level.

The analysis detailed in paragraph 4.1 may identify single failures that affect the pressure-regulation device. These failures could include poppet/shaft/diaphragm blockages or ruptures, seal leakages, etc. of a pressure reducer. If the applicant excludes any of these single failures from the TPL assessment due to

— design considerations, such as a safety factor on the yield strength, the size of damage, etc. or
— a low estimated probability of the failure occurring,

they should provide a detailed rationale for this in the certification documents and agree it with EASA.

CS 25.1453(d) provides additional specifications related to the protection of oxygen pressure sources (e.g. tanks or cylinders) against overpressure.

5.3. Isolation

When the system includes multiple bottles as oxygen sources, each source should be protected from reverse flow or reverse pressure if a failure occurs on one source. Such isolation can be achieved by installing check valves or an equivalent means in an appropriate manner.

5.4. Non-metallic hoses

Except for flexible lines from oxygen outlets to the dispensing units, or where shown to be otherwise suitable for the installation, non-metallic hoses should not be used for any oxygen line that is normally pressurised during flight.

If non-metallic hoses with anti-collapse springs are used due to installation constraints, it should be ensured that inadvertent electrical current cannot reach the spring, as this could cause the hose to melt or burn, leading to an oxygen-fed fire. As an example, correctly grounded metallic braid may be considered to prevent inadvertent electrical current from reaching the spring.

In addition, non-metallic oxygen distribution lines should not be routed where they may be subjected to elevated temperatures, electric arcing, or released flammable fluids that might result from normal operation, or from a failure or malfunction of any system.

5.5. Grounding

All the oxygen lines and hoses should be grounded as appropriate.

5.6. Joints

Joints should, as far as possible, be assembled dry. However, where compounds are used for sealing, they should be approved for that purpose.

5.7. Recharging systems

Recharging systems, if installed, should be provided with means to prevent excessive rates of charging, which could result in dangerously high temperatures within the system. The recharging system should also provide protection from contamination.

Where in situ recharging facilities are provided, the compartments in which they are located should be accessible from outside the aircraft and be as remote as possible from other service points and equipment. Placards should be provided, located adjacent to the servicing point, with adequate instructions covering the precautions to be observed when the system is being charged.

AMC – SUBPART G

Amend AMC 25.1581 as follows:

AMC 25.1581
Aeroplane Flight Manual

(…)
5 GENERAL GUIDELINES

(…)
d. Any required weight and balance information that is not a physical part of the AFM, must be incorporated by reference in the Limitations Section of the AFM per CS 25.1583(c)~~ and AMC 25.1583(c)~~.
(…)

Create AMC 25.1587(c) as follows:

AMC 25.1587(c)

Landing distances in abnormal configurations

1. Purpose

This AMC provides guidance and recommendations on how to determine and present in the aeroplane flight manual (AFM) landing distance information appropriate to abnormal configurations or following the loss of normal services, and guidelines on which failure cases should be considered.

2. Related certification specifications

CS 25.125 Landing

CS 25.1585 Operating procedures

CS 25.1587 Performance information

3. Background

When a failure occurs in flight, the flight crew has to analyse the consequences of this failure on the landing. Some failures cause an increase in the landing distance, which must be evaluated. A diversion may be necessary if the destination aerodrome runway is no longer appropriate due to the increased landing distance.

For the production of AFM data, the applicant considers all failures and assesses their probability of occurrence. In addition, the question of the best presentation of the relevant data should be addressed.

This AMC does not consider configuration deviation list (CDL) items or any unserviceabilities identified in the master minimum equipment list (MMEL) that are known prior to dispatch.

