

(R) Aircraft Seat Design Guidance and Clarifications

RATIONALE

The change in this revision represent the latest agreement obtained by the SAE SEAT Committee to integrate the new paragraph §3.18 Electrically Actuation Feature.

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## 1. SCOPE

This Aerospace Recommended Practice (ARP) documents a common understanding of terms, compliance issues and design criteria to facilitate certification of seat installations specific to Part 25 aircraft. This ARP provides general guidance for seats to be installed in Part 23 aircraft and Parts 27 and 29 rotorcraft and does not specify specific designs or design methods for such certification.

## 2. REFERENCES

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulation unless a specific exemption has been obtained.

### 2.3 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), [www.sae.org](http://www.sae.org).

AFRL-HE-WP-TR-2002-0170 CAESAR: Summary Statistics for the Adult Population (ages 18-65) of the United States of America

AS8049B Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft

### 2.4 Aerospace Industries Association (AIA) National Aerospace Standard (NAS) Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, [www.aia-aerospace.org](http://www.aia-aerospace.org).

NAS 809 Specification – Aircraft Seats and Berths

### 2.5 Code of Federal Regulations (CFR) Publications

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-0000, [www.gpoaccess.gov](http://www.gpoaccess.gov).

Code of Federal Regulations Title 14 Part 23 (14 CFR Part 23) Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes

Code of Federal Regulations Title 14 Part 25 (14 CFR Part 25) Airworthiness Standards: Transport Category Airplanes

Code of Federal Regulations Title 14 Part 27 (14 CFR Part 27) Airworthiness Standards: Normal Category Rotorcraft

Code of Federal Regulations Title 14 Part 29 (14 CFR Part 29) Airworthiness Standards: Transport Category Rotorcraft

Code of Federal Regulations Title 14 part 121 (14 CFR 121) Certification and Operations: Domestic, Flag, and Supplemental Air Carriers and Commercial Operators of Large Aircraft

## 2.6 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, [www.faa.gov](http://www.faa.gov).

AC 25-17A Transport Airplane Cabin Interiors Crashworthiness Handbook

AC 25.785-1B Flight Attendant Seat And Torso Restraint System Installations

PS-ANM100-1996-00128 Subject: Simplified Procedure for addressing the Head Injury Criteria of § 25.562

PS-ANM100-2003-10019 Subject: Policy Statement on Evaluating a Seat Armrest Cavity for a Potential Fire Hazard

Special Airworthiness Information Bulletin (SAIB) NM-04-37, issued December 22, 2003, recommends that a specific design of seat belt attachment fitting be replaced with an improved design fitting.

### 2.6.1 Department of Transportation Technical Standard Order (TSO)

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-0000, [www.gpoaccess.gov](http://www.gpoaccess.gov).

TSO-C39b Aircraft Seats and Berths

TSO-C127a Rotorcraft, Transport Airplane and Normal and Utility Airplane Seating Systems

TSO-C22g Safety Belts

TSO-C114 Torso Restraint Systems

## 2.7 Civil Aerospace Medical Institute

Available from the US Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-0000, [www.gpoaccess.gov](http://www.gpoaccess.gov).

DOT/FAA/AM-03/9 Human Factors Associated With the Certification of Airplane Passenger Seats: Life Preserver Retrieval

## 2.8 NASA Publications

Available from NASA, Documentation, Marshall Space Flight Center, AL 35812, [www.nas.nasa.gov](http://www.nas.nasa.gov).

NASA-STD-3000 Vol. I Man Systems Integration Standards Rev. B, NASA Johnson Space Center, Houston, TX, 1995.

## 2.9 Underwriters Laboratories Inc.

Available from Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096, Tel: 847-272-8800, [www.ul.com](http://www.ul.com).

UL 1439 Tests for Sharpness of Edges on Equipment

### 3. DEFINITIONS

FAR references can be considered valid across aircraft categories: 14 Code of Federal Regulations Parts 23, 25, 27 and 29.

#### 3.1 Seat back Handhold in Turbulence

##### 3.1.1 Application

###### 14 CFR Part 25.785 (j) Amendment 25-88

If the seat backs do not provide a firm handhold, there must be a handgrip or rail along each aisle to enable persons to steady themselves while using aisles in moderately rough air.

###### AC 25-17A par. 81.b (6) Crashworthiness Handbook

The seat back may serve as a firm handhold. Since many seats are capable of breaking over, the breakover load must be adequate to be considered firm. A load of 111 N (25 pounds) minimum, acting horizontally, is considered adequate when applied at the top center of the seat back.

