U.S. Department of Transportation
Federal Aviation Administration

Policy Statement

Subject:	**Date:**	**Policy No:**
Technical Criteria for Approving Side-Facing Seats	June 8, 2012	PS-ANM-25-03
	Initiated By: ANM-100	

Summary

This policy statement updates existing Federal Aviation Administration (FAA) certification policy on Title 14, Code of Federal Regulations (14 CFR) 25.562 and 25.785(a) at Amendment 25-64 for single- and multiple-place side-facing seats. This policy addresses both the technical criteria for approving side-facing seats and the implementation of those criteria.

Definition of Key Terms

In this document, the terms "must," "should," and "recommend" have specific meanings, which are explained in Attachment 3.

Current Regulatory and Advisory Material

Section 25.562(a), Amendment 25-64, requires that the seat and restraint system be designed to protect each occupant when (1) proper use is made of the seats, safety belts, and shoulder harnesses and (2) the occupant is exposed to loads resulting from the conditions prescribed in § 25.562(b).

Section 25.785(a), Amendment 25-64, requires general occupant protection for occupants of seats that are occupied during takeoff and landing. This requirement is currently codified as § 25.785(b).

Federal Aviation Administration policy statement ANM-03-115-30, "Policy Statement on Side-Facing Seats on Transport Category Airplanes," dated May 6, 2005, describes dynamic test procedures and pass/fail criteria that are considered for transport-category airplanes to provide an appropriate level of safety for occupants of both multiple-place side-facing seats, certified by exemptions, and single-place side-facing seats, certified by special conditions.

Relevant Past Practice

The performance measures of § 25.562(c) only address forward- and aft-facing seats. Side-facing seats are considered a novel design for transport-category airplanes that include Amendment

25-64 in the certification basis, and were not considered when those airworthiness standards were issued. The existing regulations do not provide adequate or appropriate safety standards for occupants of side-facing seats because they do not consider the differences in the dynamic forces that apply to a side-facing occupant. The FAA determined that additional airworthiness standards, in the form of special conditions, could provide a level of safety, for single-occupant side-facing seats, equivalent to that afforded to occupants of forward- and aft-facing seats. However, the best criteria then available for evaluating multiple-occupant side-facing seats (divans) did not ensure a level of safety equivalent to that afforded to occupants of forward- and aft-facing seats. Two areas of concern not covered by the policy were neck injury and leg injury. Therefore, the only certification method available for multiple-occupant side-facing seats, for airplanes that include Amendment 25-64 in their certification basis, was through an exemption from the general injury requirements of § 25.785(a) and § 25.562(a) at Amendment 25-64.

Policy

The FAA has been conducting research to develop an acceptable method of compliance with §§ 25.562 and 25.785(b) for side-facing-seat installations. That research has identified injury considerations and evaluation criteria in addition to those previously used to approve side-facing seats. See published report DOT/FAA/AR-09/41, July 2011.

Prior to availability of these research findings, the FAA had been granting exemptions for the multiple-place side-facing-seat installations because the existing test methods and acceptance criteria did not produce a level of safety equivalent to the level of safety provided for forward- and aft-facing seats. These exemptions were subject to many conditions that reflected the injury-evaluation criteria and mitigation strategies available at the time of the exemption issuance. The FAA has now developed a methodology to address all fully side-facing seats (i.e., seats oriented in the aircraft with the occupant facing 90 degrees to the direction of aircraft travel) and has documented those requirements in a set of proposed new special conditions. See attachment 1 for detailed requirements contained in the proposed new special conditions. Some of the conditions issued for previous exemptions are still relevant and are included in these new special conditions. However, others have been replaced by different criteria that reflect current research findings.

The FAA had been issuing special conditions to address single-place side-facing seats because we believed that those conditions provided the same level of safety as for forward- and aft-facing seats. However, one additional injury condition was identified during the FAA's research program that is not addressed in the previous special conditions. The research revealed that significant leg injuries can occur to occupants of both single- and multiple-place side-facing seats. This type of injury does not occur on forward- and aft-facing seats. Therefore, the FAA has determined that, to achieve the level of safety envisioned in Amendment 25-64, additional requirements are needed as compared to previously issued special conditions. Nonetheless, the research has now allowed the development of a single set of special conditions that is applicable to all fully side-facing seats.

Attachment 2 contains some background discussion on the new special conditions to address neck and leg injuries. Also included in attachment 2 are background and discussion on the new ES-2re Anthropomorphic Test Dummy (ATD), and the revised injury criteria that are measured with the new ATD. The ES-2re ATD has improved biofidelity and instrumentation that allows a

more accurate evaluation of injury potential than do the ATDs previously cited in the regulation and policy statements.

