U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject:	INFORMATION, Equivalent Level of Safety (ELOS) Finding for the Passageway to and Opening of Overwing Exits for Boeing 737-600, -700, -700C, -800, -900 Series Aircraft. TD8301SE-T	Date:	June 10, 2004
		Reg Ref:	§ 25.813, Amdt. 25-77
From:	Manager, Transport Airplane Directorate	Reply to Attn of:	Keith Ladderud ANM-150S
To:	Manager, Seattle ACO	ELOS Memo #:	TD8301SE-T-C-1

The purpose of this memorandum is to inform the certificate management aircraft certification office of an evaluation made by the Transport Airplane Directorate on the establishment of an equivalent level of safety finding for the 737-600, -700, -700C, -800, -900 Series Aircraft . This memorandum supersedes the equivalent level of safety memorandum TD2464SE-T-C-1.

Background

During the certification of the 737-700, Boeing chose to install a new canopy style hatch (also known as an automatically opening exit (AOE)) at the overwing exits. This new canopy hatch was considered a new design, and therefore, the certification requirements pertaining to the new hatch were changed to include the affected regulations at the most current amendments. This included updating the certification basis of the airplane to include § 25.813, Amendment 25-77, for those aspects related to the new exit.

The change in the certification basis created a configuration problem for operators of the 737-NG series aircraft because they desired flexibility to arrange their interior configurations such that economy class triple seats are installed around the overwing hatch areas in such a way that the seats can protrude into the projected opening of the exits. In order to meet their customers' requirements, Boeing requested allowance for the front edge of the seat to encroach into the exit opening from the aft edge of the hatch opening up to the centerline of the exit. This included up to 3.7 inches of vertical encroachment into the hatch opening. Boeing also requested to be allowed to reduce the required passageway to the exit from 20 inches to 13 inches in order to achieve additional flexibility in their customer's seating configurations.

Section 25.813(c)(2)(i) at Amendment 25-77 states "the projected opening of the exit provided must not be obstructed" and "there must be no interference in opening the exit". Additionally, § 25.813(c)(1)(i) at Amendment 25-77 states for triple seats, an unobstructed passageway must be provided that is 20 inches wide, and the centerline of the passageway to the centerline of the exit cannot be displaced more than 5 inches horizontally. As such, the Boeing proposed configurations did not directly comply with §§ 25.813(c)(1)(i) and 25.813(c)(2)(i).

Because the configurations do not comply directly, Boeing made a request for equivalent level of safety findings for §§ 25.813(c)(2)(i) and 25.813(c)(1)(i). In their request, Boeing proposed to provide a 13 inch unobstructed passageway with a 6.5 inches maximum offset between the exit centerline and the centerline of the passageway and to limit the seating configurations such that no part of the seats/seat cushions encroach further forward than the centerline of the exit. Boeing also proposed to allow the cushion to protrude up to 3.7 inches vertically into the lower aft projected opening of the Type III exits with the caveat that the cushion could be readily compressed by 2 inches.

This ELOS has been revised to address a change to the seat back deformation evaluations included therein. For airplanes without § 25.562(c)(5) as part of their certification basis, the FAA has determined that it is reasonable to account only for seat back deformations resulting from static and dynamic structural tests in accordance with the certification basis.

Applicable regulation(s)

§§ 21.21(b)(1), 25.807, 25.813 (as of Amendment 25-77)

Regulation(s) requiring an ELOS

§ 25.813(c)(1)(i), (c)(2)(i)

Description of compensating design features or alternative standards which allow the granting of the ELOS (including design changes, limitations or equipment needed for equivalency)

When Boeing developed the new AOE, the FAA recognized that there were safety benefits associated with its implementation. This new exit is a significant improvement over traditional Type III exits that are typically equipped with removable hatches, which can weigh up to 60 pounds. The AOE is an exit that once activated, opens quickly and automatically, and is automatically stowed outside of the aircraft. Its design is very similar to a gull wing door or a top hinged cargo door, except that it opens much faster.

