f. Thrust Reverser - Failure Conditions:

(1) Inadvertent deployment of one or more reversers.

(2) Failure of one or more reversers to deploy when commanded.

(3) Failure of reverser component restraints (i.e., opening of D-ducts in flight, release of cascades during reverser operation, etc.).

[Amdt No: 25/1]

CS 25.903 Engines

ED Decision 2016/016/R

(See AMC 25.903)

(a) *Engine type certification.*

(1) reserved

(2) Any engine not certificated to CS-E must be shown to comply with CS-E 790 and CS-E 800 or be shown to have a foreign object ingestion service history in similar installation locations which has not resulted in any unsafe condition.

(3) Any engine not certificated to CS–E must be shown to comply with CS–E 780 or be shown to have an ice accumulation service history in similar installation locations which has not resulted in any unsafe conditions.

(b) *Engine isolation*. The powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or of any system that can affect the engine, will not –

(1) Prevent the continued safe operation of the remaining engines; or

(2) Require immediate action by any crew member for continued safe operation.

(c) *Control of engine rotation*. There must be means for stopping the rotation of any engine individually in flight, except that, for turbine engine installations, the means for stopping the rotation of any engine need be provided only where continued rotation could jeopardise the safety of the aeroplane. Each component of the stopping system on the engine side of the firewall that might be exposed to fire must be at least fire resistant. If hydraulic propeller feathering systems are used for this purpose, the feathering lines must be at least fire-resistant under the operating conditions that may be expected to exist during feathering.

(d) *Turbine engine installations*. For turbine engine installations –

(1) Design precautions must be taken to minimise the hazards to the aeroplane in the event of an engine rotor failure or of a fire originating within the engine which burns through the engine case. (See AMC 25.903(d)(1) and AMC 20-128A.)

(2) The powerplant systems associated with engine control devices, systems, and instrumentation, must be designed to give reasonable assurance that those engine operating limitations that adversely affect turbine rotor structural integrity will not be exceeded in service.

(e) *Restart capability.*

(1) Means to restart any engine in flight must be provided.

(2) An altitude and airspeed envelope must be established for in-flight engine restarting, and each engine must have a restart capability within that envelope. (See AMC 25.903(e)(2).)

(3) For turbine engine powered aeroplanes, if the minimum windmilling speed of the engines, following the in-flight shutdown of all engines, is insufficient to provide the necessary electrical power for engine ignition, a power source independent of the engine-driven electrical power generating system must be provided to permit in-flight engine ignition for restarting.

[Amdt 25/16]
[Amdt 25/18]

AMC 25.903(d)(1) Torching Flames

ED Decision 2003/2/RM

Where design precautions to minimise the hazard in the event of a combustion chamber burnthrough involve the use of torching flame resistant components and/or materials, satisfaction of the standards prescribed in British Standards Institution Specification 3G100: Part 2: Section 3: Sub-section 3.13, dated December 1973, is acceptable.

AMC 25.903(e)(2) Engines

ED Decision 2003/2/RM

1 General

1.1 In general the relight envelope required in CS 25.903(e)(2) may consist of two zones –

a. One zone where the engine is rotated by windmilling at or beyond the minimum rpm to effect a satisfactory relight, and

b. Another zone where the engine is rotated with assistance of the starter at or beyond the minimum rpm to effect a satisfactory relight.

1.2 The minimum acceptable relight envelope is defined in paragraph 2.

2 Envelope of Altitude and Airspeed

2.1 Sufficient flight tests should be made over the range of conditions detailed in 2.2 and 2.3, to establish the envelope of altitude and airspeed for reliable engine restarts, taking into account the results of restart tests completed by the engine constructor on the same type of engine in an altitude test facility or flying test bed, if available, and the experience accumulated in other aircraft with the same engine. The effect of engine deterioration in service should be taken into account.

2.2 Altitude and Configuration. From sea-level to the maximum declared restarting altitude in all appropriate configurations likely to affect restarting, including the emergency descent configuration.

2.3 Airspeed. From the minimum to the maximum declared airspeed at all altitudes up to the maximum declared engine restarting altitude. The airspeed range of the declared relight envelope should cover at least 30 kt.

2.4 Delay Tests. The tests referred to in paragraph 2.2 should include the effect on engine restarting performance of delay periods between engine shut-down and restarting of –

a. Up to two minutes, and

b. At least fifteen minutes or until the engine oil temperatures are stabilised at their cold soak value.

