(d) The interconnection must be designed for the loads resulting when interconnected flap or slat surfaces on one side of the plane of symmetry are jammed and immovable while the surfaces on the other side are free to move and the full power of the surface actuating system is applied. (See AMC 25.701(d).)

[Amdt 25/18]

AMC 25.701(d) Flap and slat interconnection

ED Decision 2019/013/R

FAA Advisory Circular AC 25-14 High Lift and Drag Devices, dated 5-4-88, incorporated in FAA Advisory Circular AC 25-22, Certification of Transport Airplane Mechanical Systems, dated 14 March 2000, is accepted by EASA as providing acceptable means of compliance with CS 25.701(d).

[Amdt No: 25/23]

CS 25.703 Take-off warning system

ED Decision 2003/2/RM

(See AMC 25.703)

A take-off warning system must be installed and must meet the following requirements:

(a) The system must provide to the pilots an aural warning that is automatically activated during the initial portion of the take-off roll if the aeroplane is in a configuration, including any of the following that would not allow a safe take-off:

(1) The wing-flaps or leading edge devices are not within the approved range of take-off positions.

(2) Wing spoilers (except lateral control spoilers meeting the requirements of CS 25.671), speed brakes, or longitudinal trim devices are in a position that would not allow a safe take-off.

(3) The parking brake is unreleased.

(b) The aural warning required by sub-paragraph (a) of this paragraph must continue until –

(1) The take-off configuration is changed to allow a safe take-off;

(2) Action is taken by the pilot to terminate the take-off roll;

(3) The aeroplane is rotated for take-off; or

(4) The warning is manually silenced by the pilot. The means to silence the warning must not be readily available to the flight crew such that it could be operated instinctively, inadvertently, or by habitual reflexive action. Before each take-off, the warning must be rearmed automatically, or manually if the absence of automatic rearming is clear and unmistakable.

(c) The means used to activate the system must function properly for all authorised take-off power settings and procedures, and throughout the ranges of take-off weights, altitudes, and temperatures for which certification is requested.

AMC 25.703 Take-off Configuration Warning Systems

ED Decision 2012/008/R

1. *PURPOSE*. This AMC provides guidance for the certification of take-off configuration warning systems installed in large aeroplanes. Like all AMC material, this AMC is not mandatory and does not constitute a requirement. It is issued to provide guidance and to outline a method of compliance with the rules.

2. *RELATED CERTIFICATION SPECIFICATIONS*.

   CS 25.703, 25.1301, 25.1309, 25.1322, 25.1357, 25.1431, and 25.1529.

3. *RELATED MATERIAL*.

   a. Federal Aviation Administration and EASA Documents.

      (1) Advisory Circular 25.1309-( ), System Design and Analysis and AC 25-11 Transport Category Airplane Electronic Display Systems. Advisory circulars can be obtained from the U.S. Department of Transportation, M-443.2, Subsequent Distribution Unit, Washington, D.C. 20590.

      (2) Report DOT/FAA/RD-81/38, II, Aircraft Alerting Systems Standardization Study, Volume II, Aircraft Alerting Systems Design Guidelines. This document can be obtained from the National Technical Information Service, Springfield, Virginia 22161.

      (3) FAA report, Review of Take-off Configuration Warning Systems on Large Jet Transports, dated April 29, 1988. This document can be obtained from the Federal Aviation Administration, Transport Airplane Directorate, 1601 Lind Avenue, S.W., Renton, Washington, 98055-4056.

      (4) EASA AMC 25.1322 (Alerting Systems).

      (5) EASA AMC 25-11 (Electronic Display Systems).

      (6) EASA AMC 25.1309 (System Design and Analysis).

      (7) EASA AMC 20-115 (Software Considerations for Airborne Systems and Equipment Certification)

   b. *Industry Documents*.

      (1) Aerospace Recommended Practice (ARP) 450D, Flight Deck Visual, Audible and Tactile Signals; ARP 4012/4, Flight Deck Alerting Systems (FAS). These documents can be obtained from the Society of Automotive Engineers, Inc. (SAE), 400 Commonwealth Drive, Warrendale, Pennsylvania 15096.

      (2) EUROCAE ED-14D/RTCA document DO-160D or latest version, Environmental Conditions and Test Procedures for Airborne Equipment; AMC 20-115, Software Considerations for Airborne Systems and Equipment Certification. RTCA documents can be obtained from the RTCA, One McPherson Square, Suite 500, 1425 K Street Northwest, Washington, D.C. 20005.