Effect of Policy

The general policy stated in this document does not constitute a new regulation or create what the courts refer to as a "binding norm." The office that implements policy should follow this policy when applicable to the specified project.

Whenever a proposed method of compliance is outside this established policy, the project aircraft-certification office must coordinate it with the policy-issuing office through an issue paper. Similarly, if the project aircraft-certification office becomes aware of reasons that an applicant's proposal that meets this policy should not be approved, the office must coordinate its response with the policy-issuing office.

Applicants should expect that the certificating officials will consider this information when making findings of compliance relevant to new certificate actions, or actions relating to maintenance, alterations, and repairs. Also, as with all guidance material, this policy statement identifies one means, but not the only means, of compliance.

For inquiries regarding this policy statement, contact the FAA Transport Airplane Directorate, ANM-100, telephone (425) 227-2100.

Implementation

This policy discusses compliance methods that should be applied to new seat-certification programs on type-certificate, amended type-certificate, supplemental type-certificate, and amended supplemental type-certificate programs that are *not* covered by existing exemptions for multiple-place side-facing seats and/or special conditions for single-place side-facing seat. The compliance methods apply to those seat-certification programs with an approval date that is on or after the effective date of the final policy. If the date of application for a project precedes the effective date of the final policy, the applicant follows the "in-work" section, below.

The effective date of this policy is upon signature of final policy. In some cases, the seat design and certification process can be lengthy, so we have identified specific criteria based on the status of the program. Implementation will be considered for three cases of certification program:

- previously approved
- in-work
- new

Previously approved

For airplanes that have exemptions for multiple-place side-facing seats and/or special conditions for single-place side-facing seats that were approved prior to the effective date of this policy, this policy has no effect. Such previously approved airplane fleets with existing side-facing seats installed may continue to be operated without changes. Furthermore, modifications to existing seats, and new installations of existing seats or new seat designs using these previously approved exemptions for multiple-place side-facing seats and/or special conditions for single-place side-facing seats, may continue in airplanes addressed by these exemptions and special conditions. However, if, for any reason, the holder of these existing exemptions for multiple-place side-facing seats and/or special conditions for single-place side-facing seats requests a revision to the special condition or exemption after the effective date of this policy statement, then projects would be considered to be in the "New" implementation section.

In-work

The FAA's intent is to implement this policy to achieve the long-term safety benefits associated with a more-comprehensive examination of safety aspects relevant to side-facing-seats. For side-facing-seat certification programs currently in-work that do not have a previously granted exemption or an approved special condition in the certification basis, and if the methods of compliance have not been coordinated with and approved by the FAA, the applicant should use one of these two compliance methods to support these programs:

1. The applicant follows the criteria in this policy. The FAA prefers this method.

2. The applicant adequately addresses all requirements of 14 CFR 11.81 in petitioning for an exemption. Single- and multiple-place side-facing-seat certification programs would be treated the same, because the previous special-conditions criteria for single-place side-facing seats are no longer considered to provide a level of safety equivalent to that established by the regulations (see the requirement for a special condition in 14 CFR 21.16). If an exemption is granted, the petitioner should expect the exemption to be limited to seat-certification programs that are actually in process. The applicant would be required to identify those seat-certification programs actually in progress. Generally, any follow-on certification project that required substantiation for § 25.562 for the side-facing seat would be considered "new" for the purposes of this policy. The specific exemption limitations would depend on the circumstances associated with each individual project.

New

This policy applies to all side-facing-seat installations in new type-certificate, amended type-certificate, supplemental type-certificate, and amended supplemental type-certificate programs applied for after the effective date of the policy statement, and that do not have exemptions and/or special conditions for side-facing seats that were approved prior to the effective date of this policy.

In addition to the above, Special Federal Aviation Regulations (SFAR) 109 remains a valid certification approach for multiple-place side-facing seats for those programs that can follow those limitations. However, in light of the research findings, the FAA is considering whether rulemaking should be initiated to revise the SFAR to adopt the new criteria.

/s/ Michael Kaszycki

Michael Kaszycki
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Aircraft Certification Service

Attachments

Attachment 1

Criteria for Side-facing Seats

In addition to the requirements of §§ 25.562, and 25.785, the following special condition numbers 1 and 2 are proposed as part of the type-certification basis of the airplane(s) with side-facing-seat installations. For seat place(s) equipped with an airbag system in the shoulder belt, additional special condition numbers 3 through 16 are proposed as part of the type-certification basis.