3.1.2 Definition and Criteria: A handhold is defined as a means of providing a hand hold support for a person standing upright in an aisle during flight. If an adequate supplemental rail or handgrip is not provided in the interior, seat backs may be used as the handhold so long as they are spaced sufficiently close together to be within reach for an occupant using the aisle. For that purpose, a seat pitch of 165 cm (65 inches) or less is considered adequate in a typical commercial transport aircraft configured with forward or rearward facing passenger seats positioned along an aisle. Due to the unique and customized interior arrangement of forward, sideward or rearward facing passenger seats in business/private transport aircraft (not for hire) these configurations should be assessed individually. Divan seating and side facing seats do not normally place the seat back where it can be effectively used as a handhold.

To act as a handhold, the upper aisle-side corner of the seat back should provide either a surface to grip or push against. A seat back used as a handhold should not break over when a force of 111 N (25 pounds) in a direction perpendicular to the seat back is applied at the top center of the seat back. Seat backs with head rests that telescope more than three inches above the seat back may be used for a handhold if, in addition to all other requirements, no portion of the head rest, e.g. bendable ears and/or tilting head rest, can be moved more than 17.8 cm (seven inches) before a 111 N (25 pound) resistive force is met.

The seat back handhold should be at least 84 cm (33 inches) above the floor, even if the seat back is reclined.

#### 3.2 Seat Belt Misalignment/Disengagement

##### 3.2.1 Application

##### 3.2.1.1 Restraint

The term restraint in this section refers to any strap, webbing, or similar device designed to secure a person in an aircraft with the intention of minimizing injury, including all buckles or other fasteners, and all integral hardware.

###### 14 CFR PART 25.601

###### General.

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

14 CFR PART 25.562 Amendment 25-64

(a) The seat and restraint system in the airplane must be designed as prescribed in this section to protect each occupant during an emergency landing condition when--

(1) Proper use is made of seats, safety belts, and shoulder harnesses provided for in the design;

TSO-C127a

2.1.2 Compliance with Section 3.1 Guidance: of SAE AS8049A is not required, except for Subsections 3.1.4, 3.1.8, 3.1.11, 3.1.14 (passenger seats only), 3.1.15 and 3.1.17 through 3.1.20.

FAA Policy Memo ANM-04-115-28

Policy Statement on an Unreliable Design of Seat Belt Attachment Fittings on Passenger's Seats and Compliance with § 25.601

NAS 809

When anchorages for safety belts are provided, they should be of a type which will permit self-aligning of the belt or fitting.

3.2.2 Definition and Criteria: Seatbelt misalignment is a condition where the seatbelt and/or shackle is positioned to give the impression that the belt has been properly tightened, when in fact there is slack in the system or the shackle is positioned so that it will not carry the force generated in an emergency landing or turbulence condition.

The seat belt installation should provide a self-orienting (free rotation and self-alignment) line of pull for the belt, minimize the possibility of inadvertent disconnection and be designed to minimize an incorrect installation.

The seat belt installation should not appear to the belted occupant to be properly adjusted (snug) while there is significant [2.54 cm (one inch) or more] slack in the system which may pay out in an emergency landing situation. For example, the belt installation should not be able to be caught between seat features such that the occupant would not know there was slack in the belt which may allow the occupant to slide forward during emergency landing or turbulence.

To test the installed seat belt for misalignment, the seat should be positioned in its taxi, takeoff and landing condition. Installations on seats having bottom cushions that can be removed or incorrectly repositioned without tools should be evaluated with the cushions installed, removed and incorrectly repositioned. The belt and shackle combination should be manipulated with one hand in an attempt to place the restraint in a non-design configuration where it could carry the seatbelt adjustment forces. Particular effort should be made to place the restraint in a position that the restraint forces would not be applied to the hook of the shackle in the same manner as they would be applied in a straight tension pull on the belt. Attempts should be made with the restraint in its normal shape, a single twist of the webbing and/or a single fold of the webbing. Typical areas around the restraint shackle that should be checked are the plastic shrouding around the armrest, the hydraulic seat recline device, the seat pan, anti-rotation brackets/stops, seat pan supports and exposed fasteners. If a condition of potential misalignment is identified, the seatbelt and shackle, in that condition, should be loaded by a restorative force of 22.2 N (five pounds) applied through the belt in the direction that it would be loaded in the emergency landing or turbulence situation. If the load is carried in the misaligned condition, the design is unacceptable. The examples in Section 3.2.3 illustrate various misalignment conditions that have been found to be unacceptable, as indicated. These examples are not intended to be all-inclusive.

To test the belt for inadvertent disengagement, where disengagement is defined as the separation of the restraint's attachment fitting from the seat structure, the belt should be tested in all orientations with the seat in the taxi, takeoff and landing conditions with the seat cushions installed. Interaction of belts in adjacent seats, where the belts could be inadvertently crossed and used by occupants in those adjacent seats, must be evaluated for the possibility of disengagement.