Boeing provided additional details to define that the 2 inches of readily compressible seat cushion material would be evaluated by limiting the compression force to 170 lbs. applied over 40 square inches. Other criteria were defined by Boeing to evaluate acceptable deformations associated with dynamically tested seats installed bordering the passageways to the AOEs. Boeing also identified that an additional compensating feature was provided in that the airplanes would be configured such that the step up and step down heights would be less than the maximum allowed by the regulations.

Explanation of how design features or alternative standards provide an equivalent level of safety to the level of safety intended by the regulation

With the AOE, Boeing provided an improvement to the evacuation capability of the 737-600/700/800/900 series airplane by eliminating the difficulties associated with removing a traditional hatch and then stowing it during an emergency. This improvement in combination with data from testing conducted at the Civil Aeromedical Institute (CAMI) provided their rationale to compensate for a reduced exit passageway, with limited cushion encroachment into the exit opening. CAMI test data supported their assertion that a 13 inch passageway is just as effective as a 20 inch passageway leading to a Type III exit, when the passageway is between rows of economy class triple seats. Boeing was also required to conduct evacuation tests to further support their case using two groups of 30 volunteers, each of which exited both the AOE and baseline configuration exits. The baseline configuration consisted of the removable hatch placed on the exit seat row arm rests, lowered seat with no seat protrusion into the exit opening, a step up of 13 inches and a step down of 27 inches. The time to evacuate the airplane through the AOE configuration was equivalent to the time to evacuate through the baseline configuration.

ELOS Summary

The combination of the testing conducted at CAMI and at Boeing, control of seat deformations around the Type III exits (see below), and the compensating features (ease of use, step up and step down distances) of the AOE provide the supporting data to grant Boeing's requests for equivalent level of safety findings. An equivalent level of safety finding was therefore granted for § 25.813(c)(2)(i), Amendment 25-77, which allows 3.7 inches of vertical encroachment of the seat cushion into the Type III exit openings that are provided. This encroachment must include 2 inches of readily compressible material and the leading edge of the seat/seat cushion protruding into the exit opening cannot extend further forward than the centerline of the exit. If the vertical encroachment by the cushion is less than 3.7 inches, the requirement for 2 inches of compressible material can be correspondingly reduced. A force of 170 pounds distributed over 40 square inches is an acceptable method to determine if the cushion material is readily compressible. The step up required by § 25.807(a)(3), Amendment 25-77, should be measured from the floor to the top of the uncompressed cushion; step down should be measured from the wing to the sill or the opening, whichever is greater. Also, an equivalent level of safety finding was granted for § 25.813(c)(1)(i), Amendment 25-77, for a 13 inch unobstructed passageway to each Type III exit with a centerline offset of the passageway to the exit opening not to exceed 6.5 inches when configured with economy class triple seats in the exit area. The above findings apply only to 737-600/-700/-800/-900 series airplanes with the new Type III AOE.

Seat Deformation Considerations (§§ 25.561(d) and 25.562(c)(8))

The following information specifically addresses seat deformations resulting from § 25.561 and § 25.562 (Amendment 25-77) testing of seats to be installed at and around the Type III exit passageways. Especially critical is evaluation of the outboard seat backs as they may potentially deform into the AOE opening, and thus, negatively impact the evacuation capability. For all deformation evaluations each seat bordering the exit needs to be considered. In many cases, it may be necessary to not only evaluate the seat adjacent to the exit, but to also analyze the permanent deformations of the seats and seat backs in the seat rows installed immediately forward and aft of the exit.