1. Additional requirements applicable to tests or rational analysis conducted to show compliance with §§ 25.562 and 25.785 for side-facing seats:

    a. The longitudinal test(s) conducted in accordance with § 25.562(b)(2) to show compliance with the seat-strength requirements of § 25.562(c)(7) and (8), and these special conditions must have an ES-2re anthropomorphic test dummy (ATD) (49 CFR part 572 subpart U) or equivalent, or a Hybrid-II ATD (49 CFR part 572, subpart B as specified in § 25.562) or equivalent, occupying each seat position and including all items contactable by the occupant (e.g., armrest, interior wall, or furnishing) if those items are necessary to restrain the occupant. If included, the floor representation and contactable items must be located such that their relative position, with respect to the center of the nearest seat place, is the same at the start of the test as before floor misalignment is applied. For example, if floor misalignment rotates the centerline of the seat place nearest the contactable item 8 degrees clockwise about the aircraft x-axis, then the item and floor representations must be rotated by 8 degrees clockwise also to maintain the same relative position to the seat place, as shown in Figure 1. Each ATD's relative position to the seat after application of floor misalignment must be the same as before misalignment is applied. To ensure proper loading of the seat by the occupants, the ATD pelvis must remain supported by the seat pan, and the restraint system must remain on the pelvis and shoulder of the ATD until rebound begins. No injury-criteria evaluation is necessary for tests conducted only to assess seat-strength requirements.

    b. The longitudinal test(s) conducted in accordance with § 25.562(b)(2), to show compliance with the injury assessments required by § 25.562(c) and these special conditions, may be conducted separately from the test(s) to show structural integrity. In this case, structural-assessment tests must be conducted as specified in paragraph 1a, above, and the injury-assessment test must be conducted without yaw or floor misalignment. Injury assessments may be accomplished by testing with ES-2re ATD (49 CFR part 572 subpart U) or equivalent at all places. Alternatively, these assessments may be accomplished by multiple tests that use an ES-2re at the seat place being evaluated, and a Hybrid-II ATD (49 CFR part 572, subpart B, as specified in § 25.562) or equivalent used in all seat places forward of the one being assessed, to evaluate occupant interaction. In this case, seat places aft of the one being assessed may be unoccupied. If a seat installation includes adjacent items that are contactable by the occupant, the injury potential of that contact must be assessed. To make this assessment, tests may be conducted that include the actual item, located and attached in a representative fashion. Alternatively, the injury potential may be assessed by a combination of tests with items

having the same geometry as the actual item, but having stiffness characteristics that would create the worst case for injury (injuries due to both contact with the item and lack of support from the item).

c. If a seat is installed aft of structure (e.g., an interior wall or furnishing) that does not have a homogeneous surface contactable by the occupant, additional analysis and/or test(s) may be required to demonstrate that the injury criteria are met for the area which an occupant could contact. For example, different yaw angles could result in different injury considerations and may require additional analysis or separate test(s) to evaluate.

d. To accommodate a range of occupant heights (5^{th} percentile female to 95^{th} percentile male), the surface of items contactable by the occupant must be homogenous 7.3 inches (185 mm) above and 7.9 inches (200 mm) below the point (center of area) that is contacted by the 50^{th} percentile male size ATD's head during the longitudinal test(s) conducted in accordance with paragraphs a, b, and c, above. Otherwise, additional head-injury criteria (HIC) assessment tests may be necessary. Any surface (inflatable or otherwise) that provides support for the occupant of any seat place must provide that support in a consistent manner regardless of occupant stature. For example, if an inflatable shoulder belt is used to mitigate injury risk, then it must be demonstrated by inspection to bear against the range of occupants in a similar manner before and after inflation. Likewise, the means of limiting lower-leg flail must be demonstrated by inspection to provide protection for the range of occupants in a similar manner.

e. For 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:

(1) ATD positioning:

Lower the ATD vertically into the seat while simultaneously (see Figure 2 for illustration):

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

b) Applying a horizontal x-axis direction (in the ATD coordinate system) force of 20 lb (4.5N) to the torso at the intersection of the midsagittal plane and the bottom rib of the ES-2re or lower sternum of the Hybrid-II at the midsagittal plane, to compress the seat back cushion.

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

Once all lifting devices have been removed from the ATD:

a) Rock it slightly to settle it in the seat.

b) Separate the knees by about 4 inches (100 mm)

c) Set the ES-2re's head at the midpoint of the available range of z-axis rotation (to align the head and torso midsagittal planes).

d) Position the ES-2re's arms at the joint's mechanical detent that puts them at approximately a 40 degree angle with respect to the torso. Position the Hybrid-II ATD hands on top of its upper legs.

e) Position the feet such that the centerlines of the lower legs are approximately parallel to a lateral vertical plane (in the aircraft coordinate system).

(2) ATD clothing: Clothe each ATD in form-fitting, mid-calf-length (minimum) pants and shoes (size 11E) weighing about 2.5 lb (1.1 Kg) total. The color of the clothing should be in contrast to the color of the restraint system. The ES-2re jacket is sufficient for torso clothing, although a form-fitting shirt may be used in addition if desired.