3.2.3 Examples: Examples of various causes of seat belt misalignment are illustrated below in Figures 1 and 2.

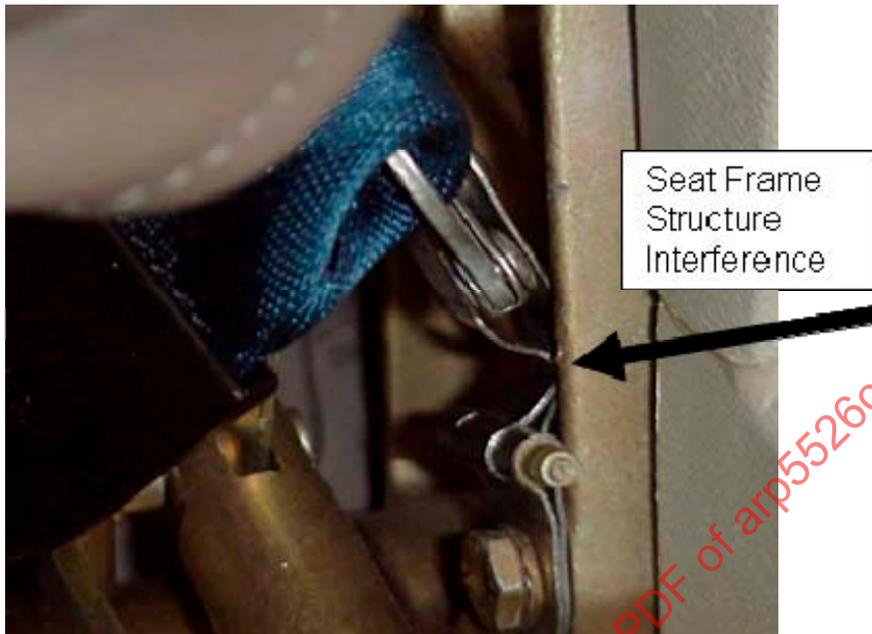


FIGURE 1 - SEAT BELT MISALIGNMENT

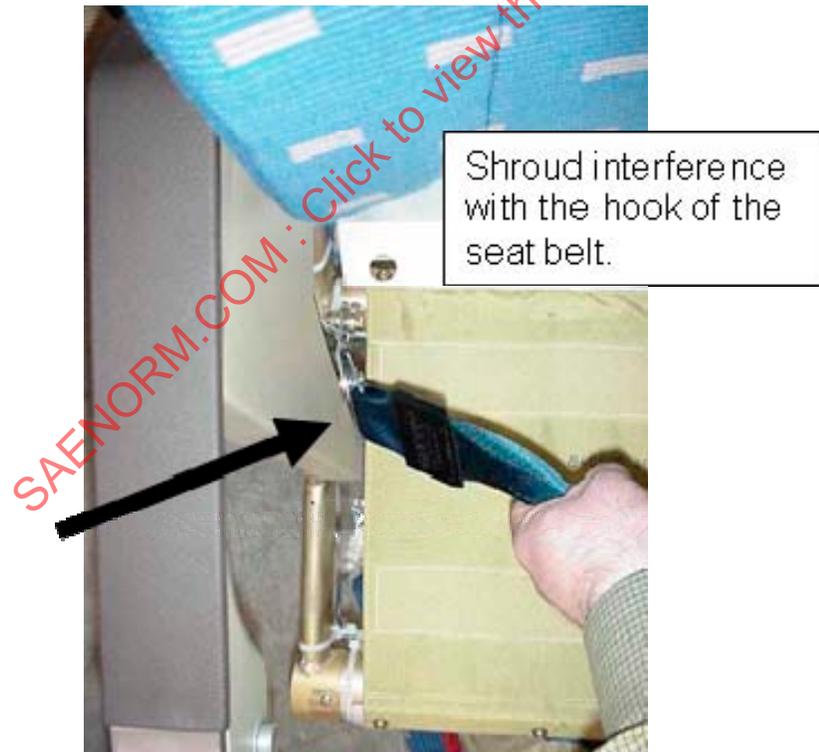


FIGURE 2 - SEAT BELT MISALIGNMENT

Examples of designs to avoid are illustrated in Figures 3 through 6.



