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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

[Docket No. FAA-2024-2570; Special Conditions No. 25-875-SC]

Special Conditions: Airbus Model A321neo ACF and A321neo XLR Series Airplanes; Dynamic Test Requirements for Single Occupant Oblique Seats at an Installation Angle of 49 Degrees with Airbags and 3-point Restraint or Pretensioner Restraint Systems

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final special conditions.

SUMMARY: These special conditions are issued for the Airbus Model A321neo ACF and A321neo XLR airplanes. These airplanes will have a novel or unusual design feature when compared to the state of technology envisioned in the airworthiness standards for transport category airplanes. This design feature is a single-occupant oblique seat with an airbag and 3-point or pretensioner restraint system positioned at a 49-degree angle from the cabin centerline. The applicable airworthiness regulations do not contain adequate or appropriate safety standards for this design feature. These special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

DATES: Effective [INSERT DATE OF PUBLICATION IN THE FEDERAL REGISTER].

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SUPPLEMENTARY INFORMATION:

Background

On April 6, 2022, Airbus SAS applied for an amendment to Type Certificate (TC) No. A28NM for the installation of a single-occupant oblique seat with an airbag and 3-point or pretensioner restraint system, positioned at a 49-degree angle from the cabin centerline in new Airbus Model A321neo ACF and A321neo XLR airplanes. Airbus Model A321neo ACF and A321neo XLR airplanes, which are derivatives of the Model A321 currently approved under TC No. A28NM, are twin-engine, transport category airplanes with a maximum passenger capacity of 244. The maximum takeoff weight of the Airbus Model A321neo ACF is approximately 213,848 pounds, while the Airbus Model A321neo XLR has a maximum takeoff weight of approximately 222,667 pounds.

Type Certification Basis

Under the provisions of 14 CFR 21.101, Airbus SAS must show that the Model A321neo ACF and A321neo XLR airplanes, as changed, continue to meet the applicable provisions of the regulations listed in TC No. A28NM or the applicable regulations in effect on the date of application for the change, except for earlier amendments as agreed upon by the FAA.

If the Administrator finds that the applicable airworthiness regulations (e.g., 14 CFR part 25) do not contain adequate or appropriate safety standards for Airbus Model A321neo ACF and A321neo XLR airplanes because of a novel or unusual design feature, special conditions are prescribed under the provisions of § 21.16.

Special conditions are initially applicable to the model for which they are issued. Should the type certificate for that model be amended later to include any other model that incorporates the same novel or unusual design feature, or should any other model already included on the same type certificate be modified to incorporate the same novel

or unusual design feature, these special conditions would also apply to the other model under § 21.101.

In addition to the applicable airworthiness regulations and special conditions, Airbus Model A321neo ACF and A321neo XLR airplanes must comply with the exhaust-emission requirements of 14 CFR part 34 and the noise-certification requirements of 14 CFR part 36.

The FAA issues special conditions, as defined in 14 CFR 11.19, in accordance with § 11.38, and they become part of the type certification basis under § 21.101.

Novel or Unusual Design Features

Airbus Model A321neo ACF and A321neo XLR airplanes will incorporate the following novel or unusual design feature: single-occupant oblique seats with airbag devices and 3-point restraints or a pretensioner restraint system installed at 49 degrees relative to the aircraft cabin centerline.

Discussion

Title 14 of the CFR, § 25.785(d), requires that each occupant of a seat installed at an angle of more than 18 degrees relative to airplane cabin centerline, must be protected from head injury using a seatbelt and an energy-absorbing rest that supports the arms, shoulders, head, and spine, or using a seatbelt and shoulder harness designed to prevent the head from contacting any injurious object.

