(c) For the most severe landing stop case, the same temperature conditions and changes used for the maximum kinetic energy accelerate-stop case should be assumed, except that further temperature change during the additional flight phase may be considered.

(d) The brake temperature at the commencement of the braking manoeuvre should be determined using the rational analysis method. However, in the absence of such analysis, an arbitrary heat sink temperature should be used equal to the normal ambient temperature, increased by the amount that would result from a 10 percent maximum kinetic energy accelerate-stop for the acceleratestop case and from a 5 percent maximum kinetic energy accelerate-stop for landing cases. The temperature determined for the beginning of the test becomes the highest allowable temperature at commencement of the take-off run unless another test is performed at a higher temperature.

(3) *Substantiation*.

(a) Substantiation is required to show that the wheel and brake assembly is capable of absorbing the determined levels of kinetic energy at all permitted wear states up to and including the declared fully worn limits. The term “wear state" is used to clarify that consideration should be given to possible inconsistencies or irregularities in brake wear in some circumstances, such as greater wear at one end of the heat sink than the other end. Qualification related to equally distributed heat sink wear may not be considered adequate. If in-service wear distribution is significantly different from wear distribution used during qualification testing, additional substantiation and/or corrective action may be necessary.

(b) The minimum initial brakes-on speed used in the dynamometer tests should not be more than the velocity (V) used in the determination of the kinetic energy requirements of CS 25.735(f). This assumes that the test procedure involved a specific rate of deceleration and, therefore, for the same amount of kinetic energy, a higher initial brakes-on speed would result in a lower rate of energy absorption. Such a situation is recognised and is similarly stated in (E)TSO-C135, which provides an acceptable means for brake approval under CS 25.735(a).

(c) For certification purposes, a brake having a higher initial brakes-on speed is acceptable if the dynamometer test showed that both the energy absorbed and the energy absorption rates required by CS 25.735(f) had been achieved.

(d) Brake qualification tests are not intended as a means of determining expected aeroplane stopping performance, but may be used as an indicator for the most critical brake wear state for aeroplane braking performance measurements.

g. Ref. CS 25.735(g) Brake Condition after High Kinetic Energy Dynamometer Stop(s)

(1) Following the high kinetic energy stop(s), the parking brake should be capable of restraining further movement of the aeroplane and should maintain this capability for the period during which the need for an evacuation of the aeroplane can be determined and then fully accomplished. It should be demonstrated that, with a parking brake application within a period not exceeding 20 seconds of achieving a

full stop, or within 20 seconds from the time that the speed is retarded to 37 km/h (20 knots) (or lower), in the event that the brakes are released prior to achieving a full stop (as permitted by (E)TSO-C135), the parking brake can be applied normally and that it remains functional for at least 3 minutes.

(2) Practical difficulties associated with dynamometer design may preclude directly demonstrating the effectiveness of the parking brake in the period immediately following the high energy dynamometer stop(s). Where such difficulties prevail, it should be shown that, for the 3-minute period, no structural failure or other condition of the brake components occurs that would significantly impair the parking brake function.

(3) Regarding the initiation of a fire, it should be demonstrated that no continuous or sustained fire, extending above the level of the highest point of the tyre, occurs before the 5-minute period has elapsed. Neither should any other condition arise during this same period or during the stop, either separately or in conjunction with a fire, that could be reasonably judged to prejudice the safe and complete aeroplane evacuation. Fire of a limited extent and of a temporary nature (e.g., those involving wheel bearing lubricant or minor oil spillage) is acceptable. For this demonstration, neither fire-fighting means nor coolants may be applied.

h. Ref. CS 25.735(h) Stored energy systems

(1) Stored energy systems use a self-contained source of power, such as a pressurised hydraulic accumulator or a charged battery (refer to CS 25.735(h)). This requirement is not applicable for those aeroplanes that provide a number of independent braking systems, including a stored energy system, but are not "reliant" on the stored energy system for the demonstration of compliance with CS 25.735(b).

(2) The indication of usable stored energy should show:

(a) The minimum energy level necessary to meet the requirements of CS 25.735(b)(1) and (h) (i.e., the acceptable level for dispatch of the aeroplane);

(b) The remaining energy level; and

(c) The energy level below which further brake application may not be possible.