FIGURE 3 - AN EXAMPLE OF A DESIGN TO AVOID



FIGURE 4 - AN EXAMPLE OF A DESIGN TO AVOID

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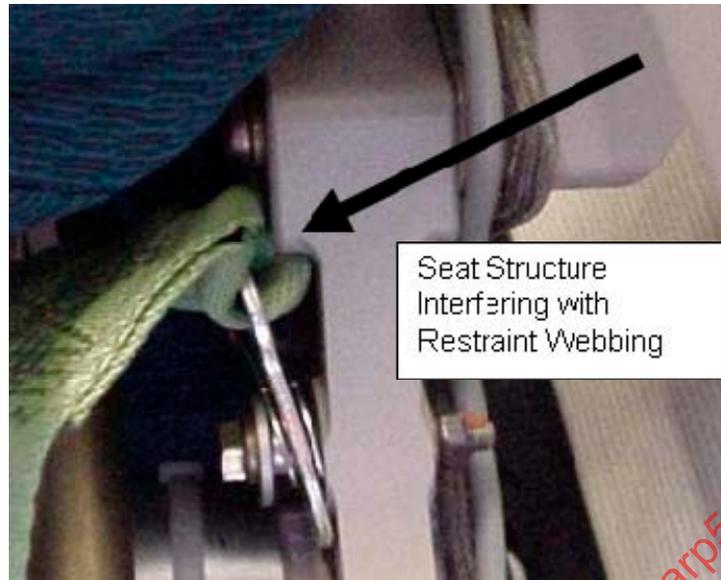


FIGURE 5 - AN EXAMPLE OF A DESIGN TO AVOID

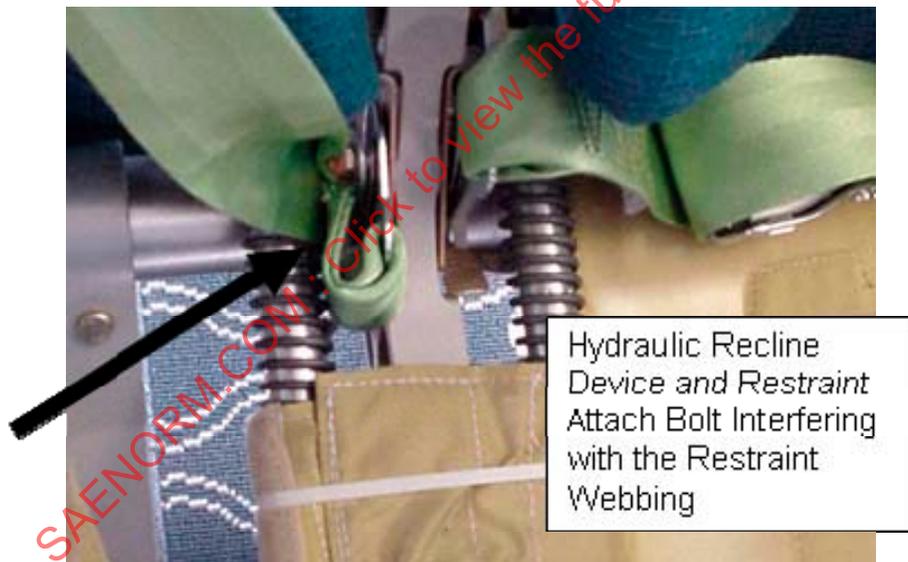


FIGURE 6 - AN EXAMPLE OF A DESIGN TO AVOID.

### 3.3 Life Vest/Lifejacket Retrieval

#### 3.3.1 Application

#### 14 CFR PART 25.1411 Amendment 25-116

- (f) Life preserver stowage provisions. The stowage provisions for life preservers described in Sec. 25.1415 must accommodate one life preserver for each occupant for which certification for ditching is requested. Each life preserver must be within easy reach of each seated occupant.

14 CFR PART 25.1541

- (a) The airplane must contain--
  - (1) The specified markings and placards; and
  - (2) Any additional information, instrument markings, and placards required for the safe operation if there are unusual design, operating, or handling characteristics.
- (b) Each marking and placard prescribed in paragraph (a) of this section--
  - (1) Must be displayed in a conspicuous place; and
  - (2) May not be easily erased, disfigured, or obscured.

14 CFR PART 27.1411 Amendment 27-11

- (a) Required safety equipment to be used by the crew in an emergency, such as flares and automatic liferaft releases, must be readily accessible.
- (b) Stowage provisions for required safety equipment must be furnished and must—
  - (1) Be arranged so that the equipment is directly accessible and its location is obvious; and
  - (2) Protect the safety equipment from damage caused by being subjected to the inertia loads specified in Sec. 27.561.

14 CFR PART 29.1411

- (f) Life preservers. Each life preserver must be within easy reach of each occupant while seated.