(3) 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. The modules must be installed such that the moving end of the rib module is toward the front of the aircraft. The three abdominal-force sensors must be installed such that they are on the side of the ATD toward the front of the aircraft.

f. The combined horizontal/vertical test, required by § 25.562(b)(1) and these special conditions, must be conducted with a Hybrid II ATD (49 CFR part 572 subpart B as specified in § 25.562), or equivalent, occupying each seat position.

g. Restraint systems:

(1) If inflatable restraint systems are used, they must be active during all dynamic tests conducted to show compliance with § 25.562.

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

2. Additional performance measures applicable to tests and rational analysis conducted to show compliance with §§ 25.562 and 25.785 for side-facing seats:

a. Body-to-body contact: Contact between the head, pelvis, torso, or shoulder area of one ATD with the adjacent-seated ATD's head, pelvis, torso, or shoulder area is not allowed. Contact during rebound is allowed.

b. Thoracic: The deflection of any of the ES-2re ATD upper, middle, and lower ribs must not exceed 1.73 inches (44 mm). Data must be processed as defined in Federal Motor Vehicle Safety Standards (FMVSS) 571.214.

c. Abdominal: The sum of the measured ES-2re ATD front, middle, and rear abdominal forces must not exceed 562 lbs (2,500 N). Data must be processed as defined in FMVSS 571.214.

d. Pelvic: The pubic symphysis force measured by the ES-2re ATD must not exceed 1,350 lbs (6,000 N). Data must be processed as defined in FMVSS 571.214.

e. Leg: Axial rotation of the upper-leg (femur) must be limited to 35 degrees in either direction from the nominal seated position.

f. Neck: As measured by the ES-2re ATD and filtered at CFC 600 as defined in SAE J211:

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

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

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

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

g. Occupant (ES-2re ATD) retention: The pelvic restraint must remain on the ES-2re ATD's pelvis during the impact and rebound phases of the test. The upper-torso restraint straps (if present) must remain on the ATD's shoulder during the impact.

h. Occupant (ES-2re ATD) support:

(1) Pelvis excursion: The load-bearing portion of the bottom of the ATD pelvis must not translate beyond the edges of its seat's bottom seat-cushion supporting structure.

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

3. For seats with an airbag system in the shoulder belts, show that the airbag system in the shoulder belt will deploy and provide protection under crash conditions where it is necessary to prevent serious injury. The means of protection must take into consideration a range of stature from a 2-year-old child to a 95th percentile male. The airbag system in the shoulder belt must provide a consistent approach to energy absorption throughout that range of occupants. When the seat system includes an airbag system, that system must be included in each of the certification tests as it would be installed in the airplane. In addition, the following situations must be considered:

a. The seat occupant is holding an infant.

b. The seat occupant is a pregnant woman.

4. The airbag system in the shoulder belt must provide adequate protection for each occupant regardless of the number of occupants of the seat assembly, considering that unoccupied seats may have an active airbag system in the shoulder belt.

5. The design must prevent the airbag system in the shoulder belt from being either incorrectly buckled or incorrectly installed, such that the airbag system in the shoulder belt would not properly deploy. Alternatively, it must be shown that such deployment is not hazardous to the occupant, and will provide the required injury protection.

6. It must be shown that the airbag system in the shoulder belt is not susceptible to inadvertent deployment as a result of wear and tear, or inertial loads resulting from in-flight or ground maneuvers (including gusts and hard landings), and other operating and environmental conditions (vibrations, moisture, etc.) likely to occur in service.

7. Deployment of the airbag system in the shoulder belt must not introduce injury mechanisms to the seated occupant, or result in injuries that could impede rapid egress. This assessment should include an occupant whose belt is loosely fastened.

8. It must be shown that inadvertent deployment of the airbag system in the shoulder belt, during the most critical part of the flight, will either meet the requirement of § 25.1309(b) or not cause a hazard to the airplane or its occupants.

9. It must be shown that the airbag system in the shoulder belt will not impede rapid egress of occupants 10 seconds after airbag deployment.

10. The airbag system must be protected from lightning and high-intensity radiated fields (HIRF). The threats to the airplane specified in existing regulations regarding lighting, § 25.1316, and HIRF, § 25.1317, are incorporated by reference for the purpose of measuring lightning and HIRF protection.