(3) If a gas pressurised hydraulic accumulator is to be used as the energy storage means, indication of accumulator pressure alone is not considered adequate means to indicate available stored energy, unless verification can be made of the correct pre-charge pressure with the hydraulic system pressure off and the correct fluid volume with the hydraulic system pressure on. Furthermore, additional safeguards may be necessary to ensure that sufficient energy will be available at the end of the flight. Similar considerations should be made if other stored energy systems are used.

(4) A full brake application cycle is defined as an application from brakes fully released to brakes fully applied, and back to fully released.

i. Ref. CS 25.735(i) Brake wear indicators

The indication means should be located such that no special tool or illumination (except in darkness) is required. Expert interpretation of the indication should not be necessary (refer to CS 25.735(i)).

j. Ref. CS 25.731(d) and CS 25.735(j) Over-temperature and Over-pressure Burst Prevention

Over-temperature and over-pressure burst prevention. Generally, two separate types of protection should be provided: one specifically to release the tyre pressure should the wheel temperature increase to an unacceptable level, and the other to release the tyre pressure should the pressure become unacceptably high, particularly during the inflation process. The temperature sensitive devices are required in braked wheels only, but the pressure sensitive devices are required in all wheels (refer to CS 25.735(j) and 25.731(d)).

(1) The temperature sensitive devices (e.g., fuse or fusible plugs) should be sufficient in number and appropriately located to reduce the tyre pressure to a safe level before any part of the wheel becomes unacceptably hot, irrespective of the wheel orientation. The devices should be designed and installed so that once operated (or triggered) their continued operation is not impaired by the releasing gas. The effectiveness of these devices in preventing hazardous tyre blow-out or wheel failure should be demonstrated. It should also be demonstrated that the devices will not release the tyre pressure prematurely during take-off and landing, including during “quick turnaround” types of operation.

(2) It should be shown that the over-pressurisation devices, or the devices in conjunction with the tyre inflation means *permanently* installed in the wheel, would not permit the tyre pressure to reach an unsafe level regardless of the capacity of the inflation source.

(3) Both types of devices should normally be located within the structure of the wheel in positions that minimise the risk of damage or tampering during normal maintenance.

k. Ref. CS 25.735(k) Compatibility

Compliance with CS 25.735(k) may be achieved by the following:

(1) As part of the overall substantiation of safe and anomaly free operation, it is necessary to show that no unsafe conditions arise from incompatibilities between the brakes and brake system with other aeroplane systems and structures. Areas that should be explored include anti-skid tuning, landing gear dynamics, tyre type and size, brake combinations, brake characteristics, brake and landing gear vibrations, etc. Similarly, wheel and tyre compatibility should be addressed. These issues should be readdressed when the equipment is modified.

(2) During brake qualification testing, sufficient dynamometer testing over the ranges of permissible brake wear states, energy levels, brake pressures, brake temperatures, and speeds should be undertaken to provide information necessary for systems integration.

l. Ref. CS 25.735(l) Wheel brake temperature.

The use of fusible plugs in the wheels is not a complete safeguard against damage due to tyre burst. Where brake overheating could be damaging to the structure of, or equipment in, the wheel wells, an indication of brake temperature should be provided to warn the pilot.

[Amdt No: 25/2]
[Amdt No: 25/8]
[Amdt No: 25/12]
[Amdt No: 25/14]
[Amdt No: 25/18]

AMC 25.735(f) Brakes

ED Decision 2003/2/RM

For determination of the design landing brake kinetic energy capacity rating, the initial condition of the brakes may be selected and can be any condition representative of service use, including new, and which satisfies the applicable ETSO or other acceptable brake qualification test standard.

CS 25.745 Nose-wheel steering

ED Decision 2016/010/R

(See AMC 25.745)

(a) The nose-wheel steering system, unless it is restricted in use to low-speed manoeuvring, must be so designed that exceptional skill is not required for its use during take-off and landing, including the case of cross-wind, and in the event of sudden power-unit failure at any stage during the take-off run. This must be shown by tests. (See AMC 25.745(a).)