3.3.2 Definition and Criteria: When required, life vest stowage should be provided at each seating position in accordance with 14 CFR 25.1411 and 25.1541. If a seat can be occupied for taxi, takeoff, and landing, while facing in more than one direction, the life vest stowage provisions should be accessible for each of these positions. The life vest container should be located such that it does not hinder, in any way, the retrieval of the life vest by a seated and belted occupant. FAA report DOT/FAA/AM-03/9, provides general guidance to assist in evaluating the life preserver installation features associated with the easy reach requirements in FAA regulations. At a minimum the life vest container should be designed and located such that the following requirements are met:

- a. The life vest location is readily apparent.
- b. Life vest stowage should be located such that each occupant has access to a life vest, and the life vest is within easy reach of each seated and belted occupant in the aircraft during taxi, takeoff or landing.
- c. The life vest is restrained under all applicable loading conditions.
- d. The container and opening are correctly sized for the specified life vest.
- e. The container opening is located to allow the life vest to be readily removed by the seated and belted occupant.
- f. The method of opening is usable over a range of angles (e.g. unidirectional straps, snaps, etc. that can only be used by pulling one direction should be avoided). When pull straps are used, they should not be difficult to reach or operate. They should operate from all reasonably anticipated angles that would be used by a seated and belted occupant as limited by structure, cushions and seat pitch.

- g. The retrieval path of the life vest should be free of obstructions due to seat or aircraft components and/or pouch movement (e.g. legs, cushions, baggage bars, shrouds, etc.)
- h. The retention device should not allow the vest to come free during a heavy landing, normal seat activity (e.g. stowage and removal of under seat baggage), takeoff or other aircraft maneuver.
- i. Normal seat operation should not sweep the pull strap into an unreachable location.
- j. The life vest container should not present any sharp edges or points that could damage the life vest or cause injury.
- k. The location of pull straps is recommended to be adequately marked per section 3.8. Pull straps are recommended to be red or labeled "PULL" or "PULL FOR LIFE VEST" in contrasting color.
- l. Life vest retrieval should not be prevented by constricting elastic at the life vest container opening.

### 3.4 Friction Fit Components

#### 3.4.1 Application

#### 14 CFR PART 25.789 Amendment 25-46

Retention of items of mass in passenger and crew compartments and galleys.

- (a) Means must be provided to prevent each item of mass (that is part of the airplane type design) in a passenger or crew compartment or galley from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of Sec. 25.561(b).

- 3.4.2 Definition and Criteria: The use of friction fit as the sole method of restraint for items of mass (with the exception of ash trays) is not recommended.

A friction fit item is one that is restrained only by static friction between two or more flat or curved surfaces in direct contact with each other. Items restrained by mechanical fasteners such as screws, bolts, nuts, hook and loop tape, hooks, springs, detents, rivets, or similar devices are not considered friction fit items.

### 3.5 Fire Containment - Cavity Fully Enclosed/Open

#### 3.5.1 Application

#### 14 CFR Part 25.601

General.

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

- 3.5.2 Definition and Criteria: In cases where seats are designed with armrest cavities (that are typically used to hold tray tables and/or video monitors) the FAA policy memo, PS-ANM100-2003-10019 should be used to determine if the cavity should be fully enclosed or have an open bottom.

The FAA performed testing that included evaluation of armrest cavities with different levels of ventilation. Federal Aviation Administration Report DOT/FAA/AR-TN02/105, "Burning Behavior Within a Seat Armrest Cavity," dated September 2002, documents the results of fire tests conducted to examine the characteristics of several fire scenarios that could occur in an armrest cavity and the fire-containment capability of the cavity. In all the tests conducted with actual seat armrests, the fire self-extinguished, the armrest material did not ignite, and the fire was contained within the armrest cavity.

The FAA reviewed the practice of requiring seat armrest cavities to either be completely enclosed or have an open bottom. They determined that armrest cavities do not constitute a significant fire hazard regardless of whether or not these conditions are met. Accordingly, the armrest cavity may be open or closed to any degree and will not be hazardous under § 25.601.

### 3.6 Hinged Aisle Armrests - Discreet Latch

#### 3.6.1 Application

##### 14 CFR PART 25.789 Amendment 25-46

Retention of items of mass in passenger and crew compartments and galleys.

- (a) Means must be provided to prevent each item of mass (that is part of the airplane type design) in a passenger or crew compartment or galley from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of Sec. 25.561(b).

##### 14 CFR PART 25.815 Amendment 25-38

Width of aisle.

The passenger aisle width at any point between seats must equal or exceed the values in the following table:

Passenger Seating	Minimum Passenger Aisle Width (Inches)	
	Less than 25 inches from floor	25 inches and more from floor
10 or less	12	15
11 through 19	12	20
20 or more	15	20

- 3.6.2 Definition and Criteria: In cases where moveable passenger seat aisle armrests intrude into the required passenger aisle width, they should be retained in the taxi, takeoff and landing position.

Hinged armrests that do not meet the following criteria are referred to as Type A armrests. They are not recommended.