      (3) ARINC 726, Flight Warning Computer System. This document can be obtained from the ARINC, 2551 Riva Road, Annapolis, Maryland 21401.

4. *BACKGROUND*. A number of aeroplane accidents have occurred because the aeroplane was not properly configured for take-off and a warning was not provided to the flight crew by the take-off configuration warning system. Investigations of these accidents have indicated a need for guidance material for design and approval of take-off configuration warning systems.

5. *DISCUSSION.*

a. Regulatory Basis.

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

(2) Prior to JAR-25 Amendment 5 and FAR Part-25 Amendment 25-42, there was no requirement for a take-off configuration warning system to be installed in large aeroplanes. Since this amendment is not retroactive, some large aeroplane models in service today may not have take-off configuration warning systems; however, all large turbojet transports currently in service, even those with a certification basis established prior to 1978, include a take-off configuration warning system in the basic design. These include the majority of large aeroplanes.

(3) Other general rules such as CS 25.1301, 25.1309, 25.1322, 25.1357 and 25.1431 for electronic system installations also apply to take-off configuration warning systems.

b. *System Criticality*.

(1) It has been Aviation Authorities policy to categorise systems designed to alert the flight crew of potentially hazardous operating conditions as being at a level of criticality associated with a probable failure condition. (For a definition of this terminology together with discussions and guidelines on the classification of failure conditions and the probability of failures, see AMC 25.1309). This is because failures of these systems, in themselves, are not considered to create an unsafe condition, reduce the capability of the aeroplane, or reduce the ability of the crew to cope with adverse operating conditions. Other systems which fall into this category include stall warning systems, overspeed warning systems, ground proximity warning systems, and windshear warning systems.

(2) Even though AMC 25.1309 does not define an upper probability limit for probable failure conditions, generally, it can be shown by analysis that such systems have a probability of failure (of the ability to adequately give a warning) which is approximately 1.0 x 10E-3 or less per flight hour. This probability does not take into account the likelihood that a warning will be needed. Systems which are designed to meet this requirement are usually single channel systems with limited built-in monitoring. Maintenance or pre-flight checks are relied on to limit the exposure time to undetected failures which would prevent the system from operating adequately.

(3) Applying the practice given in sub-paragraphs b(1) and b(2) above to take-off configuration warning systems is not considered to result in an adequate level of safety when the consequence of the combination of failure of the system and a potentially unsafe take-off configuration could result in a major/catastrophic failure condition. Therefore, these systems should be shown to meet the criteria of AMC 25.1309 pertaining to a major failure condition, including design criteria and in-service maintenance at specified intervals. This will ensure that the risk of the take-off configuration warning system being unavailable when required to give a warning, if a particular unsafe configuration occurs, will be minimised.

(4) If such systems use digital electronic technology, a software Development Assurance Level (DAL) should be used, in accordance with AMC 20-115, which is compatible with the system integrity determined by the AMC 25.1309 analysis.

(5) Since a false warning during the take-off run at speeds near V1 may result in an unnecessary rejected take-off (RTO), which could lead to a mishap, the occurrence of a false warning during the take-off should be remote in accordance with AMC 25.1309.

(6) If the take-off configuration warning system is integrated with other systems that provide crew alerting functions, the level of criticality of common elements should be commensurate with that of the take-off configuration warning system unless a higher level is dictated by one or more of the other systems.

c. *Design Considerations*.

(1) A review of existing take-off configuration warning systems has shown a trend towards increased sophistication of design, partly due to the transition towards digital electronic technology which is amenable to self-monitoring and simple testing. The net result has been an improvement in reliability, fewer unwanted warnings and enhanced safety.

(2) With the objective of continuing this trend, new systems should be designed using the objectives and criteria of AMC 25.1309. Analysis should include all the remote sensors, transducers and the elements they depend on, as well as any take-off configuration warning system line replaceable unit (LRU) and the actual visual and aural warning output devices.

(3) Unwanted warnings may be reduced by inhibiting the take-off configuration warning system where it is safer to do so, e.g., between V1 and VR, so that a hazardous rejected take-off is not attempted. Inhibition of the take-off configuration warning system at high speeds will also avoid any confusion from the occurrence of a warning during a touch-and-go landing. This is because the basic message of an alert is to stop because it is unsafe to take off. It may or may not tell

the flight crew which surface or system is wrong. A warning may be more hazardous than reliance on the flight crew's skill and training to cope with the situation.