(b) It must be shown that, in any practical circumstances, movement of the pilot's steering control (including movement during retraction or extension or after retraction of the landing gear) cannot interfere with the correct retraction or extension of the landing gear.

(c) Under failure conditions the system must comply with CS 25.1309(b) and (c). The arrangement of the system must be such that no single failure will result in a nose-wheel position, which will lead to a Hazardous Effect. Where reliance is placed on nose-wheel steering in showing compliance with CS 25.233, the nose-wheel steering system must be shown to comply with CS 25.1309. (See AMC 25.745(c).)

(d) The nose-wheel steering system, towing attachment(s), and associated elements must be designed or protected by appropriate means such that during ground manoeuvring operations effected by means independent of the aeroplane:

(1) Damage affecting the safe operation of the nose-wheel steering system is precluded, or

(2) A flight crew alert is provided, before the start of taxiing, if damage may have occurred (see AMC 25.1322).

(See AMC 25.745(d))

(e) Unless the nose-wheel, when lowered, is automatically in the fore-and-aft attitude successful landings must be demonstrated with the nose-wheel initially in all possible off-centre positions.

[Amdt 25/2]
[Amdt 25/13]
[Amdt 25/18]

AMC 25.745(a) Nose-wheel steering

ED Decision 2003/2/RM

In a powered nose-wheel steering system the normal supply for steering should continue without interruption in the event of failure of any one power-unit. With the remaining power-units operating at ground idling condition, the power supply should be adequate –

a. To complete an accelerate-stop manoeuvre following a power-unit failure which occurs during take-off, and

b. To complete a landing manoeuvre following a power-unit failure which occurs during take-off or at any later stage of flight.

AMC 25.745(c) Nose-wheel steering

ED Decision 2003/2/RM

1 No failure or disconnection need be assumed in respect of parts of proven integrity e.g. a simple jack or manual selector valve, but slow leakage from pipe joints and fracture of pipes should be considered as probable failures.

2 In assessing where the inadvertent application of steering torque as a result of a single failure would lead to danger, allowance may be made for the pilot's instinctive reaction to the effects of the fault. However, dependent on the urgency and rapidity of warning of the failure given to the pilot, allowance should be made for a reaction time before it is assumed that the pilot takes any corrective action.

AMC 25.745(d) Nose-wheel steering

ED Decision 2013/010/R

CS 25.745(d) provides for the two following options:

1. A 'no damage' situation exists, because damage is precluded.

2. Damage can occur, but indication to the flight crew is provided.

   (a) General consideration to CS 25.745(d)(1) and (2)

   Some damage may occur during ground manoeuvring activities that can be considered acceptable and judged to be normal wear and tear. It is not intended that such damage needs necessarily to be precluded or that it should initiate a flight crew alert.

   (b) To comply with CS 25.745(d)(1) the following applies:

   The aeroplane may be designed in such a way that under all ground manoeuvring operations by any towing means, no damage affecting the steering system can occur.

   Examples are:

   — The steering system is designed sufficiently strong to resist any applied towing input.

   — The steering system is designed to allow 360 degrees rotation.

   — The steering system is disconnected either automatically or by operational procedure.

   — The steering system is protected by shear sections installed on the nose landing gear.

(c) To comply with CS 25.745(d)(2), the following applies:

When protection is afforded by the flight crew alerting system, the damage detection means should be independent of the availability of aeroplane power supplies and should be active during ground manoeuvring operations effected by means independent of the aeroplane. If damage may have occurred, a latched signal should be provided to the flight crew alerting system.

(d) Alternative Acceptable Means of Compliance to CS 25.745(d)(1) and (2):

In the case where the aeroplane design does not comply with CS 25.745(d)(1) and (d)(2), the following apply:

(1) The Aeroplane Flight Manual, in the Section Limitations, should include a statement that 'Towbarless towing is prohibited', or

(2) The Aeroplane Flight Manual, in the Section Limitations, should include a statement that:

'Towbarless towing is prohibited unless the towbarless towing operations are performed in compliance with the appropriate operational regulation using towbarless towing vehicles that are designed and operated to preclude damage to the aeroplane nose wheel steering system, or which provide a reliable and unmistakable warning when damage to the steering system has occurred.