The Airbus Model A321neo ACF and A321neo XLR airplane's single occupant oblique seat installation with airbag devices and 3-point restraint or pretensioner restraint system is novel such that the current requirements do not adequately address airbag or pretensioner devices and protection of the occupant's neck, spine, torso, and legs for seating configurations that are positioned at an angle of 49 degrees from the airplane centerline. The seating configuration installation angle is beyond the installation-design limits of current special conditions issued for seat positions at angles between 18 degrees

and 45 degrees. At angles greater than 45 degrees, lateral neck bending and other injury mechanisms prevalent from a fully side-facing installation become a concern, given the addition of oblique seat properties. To address these potential injury mechanisms, these special conditions are based on FAA Policy Statement PS-AIR-25-27, "Technical Criteria for Approving Obliques Seats" as well as Policy Statement PS-ANM-25-03-R1, "Technical Criteria for Approving Side-Facing Seats."

To provide a level of safety equivalent to that afforded to the occupants of forward and aft-facing seats, new special conditions containing additional airworthiness standards for dynamic testing requirements, including both the injury criteria limits from the oblique-seat policy and the fully side-facing seat policy, are necessary.

FAA-sponsored research found that an un-restrained flailing of the upper torso, even when the pelvis and torso are nearly aligned, can produce serious spinal and torso injuries. At lower impact severities, even with significant misalignment between the torso and pelvis, these injuries did not occur. Tests with an FAA H-III anthropomorphic test device (ATD) have identified a level of lumbar spinal tension corresponding to the no-injury impact severity. The FAA has implemented this spinal tension limit in special conditions for oblique seats. The spine tension limit selected by the FAA is conservative with respect to other aviation injury criteria since it corresponds to a no-injury loading condition.

Other restraint systems, in lieu of single lap belt restrain systems, have been used to comply with the occupant injury criteria of § 25.562(c)(5). For instance, shoulder harnesses have been widely used on flight-attendant seats, flight-deck seats, in business jets, and in general-aviation airplanes to reduce occupant head injury in the event of an emergency landing. Special conditions, pertinent regulations, and published guidance exist that relate to other restraint systems. However, the use of pretensioners in the

restraint system on transport category airplane seats to comply with the occupant injury criteria of § 25.562(c)(5) is a novel design.

Pretensioner technology involves a step-change in loading experienced by the occupant for impacts below and above that at which the device deploys, because activation of the shoulder harness, at the point at which the pretensioner engages, interrupts upper-torso excursion. Such an excursion could result in the head-injury criteria (HIC) being higher at an intermediate impact condition than that resulting from the maximum impact condition corresponding to the test conditions specified in § 25.562. See condition (a)(3) in these special conditions.

The ideal triangular maximum-severity pulse is defined in Advisory Circular (AC) 25.562-1B, "Dynamic Evaluation of Seat Restraint Systems and Occupant Protection on Transport Airplanes." For the evaluation and testing of less-severe pulses for purposes of assessing the effectiveness of the pretensioner setting, a similar triangular pulse should be used with acceleration, rise time, and velocity change scaled accordingly. The magnitude of the required pulse should not deviate below the ideal pulse by more than 0.5g until 1.33 t_1 is reached, where t_1 represents the time interval between 0 and t_1 on the referenced pulse shape, as shown in AC 25.562-1B. This is an acceptable method of compliance with the test requirements of the special conditions.

Additionally, the pretensioner might not provide protection, after actuation, during secondary impacts. Therefore, the case where a small impact is followed by a large impact should be addressed. If the minimum deceleration severity at which the pretensioner is set to deploy is unnecessarily low, the protection offered by the pretensioner may be lost by the time a second, larger impact occurs.

Conditions (a) through (g) address occupant protection in consideration of the oblique-facing seats. Condition (h) addresses airbag systems. Conditions (i)(1) through (i)(3) ensure that the pretensioner system activates when intended and protects a range of

occupants under various accident conditions. Conditions (i)(4) through (9) address the maintenance and reliability of the pretensioner system, including any outside influences on the mechanism, to ensure it functions as intended. Condition (j) addresses general instructions that supplement these special conditions when tests are required to assist with test set-ups and appropriate ATD selection.

The special conditions contain the additional safety standards that the Administrator considers necessary to establish a level of safety equivalent to that established by the existing airworthiness standards.