4. Performance information

The applicant should determine information on the landing distance that is likely to be needed for landings in abnormal configurations, and following the loss of normal services. This information should consist of the horizontal distance from the point at which the main gear of the aeroplane is 50 ft above the landing surface to the point where the aeroplane comes to a complete stop for standard temperatures at each weight, altitude and wind within the operational limits established by the applicant for landing on a dry runway. This information should be established in accordance with CS 25.125(b)(4) and (5), CS 25.125(c)(1) and (2), CS 25.125(f) and with the following conditions:

(a) The aeroplane is in the landing configuration appropriate to the failure case being considered;

(b) A steady approach is maintained down to the 50-ft height, at not less than the recommended approach speed, and using the recommended approach procedure, appropriate to the failure case being considered. (See paragraph 5 below);

(c) Changes to configuration, power or thrust, and speed are made in accordance with the recommended procedure appropriate to the failure case being considered; and

(d) All deceleration devices with which the aeroplane is fitted, including reverse thrust, may be used during the on-ground part of the landing, to an extent dependent both on the characteristics of the aeroplane and on the recommended use of deceleration devices, provided that:

   (1) a practical procedure for their use has been established;

   (2) the controllability of the aeroplane during their use has been shown to be satisfactory (see paragraph 8 below); and

(3) they would be available, and their use is recommended, for the failure case being considered.

5. Operating procedures

It is intended that in deriving the landing distance of paragraph 4 above, which is required by CS 25.1585(a) to be included in the AFM, the applicant should use procedures that are generally based on the application of conventional stall and controllability margins. However, it is acknowledged that for failure cases, this is not always practical. Where the procedure uses less than the normal margin, this should be based on flight evaluation and stated in the AFM, along with advice on how this might affect the way the approach is conducted (e.g. reduced pitch manoeuvre capability and the ability to counteract wind shear). Nevertheless, for some configurations that cannot be easily flight-tested, a combination of simulation and analysis may be acceptable.

6. Effect of failures on landing distance

The applicant should determine information on landing distances in abnormal configurations in accordance with the procedures appropriate to the abnormal configuration for single failures and combinations of failures provided in the AFM that:

(a) have a probability of occurrence greater than approximately 10^{-7}; and

(b) result in more than a 10 % increase in landing distance.

If a procedure is included in the AFM for a failure case that:

(a) has a probability of occurrence less than 10^{-7}; and

(b) results in an increase in the landing distance of more than 10 %,

then information about the increase in landing distance should also be included in the AFM.

7. Effect of overspeed and wet runway

The applicant should provide information on the separate effects of a 10-kt overspeed and of a wet runway.

Note: overspeed in the above context refers to speed in excess of the approach speed recommended for the abnormal condition, which itself may be greater than the normal approach speed.

8. Deceleration devices

The applicant may include the use of deceleration devices during the on-ground part of the landing to the extent that directional control can be readily maintained during their use on a wet runway, with a crosswind component of not less than 10 kt from the adverse side.

9. Data derivation and AFM presentation

The applicant may derive the performance information described in paragraph 4 from calculations that are conservatively based on the best available information, on simulation or flight test, or any combination of these. The recommended operating procedures discussed in paragraph 5 should be presented in a simple manner (e.g. as increments in the landing distance, or approach speeds). The effects of overspeed and a wet runway may be presented as generalised information that covers a variety of abnormal configurations.

GENERAL
ACCEPTABLE MEANS OF COMPLIANCE (AMC)

Amend AMC 25-11 as follows:

(…)

CHAPTER 4
SAFETY ASPECTS OF ELECTRONIC DISPLAY SYSTEMS

21. General. (…)
e. System Safety Guidelines
(…)
(10) System Safety Assessment Guidelines. (…)

4 Heading. (…)

Table 6
Example Safety Objectives for
Heading Failure Conditions

Failure Condition	**Safety Objective**
Loss of ~~stabilised~~ heading ~~in~~ on the flight deck on both pilots' primary displays	Remote (*2*)
Loss of all heading displays ~~in~~ on the flight deck	Extremely Improbable
(…)	(…)

Notes

(1) System architecture and functional integration should be considered in determining the classification within this range. This failure may result in a sufficiently large reduction in safety margins to warrant a hazardous classification.

(2) This assumes the availability of an independent~~, non-stabilised~~ heading required by CS 25.1303 (a)(3).

(…)

Amend AMC 25-19 as follows:

AMC 25-19

Certification Maintenance Requirements

(…)

8 DESIGN CONSIDERATIONS RELATED TO SIGNIFICANT LATENT FAILURES

a. The applicant should implement practical and reliable failure monitoring and flight crew indication systems to detect failures that would otherwise be significant latent failures. A reliable failure monitoring and flight crew indication system should utilise current state-of-the-art technology to minimise the probability of falsely detecting and indicating non-existent failures.