(4) Even though CS 25.703 specifies those inputs common to most large aeroplanes that must be included in the design, each aeroplane model should be carefully reviewed to ascertain that any configuration or trim setting that could jeopardise a safe take-off has an input to the take-off warning system unless a separate and adequate warning is already provided by another system. There may be aeroplane configurations or electronically positioned lateral or longitudinal trim unique to a particular model that constitute this hazard. In the event that it is necessary to inhibit the warning from a particular system during the entire take-off roll, an equivalent level of safety finding would be required.

(5) Automatic volume adjustment should be provided to maintain the aural warning volume at an appropriate level relative to cockpit ambient sound. According to Report No. DOT/FAA/RD-81/38, II entitled "Aircraft Alerting Systems Standardisation Study, Volume II - Aircraft Alerting System Design Guidelines," aural signals should exceed masked threshold by 8 ± 3 dB.

(6) Of particular importance in the design of take-off configuration warning systems is the elimination of nuisance warnings. These are warnings generated by a system which is functioning as designed but which are inappropriate or unnecessary for the particular phase of operation. Attempting to eliminate nuisance warnings cannot be overemphasised because any indication which could cause the flight crew to perform a high speed rejected take-off, or which distracts or adversely affects the flight crew's performance of the take-off manoeuvre, creates a hazard which could lead to an accident. In addition, any time there are nuisance warnings generated, there is a possibility that the flight crew will be tempted to eliminate them through system deactivation, and by continually doing this, the flight crew may be conditioned to ignore a valid warning.

(7) There are a number of operations that could produce nuisance warnings. Specifically, single engine taxi for twin engine aeroplanes, or in the case of 3 and 4 engine aeroplanes, taxi with fewer than all engines operating is a procedure used by some operators for the purpose of saving fuel. Nuisance warnings have also been caused by trim changes and speed brake handle adjustments.

(8) The means for silencing the aural warning should not be located such that it can be operated instinctively, inadvertently, or by habitual reflexive action. Silencing is defined as the interruption of the aural warning. When silenced, it is preferred that the system will be capable of rearming itself automatically prior to take-off. However, if there is a clear and unmistakable annunciation that the system is silenced, manual re-arming is acceptable.

(9) Each aeroplane model has a different means of arming the take-off configuration warning system, therefore the potential for nuisance warnings varies accordingly. Some existing systems use only a single throttle position, some use position from multiple throttles, some use EPR or N1, and some use a combination of these. When logic from a single operating engine was used, nuisance warnings were common during less than all engine taxi operations because of the higher power settings required to move the aeroplane. These systems were not designed for that type of operation. Because this procedure is used, inputs that arm the system

should be judiciously selected taking into account any likely combination of operating and shut-down engines so that nuisance warnings will not occur if the aeroplane is not in take-off configuration.

(10) CS 25.703 requires only an aural alert for the take-off warning system. CS 25.1322 currently specify requirements for visual alerts while related reading material reference 3a(2), 3a(4) and 3b(1) provide guidance for integrated visual and aural annunciations for warnings, cautions and advisory alerting conditions. It has been common industry practice to incorporate the above mentioned references in their aeroplane designs. FAR/CS 25.1322 are planned for revision to incorporate the guidance of these references to reflect current industry practices. Manufacturers may wish to incorporate these alerting concepts to the take-off warning system. If such is the case, the following guidance is offered:

a) A master warning (red) attention getting alert may be provided in the pilot's primary field of view simultaneously with the aural attention getting alert.

b) In addition to or instead of the aural attention getting alert (tone), voice may be used to specify the general problem (Configuration), or the exact problem (slats, flaps, trim, parking brake, etc…).

c) The visual alert may also specify the general problem (Configuration), or the exact problem (slats, flaps, trim, parking brake, etc…).

d) A visual cautionary alert associated with the failure of the Take-off warning system may be provided e.g. "T/O WARN FAIL".