Discussion of Comments

The FAA issued Notice of Proposed Special Conditions No. 25-24-05-SC for the Airbus Model A321neo ACF and A321neo XLR airplanes, which was published in the *Federal Register* on December 23, 2024 (89 FR 104455).

The FAA received responses from two commenters: Airbus Commercial Aircraft (Airbus) and The Boeing Company (Boeing).

Airbus, the applicant, requested that the FAA update paragraph (j)(1) of this special condition to include cross-references to the conditions in paragraphs (c)(5), (d)(3), and (e)(3). These conditions may necessitate additional tests using the ES–2re ATD.

The FAA concurs with the comment and added the cross-references to paragraph (j)(1).

Boeing requested that the FAA add a new condition to paragraph (i) of this special condition to ensure pretensioner exhaust is not hazardous to passengers, similar to the corresponding condition required for airbag systems.

The FAA concurs with the comment. Certain pretensioner restraint systems, like airbag systems, incorporate firing mechanisms that may exhaust small amounts of gas and particulate when activated. The FAA has previously published special conditions (see Special Condition No. 25-375-SC) to address this concern for airbags and has added a

condition to paragraph (i)(8)(ii) to address the need to similarly ensure that pretensioner activation exhaust and particulate are not hazardous to passengers.

Except as discussed above, the special conditions are adopted as proposed.

Applicability

As discussed above, these special conditions are applicable to the Airbus Model A321neo ACF and A321neo XLR airplanes. Should Airbus apply at a later date for a change to the type certificate to include another model incorporating the same novel or unusual design feature, these special conditions would apply to that model as well.

Under standard practice, the effective date of final special conditions would be 30 days after the date of publication in the *Federal Register*. However, as the certification date for the Airbus Model A321neo ACF and A321neo XLR airplanes is imminent, the FAA finds that good cause exists to make these special conditions effective upon publication.

Conclusion

This action affects only a certain novel or unusual design feature on one model series of airplane. It is not a rule of general applicability.

List of Subjects in 14 CFR Part 25

Aircraft, Aviation safety, Reporting and recordkeeping requirements.

Authority Citation

The authority citation for these special conditions is as follows:

Authority: 49 U.S.C. 106(f), 106(g), 40113, 44701, 44702, 44704.

The Special Conditions

Accordingly, pursuant to the authority delegated to me by the Administrator, the following special conditions are issued as part of the type certification basis for the Airbus Model A321neo ACF and A321neo XLR airplanes.

In addition to the requirements of §§ 25.562 and 25.785, passenger seats with airbag devices and 3-point restraints or pretensioner restraints installed at an angle 49 degrees from the aircraft centerline must meet the following conditions:

(a) Head Injury Criteria (HIC)

HIC assessments are required only for head contact with the seat and other structures.

(1) Compliance with § 25.562(c)(5) is required, except when an airbag device is present in addition to the 3-point restraint system and the anthropomorphic test dummy (ATD) has no apparent contact with the seat and other structure but has contact with the airbag. An HIC score in excess of 1,000 is acceptable, provided the HIC15 score (calculated in accordance with 49 CFR 571.208) for that contact is less than 700.

(2) ATD head contact with the seat or other structure, through the airbag (if installed), or contact subsequent to contact with the airbag requires an HIC value not exceeding 1,000.

(3) The HIC value must not exceed 1,000 in any condition in which the airbag or pretensioner (if installed) does or does not deploy up to the maximum severity pulse specified by the existing requirements.

(4) To accommodate a range of occupant heights (5th percentile female to 95th percentile male), any surface, airbag or otherwise, that provides support for the occupant's head must provide that support in a consistent manner regardless of occupant stature. Otherwise, additional HIC assessment tests may be needed.

(b) Body-to-Wall/Furnishing Contact

If a seat is installed aft of a structure, such as an interior wall or furnishing that does not provide a homogenous contact surface for the expected range of occupants and yaw angles, then additional analysis and tests may be required to demonstrate that the injury criteria are met for the area an occupant could contact. For example, different yaw angles could result in different injury considerations and airbag performance, and additional analysis or separate tests may be necessary to evaluate performance.