Towbarless towing vehicles that are specifically accepted for this type of aeroplane are listed in the [appropriate maintenance documentation] provided by the aeroplane manufacturer.'

'Appropriate maintenance documentation' means Instructions for Continued Airworthiness as described in Appendix H, paragraph H25.3(a)(4) of CS-25.

(3) The acceptance by the aeroplane manufacturer of the applicable towbarless towing vehicles and its reliability of the oversteer protection and/or indication system as referred to in subparagraph ((d)(2)) above should be based on the following:

(i) The aeroplane Nose Wheel Steering Failure Analysis should include the effects of possible damage caused by towbarless towing operations.

(ii) If the Nose Wheel Steering Failure Analysis shows that damage to the steering system by the use of towbarless towing may result in a Failure Condition that can be classified as Hazardous or Catastrophic (refer to CS 25.1309), the acceptance of a towing vehicle oversteer protection and/or indication system should be based on an aeroplane safety analysis, encompassing the reliability of that vehicle system in order to meet the aeroplane safety objectives.

(iii) If the Nose Wheel Steering Failure Analysis shows that damage to the steering system by the use of towbarless towing may result in a Failure Condition that can be classified as Major or less severe, the aeroplane manufacturer can accept the design of the towing vehicle oversteer indication and/or protection system based on a 'Declaration of Compliance', issued by the towbarless towing vehicle manufacturer. This declaration will state that the vehicle design complies with the applicable standards (SAE ARPs, Aeroplane Towing Assessment Criteria Document) and that it is designed and built under ISO 9001 quality standards or equivalent.

Such a declaration must be made regarding all Towbarless Towing Vehicles to be used for ground manoeuvring of CS-25 certificated aeroplanes.

[Amdt 25/13]

PERSONNEL AND CARGO ACCOMMODATIONS

CS 25.771 Pilot compartment

ED Decision 2003/2/RM

(a) Each pilot compartment and its equipment must allow the minimum flight crew (established under CS 25.1523) to perform their duties without unreasonable concentration or fatigue.

(b) The primary controls listed in CS 25.779(a), excluding cables and control rods, must be located with respect to the propellers so that no member of the minimum flight crew (established under CS 25.1523), or part of the controls, lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the centre of the propeller hub making an angle of 5° forward or aft of the plane of rotation of the propeller.

(c) If provision is made for a second pilot, the aeroplane must be controllable with equal safety from either pilot seat.

(d) The pilot compartment must be constructed so that, when flying in rain or snow, it will not leak in a manner that will distract the crew or harm the structure.

(e) Vibration and noise characteristics of cockpit equipment may not interfere with safe operation of the aeroplane.

CS 25.772 Pilot compartment doors

ED Decision 2003/2/RM

For an aeroplane that has a lockable door installed between the pilot compartment and the passenger compartment: -

(a) For aeroplanes with passenger seating configuration of 20 seats or more, the emergency exit configuration must be designed so that neither crewmembers nor passengers require use of the flight deck door in order to reach the emergency exits provided for them; and

(b) Means must be provided to enable flight-crew members to directly enter the passenger compartment from the pilot compartment if the cockpit door becomes jammed.

(c) There must be an emergency means to enable a crewmember to enter the pilot compartment in the event that the flight crew becomes incapacitated.

CS 25.773 Pilot compartment view

ED Decision 2016/010/R

(See AMC 25.773)

(a) *Non*-precipitation conditions. For non-precipitation conditions, the following apply:

    (1) Each pilot compartment must be arranged to give the pilots a sufficiently extensive, clear, and undistorted view, to enable them to safely perform any manoeuvres within the operating limitations of the aeroplane, including taxiing, take-off, approach and landing.

    (2) Each pilot compartment must be free of glare and reflection that could interfere with the normal duties of the minimum flight crew (established under CS 25.1523). This must be shown in day and night flight tests under non-precipitation conditions.