Forward Deformation

Triple seats located adjacent to the AOE are to be located such that, after the permanent static and dynamic deformations, the forward edge of the seat must not extend more than 3.0 inches forward of the hatch centerline. In addition, at seat rows leading to Type III exits, 20 inch minimum clearance, measured above the armrests, shall be maintained between adjacent seat rows post deformation of the aft seat row. This measurement may be made with the seat backs returned to to their upright position, using no more than a 35 pound force applied to the seat back. Permanent static and dynamic deformations of triple seats with outboard armrests shall not result in the armrest encroaching into the projected exit opening. In addition, permanent static and dynamic deformations of triple seats located adjacent to the AOE shall not result in the seat back encroaching into the projected exit opening. Deformation must not permit the seat to encroach more than 3 inches into the required passageway. In the event the deformation exceeds 3 inches, the undeformed clearance must be increased accordingly.

Aft Deformation

Triple seats located adjacent to, and forward of the AOE's are to be located such that after the permanent static and dynamic deformations, the inboard and center seat backs must not extend more than 3.0 inches aft into the projected opening. The outboard portion of the outboard triple seat back must not encroach into the projected exit opening and the inboard portion of the outboard triple seat back must not extend more than 3.0 inches aft into the projected exit opening. This post deformation seat back protrusion cannot interfere with the operation of the AOE, and a 20 inch minimum clearance above the armrests must be maintained at the seat row leading to the Type III exit(s). The above seat back deformations may be measured after a push force (no more than 35 pounds) either backwards, forwards or both (in the most advantageous direction, i.e. tending to restore the seat back to its original position), is applied to the seat back.

Sideward Deformation (Outboard Direction)

The hard structure of the triple seats located adjacent to the Type III exit shall not damage the AOE lining after static or dynamic deformations in any manner that would compromise the opening of the AOE. Hard structure is defined as any part of the seat other than cushions. To prevent seat hard structure from damaging the AOE lining due to static deformation, Boeing installed bumpers to the airplane interior below and aft of the AOE lining. These bumpers must be designed to transfer outboard seat loads to the airplane structure surrounding the AOE. Permanent outboard dynamic deformations must not exceed the installation clearance (pre-deformation) between seat hard structure and the AOE lining.

Upward Deformation

Upward permanent static and dynamic deformations of the outboard seat place of a triple seat located adjacent to the AOE must be no more than 1.5 inches above the maximum certifiable height of the seat bottom cushion into the provided exit opening (5.2 inches total encroachment after deformation or waterline 227.70). In those cases where the upward deformation goes beyond this limit, the undeformed seat height must be reduced accordingly.

Other Seat Deformation Considerations

An economy class double seat located adjacent to the Type III exit is not required to comply with the above static or dynamic deformation limitations except as noted below. For a double seat adjacent to the Type III exit, two 6 inch passageways are required by § 25.813(c)(1)(ii). In these cases, the double seat must be an economy class seat, similar in configuration to a triple seat with the outboard seat place removed leaving the equivalent of a single seat width space adjacent to the exit. The maximum allowable permanent forward deformation is 3 inches. Deformation must not permit the seat to encroach more than 3 inches into the required passageway. In the event the deformation exceeds 3 inches, the undeformed clearance must be increased accordingly.

FAA approval and documentation of the ELOS

The FAA has approved the aforementioned Equivalent Level of Safety Finding in project issue paper C-1. This memorandum provides standardized documentation of the ELOS that is non-proprietary and can be made available to the public. The Transport Directorate has assigned a unique ELOS Memorandum number to facilitate archiving and retrieval of this ELOS. This ELOS Memorandum number should be listed in the Type Certificate Data Sheet under the Certification Basis section (TC's & ATC's). An example of an appropriate statement is provided below.

Equivalent Safety Findings have been made for the following regulation(s):
§ 25.813(c)(1)(i), (c)(2)(i) Emergency Exit Access (TAD ELOS Memo TD8301SE-T-C-1)

/s/ Alan Sinclair for — June 10, 2004

Manager, Transport Airplane Directorate — Date
Aircraft Certification Service

ELOS Originated by Seattle ACO:	Project Engineer: Keith Ladderud	Routing Symbol ANM-150S