(c) Neck Injury Criteria

(1) The seating system must protect the occupant from experiencing serious neck injury. The assessment of neck injury must be conducted with the airbag device activated unless there is also reason to consider that the neck injury potential would be higher for impacts below the airbag device deployment threshold.

(2) Rotation of the head about its vertical axis, relative to the torso, is limited to 105 degrees in either direction from forward-facing.

(3) The neck must not impact any surface that would produce concentrated loading on the neck.

(4) Assess neck injury for fore and aft neck bending using an FAA Hybrid III ATD, as described in SAE International (SAE) Technical Paper 1999-01-1609, "A Lumbar Spine Modification to the Hybrid III ATD for Aircraft Seat Tests," applying the following criteria:

(i) The Nij, calculated in accordance with 49 CFR 571.208, must be below 1.0, where Nij = Fz /Fzc + My/Myc, and Nij critical values are:

Fzc = 1,530 lbs (6805 N) for tension

Fzc = 1,385 lbs (6160 N) for compression

Myc = 229 lb-ft (301 Nm) in flexion

Myc = 100 lb-ft (136 Nm) in extension

(ii) In addition, peak upper-neck Fz must be below 937 lbs (4168 N) in tension and 899 lbs (3999 N) in compression.

(5) When lateral neck bending is present, assess it using an ES–2re ATD as defined by 49 CFR part 572, subpart U. The data must be filtered at channel frequency class 600 as defined in SAE Recommended Practice J211/11, "Instrumentation for Impact Test Part 1- Electronic Instrumentation."

(i) The upper-neck tension force at the occipital condyle (O.C.) location must be less than 405 lbs (1,800 N).

(ii) The upper-neck compression force at the O.C. location must be less than 405 lbs (1,800 N).

(iii) The upper-neck bending torque about the ATD x-axis at the O.C. location must be less than 1,018 in-lbs (115 Nm).

(iv) The upper-neck resultant shear force at the O.C. location must be less than 186 lbs (825 N).

(d) Spine and Torso Injury Criteria

(1) The seating system must protect the occupant from experiencing spine and torso injury. The assessment of spine and torso injury must be conducted with the airbag device activated unless it is necessary to also consider that the occupant-injury potential would be higher for impacts below the airbag-device deployment threshold.

(2) Assess spine and torso injury for oblique torso bending using an FAA Hybrid III ATD, applying the following criteria:

(i) The lumbar spine tension (Fz) cannot exceed 1,200 lbs (5338 N).

(ii) Significant concentrated loading on the occupant's spine, in the area between the pelvis and shoulders during impact, including rebound, is not acceptable. During this type of contact, the interval for any rearward (X direction) acceleration exceeding 20g must be less than 3 milliseconds, as measured by the thoracic instrumentation specified in 49 CFR part 572, subpart E, filtered in accordance with SAE Recommended Practice J211/1.

(3) When lateral torso bending is present, assess spine and torso injury using an ES–2re ATD, applying the following criteria:

(i) Thoracic: The deflection of any of the ES–2re ATD upper, middle, and lower ribs must not exceed 1.73 inches (44 mm). Process the data as defined in Federal Motor Vehicle Safety Standards (FMVSS) 571.214, title 49 of the CFR.

(ii) Abdominal: The sum of the measured ES–2re ATD front, middle, and rear abdominal forces must not exceed 562 lbs (2,500 N). Process the data as defined in FMVSS 571.214.

(iii) Upper-torso support: The lateral flexion of the ATD torso must not exceed 40 degrees from the normal upright positions during impact.

(e) Pelvic Criteria

(1) The seating system must protect the occupant from experiencing pelvis injury.

(2) Any part of the load-bearing portion of the bottom of the ATD pelvis must not translate beyond the edges of the seat-bottom seat-cushion supporting structure.

(3) When pelvis contact with the armrest or surrounding interior components is present, assess it using an ES–2re ATD. The pubic symphysis force measured by the ES–2re ATD must not exceed 1,350 lbs (6,000 N). Process the data as defined in FMVSS 571.214.