If a hinge is incorporated to allow the armrest to move, the armrest should either:

- Return to the taxi, takeoff and landing position by a positive means (e.g., spring assisted) without requiring the assistance of a passenger or attendant. This is referred to as a Type B armrest.
- Be retained in the taxi, takeoff and landing position by a discreet mechanical means (e.g., a latch) that is hidden or not obvious to a person in the seat or in nearby seats or standing in the aisle. The latch should not allow inadvertent or accidental operation under normal use of the seat. This is referred to as a Type C armrest.
- If the armrest is removable, the armrest should be retained in the taxi, takeoff and landing position by a discreet mechanical means (e.g., a latch) that is hidden or not obvious to a person in the seat or in nearby seats or standing in the aisle. The latch should not allow inadvertent or accidental operation under normal use of the seat. This is referred to as a Type D armrest.

### 3.7 Baggage Bar Loading and Retention of Items Under The Seat

#### 3.7.1 Application

##### 14 CFR PART 25.787 Amendment 25-51

- (b) There must be a means to prevent the contents in the compartments from becoming a hazard by shifting, under the loads specified in paragraph (a) of this section

##### AC 25-17A Para 102(b)(2)

Standard design criteria for underseat baggage restraint.

- 3.7.2 Definition and Criteria: Each passenger seat under which baggage is allowed to be stowed should be fitted with a means to prevent articles or baggage stowed under it from sliding forward or sideward (into the aisle or exit area).

Although it is expected that the under seat baggage area will store a variety of items, a standard bag or representative mass with the dimensions of 7.5 cm x 30.5 cm x 43.0 cm (3 in x 12 in x 17 in) and a weight of 9.0 kg (20 pounds) should be used during substantiation of the underseat baggage restraint system.

Guidance for the dimensions and loading for the baggage restraint are given in AC 25-17A. Installations that deviate from that guidance should restrain the baggage under the required loading conditions and should accommodate a step/abuse load of 1.3 kN (300 pounds) without failure (where applicable). The baggage restraint may yield and load the floor structure during step load testing.

The baggage restraint may be substantiated by test or rational analysis. Discontinuities in a baggage bar, as may be found when two double units make up a quad seat or adjacent to a sidewall, should not have a gap greater than 7.6 cm (3 in).

### 3.8 Seat Safety Placards

#### 3.8.1 Application

##### FAR 25.1411 Amendment 25-116

- (b) Stowage provisions. Stowage provisions for required emergency equipment must be furnished and must--

- (1) Be arranged so that the equipment is directly accessible and its location is obvious;

##### FAR 25.1541

- (a) The airplane must contain--

- (1) The specified markings and placards; and
- (2) Any additional information, instrument markings, and placards required for the safe operation if there are unusual design, operating, or handling characteristics.

- (b) Each marking and placard prescribed in paragraph (a) of this section--

- (1) Must be displayed in a conspicuous place; and
- (2) May not be easily erased, disfigured, or obscured.

AC 25-17A Para 1041(b)(1)

(1) Placards indicating emergency equipment should be approximately at eye level and should not blend in with the surrounding decor. A color contrast that complies with § 25.811(f)(2) is acceptable. If the emergency equipment is located in the upper or lower compartment, the eye level placard should have an arrow indicating the compartment. Each compartment containing emergency equipment such as life preservers, rafts, slides, slide/rafts, or fire extinguishers should be placarded as to its contents. For small executive airplanes which may not allow placards to be located at eye level, the placards should be located in as conspicuous a location as practicable.

3.8.2 Definition and Criteria: Safety placards on occupant seats should be permanently affixed, located such that they cannot be easily obscured and of a type that cannot be easily erased. The lettering height and color contrast should be sufficient to allow the placard to be read by the intended occupant (e.g. placards located on the back of the seat should be designed to allow the occupant seated behind to easily read it at the anticipated installed pitch.)

Placards for life vest location should be sufficiently descriptive to direct the occupant to the life vest. Acceptable examples include LIFE VEST UNDER YOUR SEAT, LIFE VEST UNDER ARMREST (with an arrow pointing to the appropriate armrest), or LIFE VEST UNDER CENTER ARMREST.

### 3.9 Literature Pocket Stowage Capacity

#### 3.9.1 Application

##### 14 CFR Part 25.601

###### General.

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

#### 3.9.2 Definition and Criteria

The weight to be carried by each passenger seat back literature pocket can be determined by multiplying 1.4 kg (three pounds) by the ratio of the pocket width to the width of a full width seat back pocket.

### 3.10 Tray Table Latch Retention

#### 3.10.1 Application

##### 14 CFR Part 25.813 Amendment 25-128

(a) There must be a passageway leading from the nearest main aisle to each Type A, Type B, Type C, Type I, or Type II emergency exit and between individual passenger areas. Each passageway leading to a Type A or Type B exit must be unobstructed and at least 36 inches wide. Passageways between individual passenger areas and those leading to Type I, Type II, or Type C emergency exits must be unobstructed and at least 20 inches wide. Unless there are two or more main aisles, each Type A or B exit must be located so that there is passenger flow along the main aisle to that exit from both the forward and aft directions. If two or more main aisles are provided, there must be unobstructed cross-aisles at least 20 inches wide between main aisles.