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

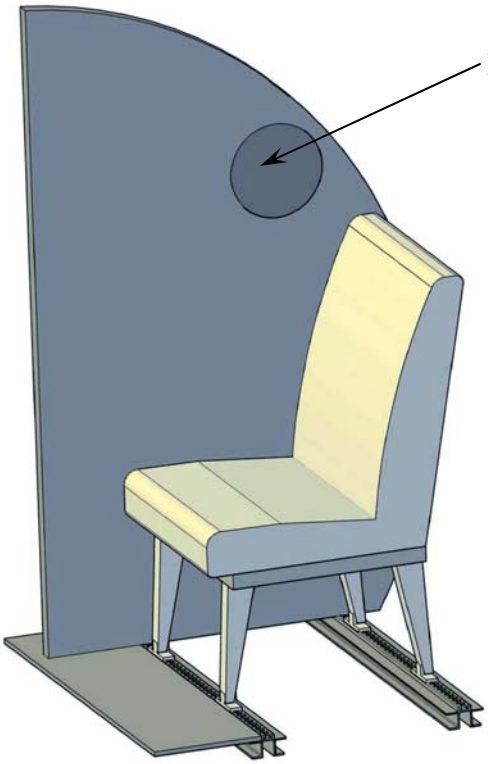
12. It must be shown that the airbag system in the shoulder belt will not release hazardous quantities of gas or particulate matter into the cabin.

13. The airbag system in the shoulder-belt installation must be protected from the effects of fire such that no hazard to occupants will result.

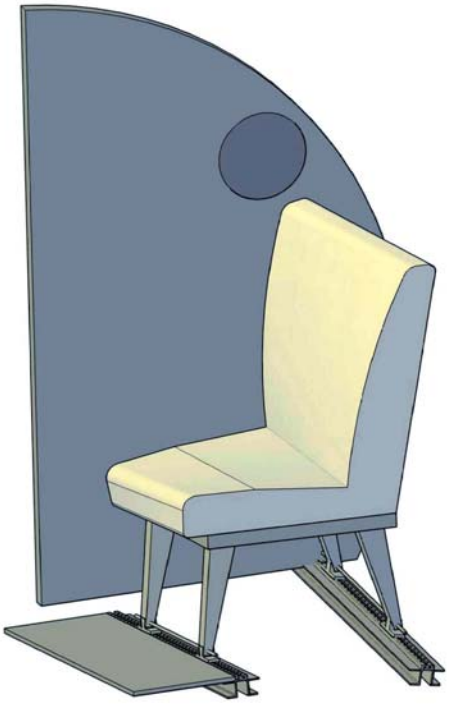
14. A means must be available for a crewmember to verify the integrity of the airbag system in the shoulder-belt activation system prior to each flight, or it must be demonstrated to reliably operate between inspection intervals. The FAA considers that the loss of the airbag-system deployment function alone (i.e., independent of the conditional event that requires the airbag-system deployment) is a major-failure condition.

15. The inflatable material may not have an average burn rate of greater than 2.5 inches/minute when tested using the horizontal flammability test defined in part 25, appendix F, part I, paragraph (b)(5).

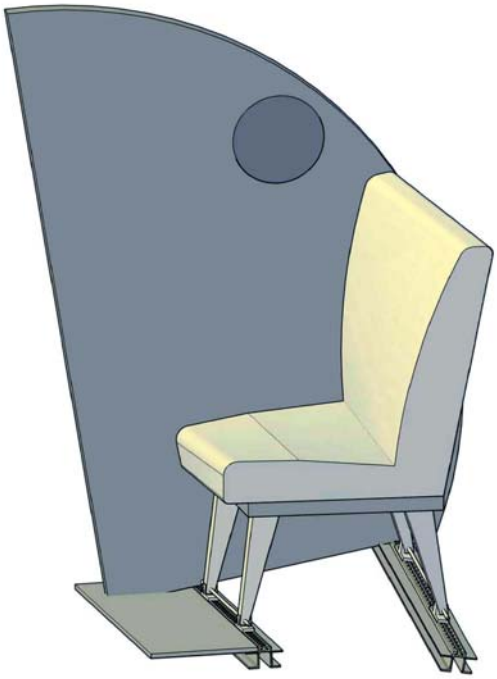
16. The airbag system in the shoulder belt, once deployed, must not adversely affect the emergency-lighting system (i.e., block floor proximity lights to the extent that the lights no longer meet their intended function).