(b) *Precipitation conditions*. For precipitation conditions, the following apply:

(1) The aeroplane must have a means to maintain a clear portion of the windshield during precipitation conditions, sufficient for both pilots to have a sufficiently extensive view along the flight path in normal flight attitudes of the aeroplane. This means must be designed to function, without continuous attention on the part of the crew, in –

(i) Heavy rain at speeds up to 1·5 V_{SR1}, with lift and drag devices retracted; and

(ii) The icing conditions specified in Appendix C and the following icing conditions specified in Appendix O, if certification for flight in icing conditions is sought (See AMC 25.773(b)(1)(ii)):

(A) For aeroplanes certificated in accordance with CS 25.1420(a)(1), the icing conditions that the aeroplane is certified to safely exit following detection.

(B) For aeroplanes certificated in accordance with CS 25.1420(a)(2), the icing conditions that the aeroplane is certified to safely operate in and the icing conditions that the aeroplane is certified to safely exit following detection.

(C) For aeroplanes certificated in accordance with CS 25.1420(a)(3), all icing conditions.

(2) No single failure of the systems used to provide the view required by sub-paragraph (b)(1) of this paragraph must cause the loss of that view by both pilots in the specified precipitation conditions.

(3) The first pilot must have a window that:

(i) is openable under the conditions prescribed in sub-paragraph (b)(1) of this paragraph when the cabin is not pressurised;

(ii) provides the view specified in (b)(1); and

(ii) gives sufficient protection from the elements against impairment of the pilot's vision

(4) The openable window specified in sub-paragraph (b)(3) of this paragraph need not be provided if it is shown that an area of the transparent surface will remain clear sufficient for at least one pilot to land the aeroplane safely in the event of -

(i) Any system failure or combination of failures, which is not, Extremely Improbable in accordance with CS 25.1309, under the precipitation conditions specified in sub-paragraph (b)(1) of this paragraph.

(ii) An encounter with severe hail, birds, or insects. (See AMC 25.773(b)(4))

(c) *Internal windshield and window fogging*. The aeroplane must have a means to prevent fogging to the internal portions of the windshield and window panels over an area which would provide the visibility specified in sub-paragraph (a) of this paragraph under all internal and external ambient conditions, including precipitation conditions, in which the aeroplane is intended to be operated. (See AMC 25.773(c))

(d) Fixed markers or other guides must be installed at each pilot station to enable the pilots to position themselves in their seats for an optimum combination of outside visibility and instrument scan. If lighted markers or guides are used they must comply with the requirements specified in CS 25.1381.

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[Amdt No: 25/4]
[Amdt No: 25/16]
[Amdt No: 25/18]

AMC 25.773 Pilot compartment view

ED Decision 2015/008/R

The FAA Advisory Circular AC 25.7731: Pilot Compartment View Design Considerations (January 8, 1993), may be used to support the demonstration of compliance with CS 25.773.

[Amdt 25/4]
[Amdt 25/16]

AMC 25.773(b)(1)(ii) Pilot compartment view in icing conditions

ED Decision 2016/010/R

CS 25.773(b)(1)(ii) requires that the aeroplane have a means of maintaining a clear portion of windshield in the icing conditions defined in Appendix C and in certain Appendix O icing conditions (corresponding to the CS 25.1420 certification option selected).

The effectiveness of all cockpit windows and windshield ice and precipitation protective systems should be established within relevant icing environment. Sufficient tests, including flight test in natural or simulated Appendix C icing conditions, should be performed to validate the performance prediction done by analysis.

When thermal ice protection systems are used (e.g. electrical heating system), a thermal analysis should be conducted to substantiate the selected nominal heated capacity. Past certification experience has shown that a nominal heating capacity of 70 W/dm^2 provide adequate protection in icing conditions; such value, if selected, should anyway be substantiated by the thermal analysis. The applicant should conduct dry air flight tests to verify the thermal analysis. Measurements of both the inner and outer surface temperature of the protected windshield area may be needed to verify the thermal analysis. The thermal analysis should show that the windshield surface temperature is sufficient to maintain anti-icing capability without causing structural damage to the windshield.

When anti-icing fluid systems are used, tests shall be performed to demonstrate that the fluid does not become opaque at low temperatures. The AFM should include information advising the flight crew how long it will take to deplete the amount of fluid remaining in the reservoir.

An evaluation of visibility, including distortion effects through the protected area, should be made for both day and night operations. In addition, the size and location of the protected area should be reviewed to confirm that it provides adequate visibility for the flight crew, especially during the approach and landing phases of flight.

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.

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