(f) Femur Criteria

Limit axial rotations of the upper leg (about the z-axis of the femur, per SAE Recommended Practice J211/1) to 35 degrees from the nominal seated position. Evaluation during rebound does not need to be considered.

(g) ATD and Test Condition

(1) Perform longitudinal tests to measure the injury criteria above using the FAA Hybrid III ATD or the ES–2re ATD. Conduct the tests with the undeformed floor, at the most critical yaw cases for injury, and with all lateral structural supports (e.g., armrests or walls) installed.

(2) For longitudinal tests conducted in accordance with § 25.562(b)(2), show compliance with the seat-strength requirements of § 25.562(c)(7) and (8), and these special conditions, to ensure proper loading of the seat by the occupant, the ATD pelvis must remain supported by the seat pan, and the restraint system must remain on the pelvis of

the ATD until rebound begins. No injury criteria evaluation is necessary for tests conducted only to assess seat-strength requirements.

(3) If a seat installation includes adjacent items that are within contact range of an occupant, assess the injury potential of that contact. To make this assessment, tests may be conducted to include the actual contact item, located and attached in a representative fashion. Alternatively, the injury potential may be assessed through a combination of tests with contact items having the same geometry as the actual contact item but having stiffness characteristics that would create the worst case for injury, such as injuries due to both contact with the item and lack of support from the item.

(4) Conduct the combined horizontal and vertical test, required by § 25.562(b)(1) and these special conditions, with a Hybrid II ATD (49 CFR part 572, subpart B, as specified in § 25.562) or equivalent.

(5) The design and installation of seat belt buckles must prevent unbuckling due to applied inertial forces or impact from seat occupant hands and arms during an emergency landing.

(h) Inflatable Airbag-Restraint System Special Conditions (when installed):

An inflatable airbag-restraint system must meet the requirements of Special Conditions No. 25-375-SC, "Airbus A318, A319, A320 and A321 Series Airplanes Inflatable Restraints."

(i) Pretensioner System Special Conditions (when installed):

(1) Protection During Secondary Impacts:

The pretensioner activation setting must be demonstrated to maximize the probability of the protection being available when needed, considering secondary impacts.

(2) Protection of Occupants Other than 50th Percentile:

Protection of occupants for a range of stature from a 2-year-old child to a 95th percentile male must be shown. For shoulder harnesses that include pretensioners, protection of

occupants other than a 50th percentile male may be shown by test or analysis. In addition, the pretensioner must not introduce a hazard to passengers due to the following seating configurations:

(i) The seat occupant is holding an infant.

(ii) The seat occupant is a child in a child-restraint device.

(iii) The seat occupant is a pregnant woman.

(3) Occupants Adopting the Brace Position:

Occupants in the traditional brace position, when the pretensioner activates, must not experience adverse effects from the pretensioner activation.

(4) Inadvertent Pretensioner Actuation:

(i) The probability of inadvertent pretensioner actuation must be shown to be extremely remote (i.e., average probability per flight hour of less than 10^{-7}).

(ii) The system must be shown not susceptible to inadvertent pretensioner actuation due to wear and tear or inertia loads resulting from in-flight or ground maneuvers likely to be experienced in service.

(iii) The seated occupant must not be seriously injured due to inadvertent pretensioner actuation.

(iv) Inadvertent pretensioner activation must not cause a hazard to the airplane nor cause serious injury to anyone positioned close to the retractor or belt (e.g., seated in an adjacent seat or standing adjacent to the seat).

(5) Availability of the Pretensioner Function Before Flight:

The design must provide means for a crewmember to verify the availability of the pretensioner function before each flight or the probability of failure of the pretensioner function must be demonstrated to be extremely remote (i.e., average probability per flight hour of less than 10-7 between inspection intervals.)

(6) Incorrect Seat Belt Orientation:

The system design must ensure that any incorrect orientation (twisting) of the seat belt does not compromise the pretensioner protection function.