A. Prior to Test Setup



B. Inboard Seat Tracks Twisted 10° down and Outboard Seat Tracks Rolled 10° Outboard



C. Partition Rotated to maintain Head Target Area Relationship.

Figure 1

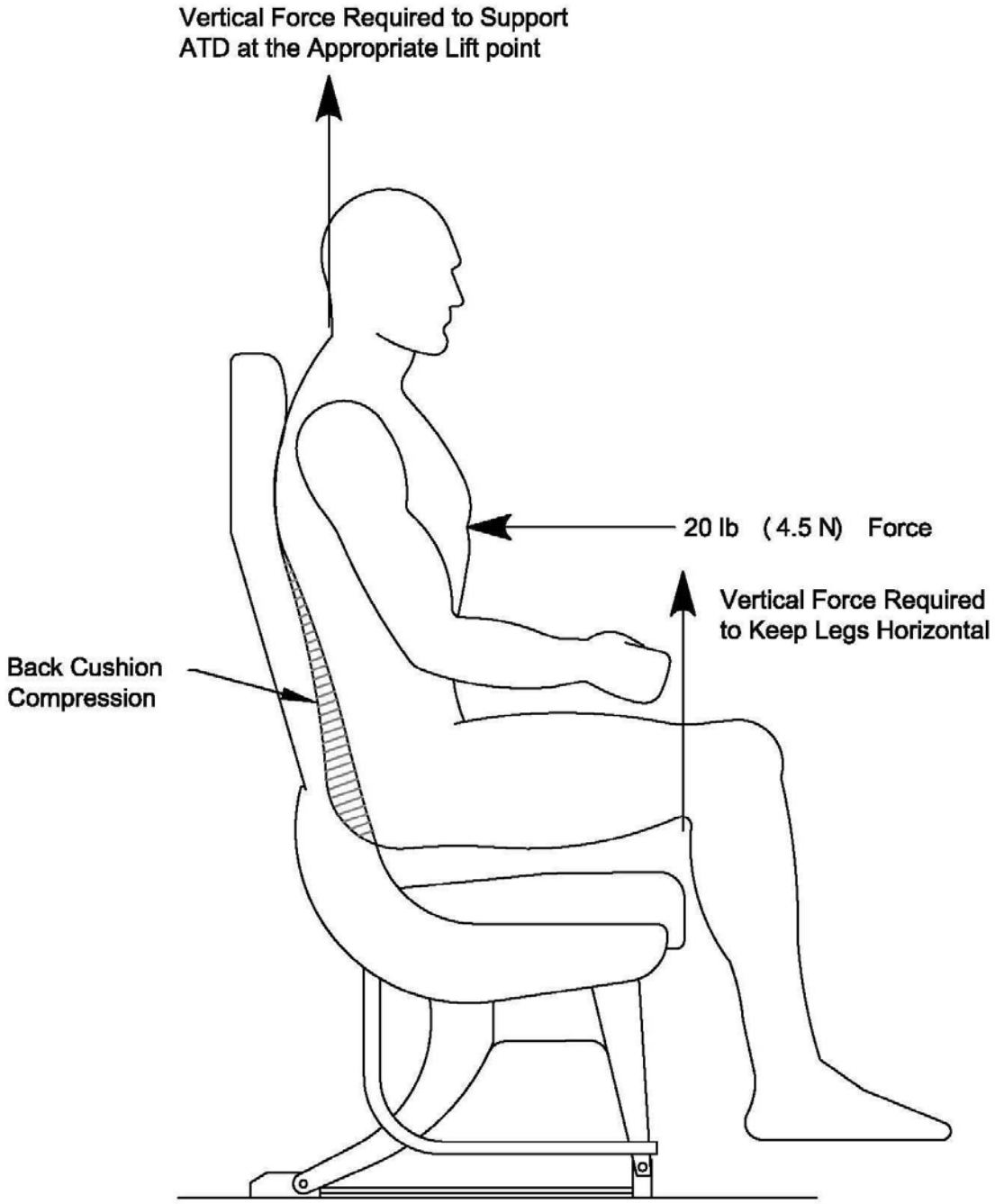

Vertical Force Required to Support
ATD at the Appropriate Lift point
20 lb (4.5 N) Force
Vertical Force Required
to Keep Legs Horizontal
Back Cushion
Compression

Figure 2

Attachment 2

The new special conditions utilize the ES-2re Anthropomorphic Test Dummy (ATD) and the associated injury criteria cited in current Federal Motor Vehicle Safety Standards (FMVSS) for side-impact testing (FMVSS 571.214). This ATD has improved biofidelity and instrumentation that allow more accurate evaluations of injury potential than the previously cited U.S. side-impact dummy (SID). Rib deflection and abdominal forces measured by the ES-2re, rather than the Thoracic Trauma Index (TTI), are used to predict the risk of thoracic injury, and pubic symphysis force is used in lieu of pelvic acceleration to predict pelvis-injury risk. The FAA has evaluated and documented the ES-2re ATD performance in several seating configurations in report DOT/FAA/AM-07/13. This ATD is appropriate for measuring all injury criteria cited in the special conditions and § 25.562(c), except for the compressive load between the pelvis and the lumbar column cited in (c)(2). Either the ES-2re or the ATD currently specified in § 25.562 may be used in tests showing the structural integrity of the seat and restraint system.