CS 25.904 Automatic Takeoff Thrust Control System (ATTCS)

ED Decision 2003/2/RM

Aeroplanes equipped with an engine power control system that automatically resets the power or thrust on the operating engine(s) when any engine fails during the takeoff must comply with the requirements of Appendix I.

CS 25.905 Propellers

ED Decision 2016/010/R

(See AMC 25.905)

(a) *reserved*

(b) Engine power and propeller shaft rotational speed may not exceed the limits for which the propeller is certificated. (See CS-P 50.)

(c) Each component of the propeller blade pitch control system must meet the requirements of CS-P 420.

(d) Design precautions must be taken to minimise the hazards to the aeroplane in the event a propeller blade fails or is released by a hub failure. The hazards which must be considered include damage to structure and critical systems due to impact of a failed or released blade and the unbalance created by such failure or release. (See AMC 25.905(d).)

[Amdt 25/3]
[Amdt 25/18]

AMC 25.905(d) Release of Propeller Debris

ED Decision 2003/2/RM

1 *Propeller Installation*. Design features of the propeller installation, including its control system, which are considered to influence the occurrence of propeller debris release and/or mode of such a failure should be taken into account when assessing the aeroplane against CS 25.905(d).

2 *Aeroplane Design Conditions*

2.1 *Impact Damage Zone*. All practical precautions should be taken in the aeroplane design to minimise, on the basis of good engineering judgement, the risk of Catastrophic Effects due to the release of part of, or a complete propeller blade. These precautions should be taken within an impact zone defined by the region between the surfaces generated by lines passing through the centre of the propeller hub making angles of at least five degrees forward and aft of the plane of rotation of each propeller. Within this zone at least the following should be considered.

a. The vulnerability of critical components and systems (e.g. location, duplication, separation, protection); and

b. The fire risk in the event of flammable fluid release in association with potential ignition sources (e.g. location, protection, shut-off means).

2.2 *Other Considerations*. Consideration should be given to the effects on the aeroplane resulting from –

a. The likely out of balance forces due to the release of part of, or a complete propeller blade; and

b. Loss of a complete propeller.

CS 25.907 Propeller vibration

ED Decision 2007/010/R

(See CS-P 530 and CS-P 550.)

(a) The magnitude of the propeller blade vibration stresses under any normal condition of operation must be determined by actual measurement or by comparison with similar installations for which these measurements have been made.

(b) The determined vibration stresses may not exceed values that have been shown to be safe for continuous operation.

[Amdt 25/3]

AMC 25.907 Propeller vibration

ED Decision 2021/015/R

EASA accepts Federal Aviation Administration (FAA) Advisory Circular (AC) 20-66B ‘Propeller Vibration and Fatigue’, of 24 March 2011, as an acceptable means of compliance with CS 25.907 regarding the evaluation of vibratory stresses on propellers. The applicant should use in that evaluation fatigue and structural data that is obtained in accordance with the Certification Specifications and Acceptable Means of Compliance for Propellers (CS-P).

When investigating the actual vibration behaviour of each propeller, the applicant should include the operating conditions that correspond to descent with the power levers at flight idle position and with speeds around maximum operating limit speed (V_{MO}). Experience has shown that such conditions may cause cyclic loads and vibrations that may exert excessive stress on some parts of the propeller. As aerodynamic loads differ depending on the position of the engine-propeller assembly on the aeroplane, the applicant should investigate the propellers’ vibration behaviour at all engine-propeller assembly positions.

[Amdt No: 25/27]

CS 25.925 Propeller clearance

ED Decision 2016/010/R

Unless smaller clearances are substantiated, propeller clearances with the aeroplane at maximum weight, with the most adverse centre of gravity, and with the propeller in the most adverse pitch position, may not be less than the following:

(a) *Ground clearance*. There must be a clearance of at least 18 cm (7 inches) (for each aeroplane with nose wheel landing gear) or (23 cm 9 inches (for each aeroplane with tail-wheel landing gear) between each propeller and the ground with the landing gear statically deflected and in the level take-off, or taxying attitude, whichever is most critical. In addition, there must be positive clearance between the propeller and the ground when in the level take-off attitude with the critical tyre(s) completely deflated and the corresponding landing gear strut bottomed.

(b) *Reserved*.