(c) The following must be provided for each Type III or Type IV exit--

(1) There must be access from the nearest aisle to each exit. In addition, for each Type III exit in an airplane that has a passenger seating configuration of 60 or more

(i) Except as provided in paragraph (c)(1)(ii), the access must be provided by an unobstructed passageway that is at least 10 inches in width for interior arrangements in which the adjacent seat rows on the exit side of the aisle contain no more than two seats, or 20 inches in width for interior arrangements in which those rows contain three seats. The width of the passageway must be measured with adjacent seats adjusted to their most adverse position. The centerline of the required passageway width must not be displaced more than 5 inches horizontally from that of the exit.

(ii) In lieu of one 10- or 20-inch passageway, there may be two passageways, between seat rows only, that must be at least 6 inches in width and lead to an unobstructed space adjacent to each exit. (Adjacent exits must not share a common passageway.) The width of the passageways must be measured with adjacent seats adjusted to their most adverse position. The unobstructed space adjacent to the exit must extend vertically from the floor to the ceiling (or bottom of sidewall stowage bins), inboard from the exit for a distance not less than the width of the narrowest passenger seat installed on the airplane, and from the forward edge of the forward passageway to the aft edge of the aft passageway. The exit opening must be totally within the fore and aft bounds of the unobstructed space.

(2) In addition to the access--

(i) For airplanes that have a passenger seating configuration of 20 or more, the projected opening of the exit provided must not be obstructed and there must be no interference in opening the exit by seats, berths, or other protrusions (including any seatback in the most adverse position) for a distance from that exit not less than the width of the narrowest passenger seat installed on the airplane.

(ii) For airplanes that have a passenger seating configuration of 19 or fewer, there may be minor obstructions in this region, if there are compensating factors to maintain the effectiveness of the exit.

### 3.10.2 Definition and Criteria

To prevent inadvertently deployed tray tables from blocking escape paths or interfering with door motion, the seat back table latch should prevent the table from deploying following a moderate bump on the upper surface of the seat back, or by a person brushing past.

The following design features may aid in meeting that objective:

- The tray table latch is independently locked.

The latch has an independent locking feature that is out of the plane of motion. This locking feature must be independently released for the latch to be opened and must automatically lock the table latch when the tray table is stowed.

- The tray table latch motion is in a direction other than that of passenger egress.

The passengers will predominantly generate the inadvertent release force in the direction of travel. If the tray table latch must be moved in a direction perpendicular or opposite to that travel in order to release the table, inadvertent release will be less likely.

- The tray table latch is recessed below surrounding structure.

Maintain the latch below a plane of surrounding structure. If the latch cannot be contacted by a straight edge as it is slid over the tray latch area, then the latch is sufficiently recessed so that inadvertent release is unlikely.

### 3.11 Pinch Hazards

#### 3.11.1 Application

##### 14 CFR Part 25.601

##### General.

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

3.11.2 Definition and Criteria: Under normal operation and proper usage moving parts accessible to passengers and crew (e.g. legrests, deployable video, integral tables, etc.) should be designed to minimize the potential for pinching and/or shearing hazards.

Designs that contain the potential for pinching and/or shearing should be evaluated for passenger (children and adults) accessibility defined in section 3.11.2.1. If the suspect area(s) is accessible the injury potential analysis in section 3.11.2.2 should be performed.

NOTE: A rate check device, in the context of this section (3.11), is a device that slows the movement of a feature to an extent that injury will not occur.

3.11.2.1 Accessibility: Any opening greater than 0.64 cm (0.25 in) diameter or equivalent opening if in a shape other than a circle that separates an occupant from a hazard is considered accessible.

3.11.2.2 Injury Potential Analysis: Table 1 should be used in conjunction with the actuation and multiplier categories to determine if testing or eliminating accessibility (through the use of a shroud for example) is appropriate.

TABLE 1 - INJURY POTENTIAL ANALYSIS

		Actuation Category			
		1	2	3	4
Multiplier Category	a	Green	Green	Green	Green
	b	Green	Green	Yellow	Yellow
	c	Green	Yellow	Yellow	Yellow
	d	Yellow	Yellow	Yellow	Red
	e	Red	Red	Red	Red

##### Legend:

**Green** – A shroud or test is not recommended.

**Yellow** – A shroud or a test may be needed.

**Red** – Recommended that a test be performed or a shroud be used as appropriate.

3.11.2.3 Actuation Category Definition: The actuation category is a rating assigned to a design that ranges in scale from 1 to 4. The rating is a combination of effects that include the method by which an action can occur and the individual causing the action. The category scale, from 1 to 4, is defined below.