As noted in previous memos, neck injury was a concern but no data was available to establish injury criteria. Neck-injury evaluation methods applicable to the most common side-facing-seat configurations were identified during the recent FAA research. A recently published report, DOT/FAA/AR-09/41, contains the data supporting the cited neck-injury criteria. The scope of that research, however, did not include deriving specific injury criteria for all possible loading scenarios that could affect occupants of fully side-facing seats. To limit the injury risk in those cases, these special conditions provide conservative injury-evaluation means that are derived from past practice and applicable scientific literature.

Initial FAA neck-injury research did not produce high lateral-bending moments in the absence of tension. This loading condition was of interest because in some tests, potential injury-mitigation technology (such as inflatable restraint systems) has produced relatively high bending loads with little tension (DOT/FAA/AM-07/13). The Post Mortem Human Subject (PMHS) test associated with the highest moment recorded during the initial research did not result in neck injury. This indicated that the onset of serious injury was likely greater than the 673 in-lb (76 N-m) measured by an ES-2re ATD subjected to the same test conditions (DOT/FAA/AR-09/41). To investigate further, a follow-on project was conducted to assess the load case consisting of low-tension/high-lateral moments. The highest bending moment produced at the occipital condyles of the PMHS, during that follow-on research, was 651 in-lb (74 N-m). This load did not result in a detectable injury. A comparison between ES-2 and PMHS response, when loaded in the same manner and at the same severity, indicates that this load corresponds to a 1,018 in-lb (115 N-m) moment measured by the ES-2. (Yoganadan, “Neck Injury Criteria for Side-Facing Aircraft Seats – Phase 2” DOT /FAA, *In Press*) Therfore, a value of 1,018 in-lb (115 N-m) lateral bending moment (as measured at the occipital condyle location of the ES-2) can be considered a threshold below which neck injury is not expected.

Serious leg injuries, such as femur fracture, can occur in aviation side-facing seats that could threaten the occupant’s life directly or eliminate the occupant’s ability to evacuate. Femur fractures of the leading leg were seen in PMHS tests using an aviation seating configuration that produced torque in the femur (DOT/FAA/AR-09/41). The test protocol for that project (which was focused on neck injury) did not allow for a determination of PMHS femur torque or the specific angle that causes injury. However, if the upper leg’s axial rotation, with respect to the

pelvis, is limited to the normal static range of motion, then the risk of injury should be low. That range of motion for a seated occupant's internal and external rotation ranges from 18 degrees for the least flexible persons (the male population's 5^{th} percentile rotation value) to 45 degrees for the most flexible persons (the female population's 95^{th} percentile rotation value) (Dreyfus, "The Measure of Man and Woman," 2002). ATD tests in the same seat configuration as the PMHS tests showed that the ES-2re leg will rotate at least 60 degrees in this loading scenario (DOT/FAA/AM-07/13). Therefore, limiting upper-leg axial rotation with respect to the pelvis to 35 degrees from the nominal seated position (approximately the 50 percentile range of motion for both genders) should also limit the risk of serious leg injury. One means of determining the amount of relative upper-leg rotation is by observing lower-leg flailing in typical high-speed video of the dynamic tests. Since the lap belt tends to prevent significant lateral rotation of the pelvis, the motion of the lower leg with respect to its initial position is sufficient to derive the upper-leg relative rotation with respect to the pelvis. This requirement complies with the intent of the § 25.562 (c)(6) injury criteria in preventing serious leg injury.

The requirement to provide support for the pelvis, upper arm, chest, and head, contained in the previous special conditions for single-place side-facing seats, has been replaced in the new special conditions applicable to all fully side-facing seats with requirements for neck-injury evaluation, leg-flailing limits, pelvis-excursion limits, head-excursion limits, and torso lateral-bending limits that directly assess the effectiveness of the support provided by the seat and restraint system.

One factor in determining if a dynamic test is successful is whether the primary load path between the occupant and the seat attachments is maintained (Advisory Circular (AC) 25.562-1B). Since the bottom seat cushion supporting structure is a primary load path, the load-bearing portion of the occupant's pelvis must be supported by it throughout the impact event. The area of the cushion under the ATD having the greatest effect on performance is defined in AC 25.562-1B, appendix 3, paragraph 9b. This means the corresponding area on the bottom of the pelvis is the principal load-bearing area, and can be used when determining whether the load path between the ATD and seat pan is maintained.