(…)

11 SELECTION OF CMRs

a. Each CCMR should be reviewed and a determination made as to whether or not it should be a CMR.

Criteria and guidance are provided below for CMR selection or non-selection. The applicant may seek additional input from an advisory committee, as described in Appendix 2, before proposing CMRs to EASA for final review and approval.

b~~a~~. The applicant should provide sufficient information to enable an understanding of the Failure Conditions and the failure or event combinations that result in the CCMRs. CCMRs are evaluated in the context of the Failure Conditions in which they are involved, e.g. whether the significant latent failure is part of a dual failure, a triple failure, or more.

c~~b~~. The CMR designation should be applied in the case of catastrophic dual failures where one failure is latent. The CMR designation should also be applied to tasks that address wear out of a component involved in a Catastrophic Failure Condition that results from two failures.

d~~c~~. In all other cases, the CMR designation may not be necessary if there is a compatible MRBR task to accommodate the CCMR, provided that the applicant has the means in place to ensure that the CCMRs are protected in service. Appendix 3 provides examples of acceptable means of protection. Any means should be presented to EASA for acceptance.

These means of protection should address future evolutions of the compatible MRBR task proposed by the applicant or by the operator. In this respect, these means should ensure that in service:

— the compatible MRBR task would not be changed to the extent that the CCMR task intent is adversely affected, and

— the compatible MRBR task would not be escalated beyond the interval that would otherwise be required by a CMR.

The TC applicant should adequately describe the selected means of protection in the associated technical publication in order for the operator to be aware of the process to be followed if there are modifications to any compatible MRBR tasks that are included in the operator's aeroplane maintenance program (AMP).

e~~d~~. The rationale for the disposition of each CCMR should be presented to EASA for acceptance.

f~~e~~. Since the MSG-3 logic may not consider a Failure Condition containing three or more failures, it is possible that a CCMR might not have any identified MRBR tasks. In this case, a CMR will be required.

g~~f~~. Where the SSA identifies the need for a scheduled maintenance task, the CMR designation may also be used to detect a latent failure that would, in combination with one specified failure or event, lead to a Major Failure Condition. This CMR designation may be necessary if no adequate scheduled maintenance task has been identified in any other Instructions for Continued Airworthiness.

h~~g~~. If the SSA does not specify an interval shorter than the life of the aeroplane, an interval may be established by considering the factors that influence the outcome of the Failure Condition, such as the nature of the fault, the system(s) affected, field experience, or task characteristics.

(…)

APPENDIX 3

MEANS OF PROTECTION PROPOSED BY THE DESIGN APPROVAL HOLDER (DAH) AGAINST FUTURE EVOLUTIONS OF THE COMPATIBLE MRBR TASKS AND ~~DERIVED~~ TASKS OF THE OPERATOR'S AEROPLANE MAINTENANCE PROGRAM — EXAMPLES

(…)

EXAMPLE 1 — Traceability of CCMRs and MRBR tasks in the Airworthiness Limitations Section

(…)

d. If the DAH changes the compatible MRBR task to the extent that the intent of the corresponding CCMR task is adversely affected, this corresponding CCMR task is no longer accommodated. Therefore, the DAH could either propose ~~another~~ a new compatible MRBR ~~reference~~ task, if one exists, or create a new CMR in line with the intent of the previously referenced CCMR limitation. These changes to the ALS require EASA approval.

(…)

EXAMPLE 2 — Uniquely identifying the compatible MRBR tasks

(…)

g. Furthermore, the DAH shall describe in the MRBR what the operator needs to observe when changing the operator's aeroplane maintenance program (AMP). For tasks included in the AMP, which are based on marked MRBR tasks, the following applies:

   i. If the operator proposes to change the intent of a task, the operator should ask for the DAH's confirmation that this change does not adversely affect the intent of the corresponding CCMR task. ~~If the corresponding CCMR task is no longer accommodated, the operator needs to propose the inclusion of a mandatory task in the AMP in order to satisfy the intent of the referenced CCMR limitation.~~ These changes to the AMP require the approval of the competent authority responsible for the oversight of the operator.

(…)