(c) *Structural clearance*. There must be –

(1) At least 25 mm (1·0 inches) radial clearance between the blade tips and the aeroplane structure, plus any additional radial clearance necessary to prevent harmful vibration;

(2) At least 13 mm (0·5 inches) longitudinal clearance between propeller blades or cuffs and stationary parts of the aeroplane; and

(3) Positive clearance between other rotating parts of the propeller or spinner and stationary parts of the aeroplane.

[Amdt 25/18]

CS 25.929 Propeller de-icing

ED Decision 2016/010/R

(See AMC 25.929)

(a) If certification for flight in icing conditions is sought, there must be a means to prevent or remove hazardous ice accumulations that could form in the icing conditions defined in Appendices C and O on propellers or on accessories where ice accumulation would jeopardise engine performance (see AMC 25.929(a)).

(b) If combustible fluid is used for propeller de-icing, CS 25.1181 to CS 25.1185 and CS 25.1189 apply.

[Amdt 25/16]
[Amdt 25/18]

AMC 25.929(a) Propeller de-icing

ED Decision 2016/010/R

1. Analysis.

The applicant should perform an analysis that:

(1) substantiates ice protection coverage in relation to chord length and span.

(2) substantiates the ice protection system power density.

(3) consider the effect of intercycle ice accretions and potential for propeller efficiency degradation for all flight phases.

(4) assess the different propeller Ice Protection System failure modes which are not extremely improbable and leading to the:

(i) highest propeller performance level degradation, and

(ii) highest propeller vibration levels taking also into account possible ice shedding.

(5) assess the impact of ice released by the propeller on the vibration levels, the adjacent components (if any) and the aircraft structure, both for normal operation and in the different propeller de-icing system failure modes.

Similarity to prior designs with successful service histories in icing may be used to show compliance. A demonstration of similarity requires an evaluation of both system and installation differences. The applicant should show specific similarities in the areas of physical, functional, thermodynamic, pneumatic, and aerodynamic characteristics as well as in environmental exposure. The analysis should show that propeller installation, operation, and effect on the aeroplane's performance and handling are equivalent to that of the same or similar propeller in the previously approved configuration. Differences should be evaluated for their effect on IPS functionality and on safe flight in icing. If there is uncertainty about the effects of the differences, the applicant should conduct additional tests and/or analysis as necessary and appropriate to resolve the open issues.

For showing compliance with the CS-25 certification specifications relative to SLD icing conditions represented by Appendix O, the applicant may use a comparative analysis. AMC 25.1420(f) provides guidance for comparative analysis.

2. Compliance Tests.

2.1 Surface temperature measurements should be made and monitored in dry air flight testing. These measurements are useful for correlating analytically predicted dry air temperatures with actual temperatures, and as a general indicator that the system is functioning and that each de-icer is heating. It is suggested that system current, brush block voltage (i.e., between each input brush and the ground brush) and system duty cycles be monitored to ensure that adequate power is applied to the de-icers.

2.2 System operation should be checked throughout the full rotation speed range. and propeller cyclic pitch range expected during flight in icing. Additionally, if the propeller Ice Protection System is regulated based on different outside parameters such as temperature, then system operation should also be checked against those parameters. All significant vibrations should be investigated.

2.3 The analysis assessing the effect of intercycle ice accretions and potential for propeller efficiency degradation should be adequately validated by tests.

2.4 The Ice Protection System failure modes determined in 1.4 above should be adequately validated by tests.

2.5 The applicant should consider the maximum temperatures a composite propeller blade may be subjected to when de-icers are energized. It may be useful to monitor de-icer bond-side temperatures. When performing this evaluation, the most critical conditions should be investigated (e.g., aeroplane on the ground; propellers not rotating) on a hot day with the system inadvertently energized.

2.6 Shedding procedures and post failure procedures mentioned in the AFM should be demonstrated by test.

3. Runback Ice.

Water not evaporated by thermal ice protection systems and unfrozen water in near-freezing conditions (or in conditions when the freezing fraction is less than one) may run aft and form runback ice. This runback ice can then accumulate additional mass from direct impingement. Computer codes may be unable to estimate the characteristics of the runback water or resultant ice shapes (rivulets or thin layers), but some codes may be able to estimate the mass of the runback ice. Thus runback ice should be determined experimentally, or the mass determined by computer codes with assumptions about runback extent and thickness similar to those used successfully with prior models. The runback ice should be determined both for normal operation and for propeller Ice Protection System failure modes when not operating in the predefined cycles.

The applicant should consider potential hazards resulting from the loss of propeller performance, the increased vibration level and the runback ice shedding.