(11) The EASA Agency approved Master Minimum Equipment List (MMEL) includes those items of equipment related to airworthiness and operating regulations and other items of equipment which the Agency finds may be inoperative and yet maintain an acceptable level of safety by appropriate conditions and limitations. No MMEL relief is provided for an inoperative take-off configuration warning. Therefore, design of these systems should include proper system monitoring including immediate annunciation to the flight crew should a failure be identified or if power to the system is interrupted.

d. *System Tests and Test Intervals*.

(1) When manual tests or checks are required to show compliance with CS 25.1309, by detecting the presence of and limiting the exposure time to a latent failure that would render the warning inoperative, they should be adequate, simple and straight forward in function and interval to allow a quick and proper check by the flight crew and maintenance personnel. Flight crew checks may be specified in the approved Aeroplane Flight Manual (AFM) and, depending on the complexity of the take-off configuration warning system and the aeroplane, maintenance tasks may be conventional Maintenance Review Board (MRB) designed tasks or listed as Certification Check Requirements (CCR) where appropriate, as defined in AMC 25.1309, and determined as part of the approval process between the manufacturer and the certification office.

(2) The specified tests/checks established in accordance with sub-paragraph 5d(1) above should be demonstrated as part of the approval process and should show that each input sensor as well as the control and logic system and its emitters, including the indication system, are individually verified as required to meet sub-paragraph 5b(3). It should also be demonstrated that the warning self cancels

when required to do so, for example by retarding the throttles or correcting the wrong configuration.

e. *Test Considerations*.

(1) During flight testing it should be shown that the take-off configuration warning system does not issue nuisance alerts or interfere with other systems. Specific testing should be conducted to ensure that the take-off configuration warning system works satisfactorily for all sensor inputs to the system. Flight testing should include reconfiguration of the aeroplane during touch and go manoeuvres.

(2) It should be shown by test or analysis that for all requested power settings, feasible weights, taxiway slopes, temperatures and altitudes, there will be no nuisance warnings, nor failure to give a warning when necessary (e.g., cold conditions, derated take-off), for any reasonable configuration of engines operating or shut down. This is to test or simulate all expected operational configurations. Reasonable pilot technique for applying power should be presumed.

(3) The means for silencing the aural warning by the flight crew will be evaluated to assure that the device is not accessible instinctively and it is properly protected from inadvertent activation. Automatic or manual re-arming of the warning system will be evaluated.

[Amdt 25/2]
[Amdt 25/8]
[Amdt 25/12]

CS 25.705 Runway overrun awareness and alerting systems

ED Decision 2020/001/R

(See AMC 25.705)

A runway overrun awareness and alerting system (ROAAS) must be installed. The ROAAS shall reduce the risk of a longitudinal runway excursion during landing by providing alert, in flight and on ground, to the flight crew when the aeroplane is at risk of not being able to stop within the available distance to the end of the runway.

(a) During approach (from a given height above the selected runway) and landing, the ROAAS shall perform real-time energy-based calculations of the predicted landing stopping point, compare that point with the location of the end of the runway, and provide the flight crew with:

(1) in-flight, timely, and unambiguous predictive alert(s) of a runway overrun risk, and

(2) on-ground, timely, and unambiguous predictive alert(s) of a runway overrun risk. At the option of the applicant, the ROAAS may also provide an automated means of deceleration control that prevents or minimises runway overrun during landing.

(b) The ROAAS shall at least accommodate dry and wet runway conditions for normal landing configurations.

[Amdt 25/24]

AMC 25.705 Runway overrun awareness and alerting systems

ED Decision 2020/001/R

1. When demonstrating compliance with CS 25.705, the applicant should take account of EUROCAE Document ED-250, 'Minimum Operational Performance Standard for a Runway Overrun Awareness and Alerting System', dated December 2017.

2. When demonstrating compliance with CS 25.1581 and CS 25.1585, the applicant should include in the aeroplane flight manual the following elements:

   (1) A description of the runway overrun awareness and alerting system (ROAAS) operational domain, including all conditions for which the ROAAS is expected to perform its intended function,

   (2) Any operational limitations applicable to the ROAAS, and

   (3) Operational procedures to be used by the flight crew when ROAAS alerts are triggered.

[Amdt 25/24]

LANDING GEAR

CS 25.721 General

ED Decision 2007/010/R

(See AMC 25.963(d))

(a) The landing gear system must be designed so that when it fails due to overloads during take-off and landing, the failure mode is not likely to cause spillage of enough fuel to constitute a fire hazard. The overloads must be assumed to act in the upward and aft directions in combination with side loads acting inboard and outboard. In the absence of a more rational analysis, the side loads must be assumed to be up to 20% of the vertical load or 20% of the drag load, whichever is greater.