To protect occupants in aft-facing seats, those seats must have sufficient height and stiffness to support their head and spine. Providing this support is intended to reduce spinal injuries when occupant inertial forces cause the spine to load against the seat back. Some side-facing seat configurations have been found to produce loading that causes the occupant's head to flail beyond the top of the seat back. Ensuring the seat has sufficient height and stiffness to support the head and spine is one way to prevent the potentially injurious spine loads created by that articulation. Of the common seating configurations tested by the FAA, the ones that resulted in flailing beyond the seat back produced upper-neck tension and shear forces exceeding the injury limits cited in these special conditions. This finding implies that excessive rearward articulation of the neck is unlikely in common seating configurations if upper-neck forces are below the cited values. Therefore, in side-facing seat tests, the intent of the requirement to provide sufficient rearward support for the spine and head can be met by limiting the magnitude of neck loads. Applying either of these approaches to side-facing seats (providing spinal support or limiting neck loads) would provide the same level of safety afforded occupants of forward- and aft-facing seats.

Serious injuries, including spinal fractures, have been observed in tests that produce lateral flailing over an armrest (Pintar, et al., "Comparison of PMHS, WorldSID, and THOR-NT Responses in Simulated Far Side Impact," Stapp 2007-22-0014). The ES-2re's abdominal-force measurement has been shown to correspond to injuries resulting from horizontal impact in this area. Limiting the loading in this area may prevent some of the injuries produced when occupants flail over armrest structure. However, this criteria was not intended to evaluate spinal or internal injuries caused by excessive lateral bending of the occupant, as those types of injuries were not observed in the typical automotive side impacts that formed the basis of the criteria. In the automotive side-impact tests, the occupants are typically fully supported through the vehicle door and window. While there is currently no criteria relating the amount of lateral flail to a specific risk of injury, if lateral flexion is limited to the normal static range of motion, then the risk of injury should be low. This range of motion is approximately 40 degrees from the upright position (Dreyfus, "The Measure of Man and Woman," 2002). Ensuring that lateral flexion does not create a significant injury risk is consistent with the goal of providing an equivalent level of safety to a forward-or aft-facing seat, since that type of articulation does not occur during forward impacts of those seats.

Section 25.562 of 14 CFR requires that the restraints remain on the shoulder and pelvis of the occupant during impact. AC 25.562-1B clarifies this by stating that restraints must remain on the shoulder and pelvis when loaded by the occupant. This criterion is necessary to protect the occupant from serious injury that could be caused by lap-belt contact forces applied to soft tissue, or by ineffective restraint of the upper torso caused by the upper-torso restraint sliding off the shoulder. In forward-facing seats (the type specifically addressed by that AC), occupant motion during rebound, and any subsequent re-loading of the belts, is limited by interaction with the seat back. However, in a side-facing seat subjected to a forward impact, the restraint system may be the only means of limiting the occupant's rearward (rebound) motion. To limit abdominal-injury risk in side-facing seats, the lap belt must remain on the pelvis throughout the impact event, including rebound.

During side-facing-seat dynamic tests, the risk for head injury is assessed with only one occupant size (the 50^{th} percentile male as represented by the ES-2re). However, protection for a range of occupant statures can be provided if the impacted surface is homogenous in the area contactable by that range of occupants. Anthropometry statistics (Harrison, C.R., "CAESAR: Summary Statistics for the Adult Population (Ages 18-65) of the United States of America," AFRL-HE-WP-TR-2002-0170) are useful in determining the potential contact area relative to the point contacted by the 50^{th} percentile ATD during dynamic tests.

The FAA has issued special conditions in the past for airbag systems on lap belts for some forward-facing seats. These special conditions for the airbag system in the shoulder belt are based on the previous special conditions for airbag systems on lap belts, with some changes to address the specific issues of side-facing seats. The airbag system in the shoulder belt is designed to limit occupant forward excursion in the event of an accident. The airbag system in the shoulder belt behaves similarly to an automotive inflatable airbag, but in this case, the airbag is integrated into the shoulder belt and inflates away from the seated occupant. While inflatable airbags are now standard in the automotive industry, the use of an airbag system in the shoulder belt is novel for commercial aviation.

The FAA has considered the installation of an airbag system in the shoulder belt to have two primary safety concerns: first, that the system performs properly under foreseeable operating conditions, and second, that the system does not perform in a manner or at such times as would constitute a hazard to the airplane or occupants. This latter point has the potential to be the more rigorous of the requirements, owing to the active nature of the system. See attachment 1 for detailed requirements for airbag systems. These additional requirements are similar to the additional requirements for seat belts equipped with airbag systems.

Attachment 3

Terms

Table A-1 defines the use of key terms in this policy statement. The table describes the intended functional impact.

Table A-1 Definition of Key Terms

	Regulatory Requirements	Acceptable Methods of Compliance (MOC)	Recommendations
Language	Must	Should	Recommend
Meaning	Refers to a regulatory requirement that is mandatory for design approval	Refers to instructions for a particular MOC	Refers to a recommended practice that is optional
Functional Impact	No Design Approval if not met	Alternative MOC has to be approved by issue paper.	None, because it is optional