[Amdt 25/16]
[Amdt 25/18]

CS 25.933 Reversing systems

ED Decision 2020/001/R

(See AMC 25.933)

(a) For turbojet reversing systems:

(1) Each system intended for ground operation only must be designed so that either:

(i) The aeroplane can be shown to be capable of continued safe flight and landing during and after any thrust reversal in flight; or

(ii) It can be demonstrated that any in-flight thrust reversal complies with CS 25.1309(b).

(See AMC 25.933(a)(1))

(2) Each system intended for inflight use must be designed so that no unsafe condition will result during normal operation of the system, or from any failure (or reasonably likely combination of failures) of the reversing system, under any anticipated condition of operation of the aeroplane including ground operation. Failure of structural elements need not be considered if the probability of this kind of failure is extremely remote.

(3) Each system must have means to prevent the engine from producing more than idle thrust when the reversing system malfunctions, except that it may produce any greater forward thrust that is shown to allow directional control to be maintained, with aerodynamic means alone, under the most critical reversing condition expected in operation.

(b) For propeller reversing systems:

(1) Each system intended for ground operation only must be designed so that no single failure (or reasonably likely combination of failures) or malfunction of the system will result in unwanted reverse thrust under any expected operating condition. Failure of structural elements need not be considered if this kind of failure is extremely remote.

(2) Compliance with this paragraph may be shown by failure analysis or testing, or both, for propeller systems that allow propeller blades to move from the flight low-pitch position to a position that is substantially less than that at the normal flight low-pitch position. The analysis may include or be supported by the analysis made to show compliance with the requirements of CS-P 70 for the propeller and associated installation components.

[Amdt 25/1]
[Amdt 25/18]
[Amdt 25/24]

AMC 25.933(a)(1) Unwanted in-flight thrust reversal of turbojet thrust reversers

ED Decision 2020/001/R

1. PURPOSE.

This Acceptable Means of Compliance (AMC) describes various acceptable means, for showing compliance with the requirements of CS 25.933(a)(1), "Reversing systems", of CS-25. These means are intended to provide guidance to supplement the engineering and operational judgement that must form the basis of any compliance findings relative to in-flight thrust reversal of turbojet thrust reversers.

2. RELATED CERTIFICATION SPECIFICATIONS.

CS 25.111, CS 25.143, CS 25.251, CS 25.571, CS 25.901, CS 25.903, CS 25.1155, CS 25.1305, CS 25.1309, CS 25.1322 and CS 25.1529

3. APPLICABILITY.

The requirements of CS 25.933 apply to turbojet thrust reverser systems. CS 25.933(a) specifically applies to reversers intended for ground operation only, while CS 25.933(b) applies to reversers intended for both ground and in-flight use.

This AMC applies only to unwanted thrust reversal in flight phases when the landing gear is not in contact with the ground; other phases (i.e., ground operation) are addressed by CS 25.901(c) and CS 25.1309.

4. BACKGROUND.

4.a. General. Most thrust reversers are intended for ground operation only. Consequently, thrust reverser systems are generally sized and developed to provide high deceleration forces while avoiding foreign object debris (FOD) ingestion, aeroplane surface efflux impingement, and aeroplane handling difficulty during landing roll. Likewise, aircraft flight systems are generally sized and developed to provide lateral and directional controllability margins adequate for handling qualities, manoeuvrability requirements, and engine-out VMC lateral drift conditions.

In early turbojet aeroplane designs, the combination of control system design and thrust reverser characteristics resulted in control margins that were capable of recovering from unwanted in-flight thrust reversal even on ground-use-only reversers; this was required by the previous versions of CS 25.933.

As the predominant large aeroplane configuration has developed into the high bypass ratio twin engine-powered model, control margins for the in-flight thrust reversal case have decreased. Clearly, whenever and wherever thrust reversal is intended, the focus must remain on limiting any adverse effects of thrust reversal. However, when demonstrating compliance with CS 25.933(a) or CS 25.933(b), the Authority has accepted that applicants may either provide assurance that the aeroplane is controllable after an in-flight thrust reversal event or that the unwanted in-flight thrust reversal event will not occur.

Different historical forms of the rule have attempted to limit either the effect or the likelihood of unwanted thrust reversal during flight. However, experience has demonstrated that neither method is always both practical and effective. The current rule, and this related advisory material, are intended to allow either of these assurance methods to be applied in a manner which recognises the limitations of each, thereby maximising both the design flexibility and safety provided by compliance with the rule.