(7) Contamination Protection:

The pretensioner mechanisms and controls must be protected from external contamination that could occur on or around passenger seating.

(8) Prevention of Hazards:

(i) The pretensioner system must not induce a hazard to passengers in case of fire, nor create a fire hazard if activated.

(ii) The pretensioner system must not release hazardous quantities of gas or particulate matter into the cabin.

(9) Functionality After Loss of Power:

The system must function properly after the loss of normal airplane electrical power and after a transverse separation in the fuselage at the most critical location. A separation at the location of the system does not have to be considered.

(j) General Test Instructions

(1) The appropriate ATD to assess occupant injury (FAA Hybrid III or ES-2re) will be determined based on the occupant kinematics at the selected test angle. At the +10 degree yaw angle, the occupant kinematics show that occupant injury tests using both ATDs may be required. See the conditions in (c)(5), (d)(3), and (e)(3) when determining the necessity for additional tests using an ES-2re ATD.

(2) Conduct vertical tests with the Hybrid II ATD or equivalent, with existing pass/fail criteria.

(3) Conduct longitudinal structural tests with the Hybrid II ATD or equivalent, deformed floor, with 10 degrees yaw, and with all lateral structural supports (e.g., armrests or walls) required to support the occupant.

(4) Conduct longitudinal occupant injury tests, as necessary, with the Hybrid III ATD or ES-2re ATD, or both, undeformed floor, yaw, and with all lateral structural supports (e.g., armrests or walls) critically represented which are within the contact range of the occupant.

(i) Pass/fail injury assessments:

(A) Perform HIC, fore/aft neck injury, spinal tension, and femur evaluations using an FAA Hybrid III ATD.

(B) Perform lateral neck injury, thoracic, abdominal, pelvis, and femur evaluations using an ES-2re ATD.

(ii) [Reserved]

(5) For injury assessments accomplished by testing with the ES-2re ATD for the longitudinal test(s) conducted in accordance with § 25.562(b)(2) and these special conditions, the ATDs must be positioned, clothed, and have lateral instrumentation configured as follows:

(i) ES-2re ATD Lateral Instrumentation:

The rib-module linear slides are directional (i.e., deflection occurs in either a positive or negative ATD y-axis direction). Install the modules such that the moving end of the rib module is toward the front of the airplane. Install the three abdominal-force sensors so that they are on the side of the ATD and toward the front of the airplane.

(ii) ATD Clothing:

Clothe each ATD in form-fitting cotton stretch garments with short to full-length sleeves, mid-calf to full-length pants, and size 11E (45) shoes weighing about 2.5 lbs (1.1 kg) and having a heel height of about 1.5 inches (3.8 cm). The color of the clothing should be in contrast to the color of the restraint system and the background. The color of the clothing should be chosen to avoid overexposing the high-speed images taken during the test. The

ES-2re jacket is sufficient for torso clothing, although a form-fitting shirt may be used if desired.

(iii) ATD Positioning:

(A) Lower the ATD vertically into the seat while simultaneously:

(1) Aligning the midsagittal plane (a vertical plane through the midline of the body; dividing the body into right and left halves) with approximately the middle of the seat place.

(2) Keeping the upper legs horizontal by supporting them just behind the knees.

(3) Applying a horizontal x-axis direction (in the ES-2re ATD coordinate system) force of about 20 lbs (89 N) to the bottom rib of the ES-2re to compress the seat back cushion.

(B) After all lifting devices have been removed from the ATD:

(1) Rock it slightly to settle it in the seat.

(2) Bend the knees of the ATD.

(3) Separate the knees by about 4 inches (100 mm).

(4) Set the ATD's head at approximately the midpoint of the available range of z-axis rotation (to align the head and torso midsagittal planes).

(5) Position the ATD's arms at the joint's mechanical detent to position them to an approximately 20 to 40-degree angle with respect to the torso.

(6) Position the feet such that the centerlines of the lower legs are approximately parallel.

Issued in Kansas City, Missouri, on January 30, 2025.

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