(b) The aeroplane must be designed to avoid any rupture leading to the spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway, under the following minor crash landing conditions:

(1) Impact at 1.52 m/s (5 fps) vertical velocity, with the aeroplane under control, at Maximum Design Landing Weight,

(i) with the landing gear fully retracted and, as separate conditions,

(ii) with any other combination of landing gear legs not extended.

(2) Sliding on the ground, with -

(i) the landing gear fully retracted and with up to a 20° yaw angle and, as separate conditions,

(ii) any other combination of landing gear legs not extended and with 0° yaw angle.

(c) For configurations where the engine nacelle is likely to come into contact with the ground, the engine pylon or engine mounting must be designed so that when it fails due to overloads (assuming the overloads to act predominantly in the upward direction and separately predominantly in the aft direction), the failure mode is not likely to cause the spillage of enough fuel to constitute a fire hazard.

[Amdt 25/3]

CS 25.723 Shock absorption tests

ED Decision 2003/2/RM

(See AMC 25.723)

(a) The analytical representation of the landing gear dynamic characteristics that is used in determining the landing loads must be validated by energy absorption tests. A range of tests must be conducted to ensure that the analytical representation is valid for the design conditions specified in CS 25.473.

(1) The configurations subjected to energy absorption tests at limit design conditions must include at least the design landing weight or the design takeoff weight, whichever produces the greater value of landing impact energy.

(2) The test attitude of the landing gear unit and the application of appropriate drag loads during the test must simulate the aeroplane landing conditions in a manner consistent with the development of rational or conservative limit loads.

(b) The landing gear may not fail in a test, demonstrating its reserve energy absorption capacity, simulating a descent velocity of 3.7 m/s (12 fps) at design landing weight, assuming aeroplane lift not greater than the aeroplane weight acting during the landing impact.

(c) In lieu of the tests prescribed in this paragraph, changes in previously approved design weights and minor changes in design may be substantiated by analyses based on previous tests conducted on the same basic landing gear system that has similar energy absorption characteristics.

AMC 25.723 Shock absorption tests

ED Decision 2006/005/R

1. PURPOSE. This AMC sets forth an acceptable means, but not the only means, of demonstrating compliance with the provisions of CS-25 related to the use of landing gear shock absorption tests and analyses to determine landing loads for large aeroplanes.

2. RELATED CERTIFICATION SPECIFICATIONS. CS 25.723 "Shock absorption tests" and CS 25.473 "Landing load conditions and assumptions."

3. SHOCK ABSORPTION TESTS.

   a. Validation of the landing gear characteristics. Shock absorption tests are necessary to validate the analytical representation of the dynamic characteristics of the landing gear unit that will be used to determine the landing loads. A range of tests should be conducted to ensure that the analytical model is valid for all design conditions. In addition, consideration should be given to ensuring that the range of test configurations is sufficient for justifying the use of the analytical model for foreseeable future growth versions of the aeroplane.

   b. Recommended test conditions for new landing gear units. The design takeoff weight and the design landing weight conditions should both be included as configurations subjected to energy absorption tests. However, in cases where the manufacturer has supporting data from previous experience in validating the analytical model using landing gear units of similar design concept, it may be sufficient to conduct tests of the new landing gear at only the condition associated with maximum energy. The landing gear used to provide the supporting data may be from another model aircraft but should be of approximately the same size with similar components.

   c. Changes to type designs. CS 25.723(c) allows changes in previously approved design weights and minor changes in design to be substantiated by analyses based on tests of the same basic landing gear unit with similar energy absorption characteristics.

   A landing gear unit would be considered to be of “the same basic landing gear system” when the design concept has not been changed. “Similar energy absorption characteristics” means that the changes to the landing gear unit, either taken individually or as a whole, would not have a significant effect on the validation of the analytical results for the modified aeroplane. Changes that may be acceptable without further energy absorption tests include minor changes and adjustments incorporated in the landing gear unit to maintain similar energy absorption characteristics with changes in design weight and landing speeds.

   For example, the following changes may be acceptable without further tests:

   (1) Minor changes in shock absorber details including pre-load, compression ratio, orifice sizes, metering pin profiles.