4.b. Minimising Adverse Effects. The primary purpose of reversing systems, especially those intended for ground operation only, is to assist in decelerating the aeroplane during landing and during an aborted take-off. As such, the reverser must be rapid-acting and must be effective in producing sufficient reverse thrust. These requirements result in design characteristics (actuator sizing, efflux characteristics, reverse thrust levels, etc.) that, in the event of thrust during flight, could cause significant adverse effects on aeroplane controllability and performance.

If the effect of the thrust reversal occurring in flight produces an unacceptable risk to continued safe flight and landing, then the reverser operation and de-activation system must be designed to prevent unwanted thrust reversal. Alternatively, for certain aeroplane configurations, it may be possible to limit the adverse impacts of unwanted thrust reversal on aeroplane controllability and performance such that the risk to continued safe flight and landing is acceptable (discussed later in this AMC).

For reversing systems intended for operation in flight, the reverser system must be designed to adequately protect against unwanted in-flight thrust reversal.

CS 25.1309 and CS 25.901(c) and the associated AMC (AMC 25.1309 and AMC 25.901(c) provide guidance for developing and assessing the safety of systems at the design stage. This methodology should be applied to the total reverser system, which includes:

— the reverser;

— the engine (if it can contribute to thrust reversal);

— the reverser motive power source;

— the reverser control system;

— the reverser command system in the cockpit; and

— the wiring, cable, or linkage system between the cockpit and engine.

Approved removal, deactivation, reinstallation, and repair procedures for any element in the reverser or related systems should result in a safety level equivalent to the certified baseline system configuration.

Qualitative assessments should be done, taking into account potential human errors (maintenance, aeroplane operation).

Data required to determine the level of the hazard to the aeroplane in case of in-flight thrust reversal and, conversely, data necessary to define changes to the reverser or the aeroplane to eliminate the hazard, can be obtained from service experience, test, and/or analysis. These data also can be used to define the envelope for continued safe flight.

There are many opportunities during the design of an aeroplane to minimise both the likelihood and severity of unwanted in-flight thrust reversal. These opportunities include design features of both the aeroplane and the engine/reverser system. During the design process, consideration should be given to the existing stability and control design features, while preserving the intended function of the thrust reverser system.

Some design considerations, which may help reduce the risk from in-flight thrust reversal, include:

4.b.(1) Engine location to:

(i) Reduce sensitivity to efflux impingement.

(ii) Reduce effective reverse thrust moment arms

4.b.(2) Engine/Reverser System design to:

(i) Optimise engine/reverser system integrity and reliability.

(ii) Rapidly reduce engine airflow (i.e. auto-idle) in the event of an unwanted thrust reversal. Generally, such a feature is considered a beneficial safety item. In this case, the probability and effect of any unwanted idle command or failure to provide adequate reverse thrust when selected should be verified to be consistent with AMC 25.1309 and AMC 25.901(c).

(iii) Give consideration to the aeroplane pitch, yaw, and roll characteristics.

(iv) Consider effective efflux diameter.

(v) Consider efflux area.

(vi) Direct reverser efflux away from critical areas of the aeroplane.

(vii) Expedite detection of unwanted thrust reversal, and provide for rapid compensating action within the reversing system.

(viii) Optimise positive aerodynamic stowing forces.

(ix) Inhibit in-flight thrust reversal of ground-use-only reversers, even if commanded by the flight crew.

(x) Consider incorporation of a restow capability for unwanted thrust reversal.

4.b.(3) Airframe/System design to:

(i) Maximise aerodynamic control capability.

(ii) Expedite detection of thrust reversal, and provide for rapid compensating action through other airframe systems.

(iii) Consider crew procedures and responses.

The use of formal «lessons learned»-based reviews early and often during design development may help avoid repeating previous errors and take advantage of previous successes.

5. DEFINITIONS.

The following definitions apply for the purpose of this AMC:

a. Catastrophic: see AMC 25.1309

b. Continued Safe Flight and Landing: The capability for continued controlled flight and safe landing at an airport, possibly using emergency procedures, but without requiring exceptional pilot skill or strength. Some aeroplane damage may be associated with a failure condition, during flight or upon landing.

c. Controllable Flight Envelope and Procedure: An area of the Normal Flight Envelope where, given an appropriate procedure, the aeroplane is capable of continued safe flight and landing following an in-flight thrust reversal.