1 – Is defined as a manual action initiated by an individual onto themselves. It is the least risk because the action will stop as the pressure is applied. Sharp edges are assumed to be eliminated.

2 – Is defined as a manual action involving two persons. It is a higher risk because the person controlling the action does not necessarily know the action has the potential to cause injury.

3 – Is defined as a controlled powered (electrical) actuation (an action that can be terminated by releasing the controlled command) is an action that is still a higher risk because of the ease the operator can apply the pressure.

4a – Uncontrolled powered (electrical) actuation: The action, once initiated, may not be able to be interrupted to stop the actuation. This is an additional risk because of the potential for the action not to be stopped.

4b – Stored energy devices: This is a device that includes stored hydraulics, spring loaded, etc., where the stored energy is used to activate the motion that could cause the injury. This device, once initiated, may not be interrupted to stop the actuation.

3.11.2.4 Multiplier Categories: The multiplier category is a subjective value that combines an edge sharpness with the maximum rate of movement of the pinching elements that will most likely be seen in service. The edge sharpness ranges from blunt to the sharpest edge that is not excluded by paragraph 3.12. The category ranges from a-e where “a” is a blunt edge and permits a reasonable person to easily remove their body part from the pinch area and “e” is a relative sharp edge that operates at a rate that a reasonable person will not have sufficient time to remove their body part.

3.11.2.5 Examples of potential pinch hazards are shown in Figures 7 through 12.



FIGURE 7 - THIS IS THE HINGE FOR AN IN-ARM VIDEO DISPLAY. IT IS AN EXAMPLE OF A TYPE 1A SCORE FROM THE INJURY POTENTIAL ANALYSIS TABLE.



FIGURE 8 - THIS IS THE ARM CAP FOR AN IN-ARM TRAY TABLE SEAT. IT IS AN EXAMPLE OF A TYPE 1A SCORE FROM THE INJURY POTENTIAL ANALYSIS TABLE.



FIGURE 9 - THIS IS A HINGE FOR AN IN-ARM TRAY TABLE. IT IS AN EXAMPLE OF A TYPE 1A SCORE FROM THE INJURY POTENTIAL ANALYSIS TABLE.



FIGURE 10 - THIS IS A SPRING MOUNTED STOWAGE BOX DOOR. IT IS AN EXAMPLE OF A TYPE 4A SCORE FROM THE INJURY POTENTIAL ANALYSIS TABLE BASED ON SPRING FORCE POTENTIAL.



FIGURE 11 - THIS IS AN AFT MOUNTED FOOD TRAY TABLE. IT IS AN EXAMPLE OF A TYPE 1A SCORE FROM THE INJURY POTENTIAL ANALYSIS TABLE.

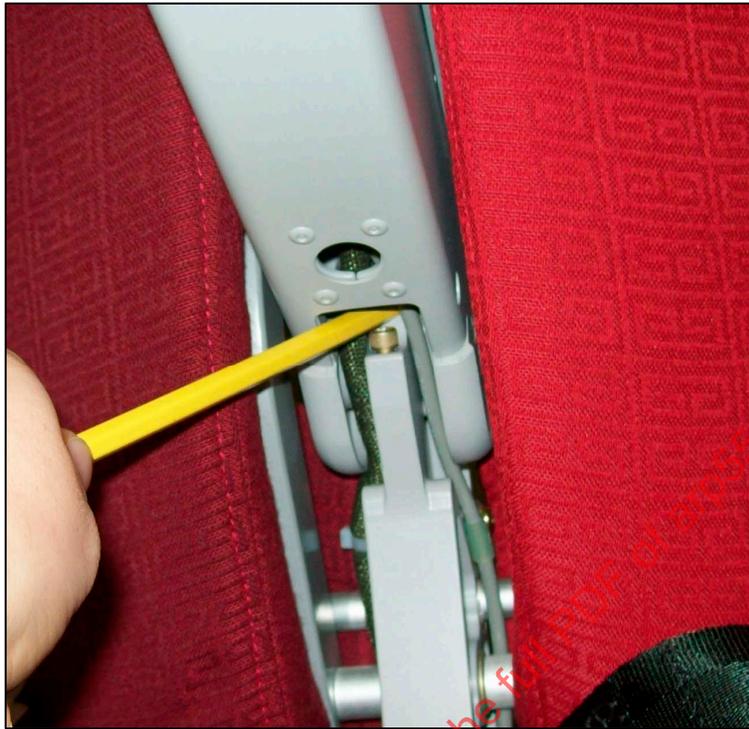


FIGURE 12 - THIS IS THE HINGE POINT FOR A ROTATING ARMREST. IT IS AN EXAMPLE OF A TYPE 2B SCORE FROM THE INJURY POTENTIAL ANALYSIS TABLE.

Additional examples of scores from the injury potential analysis table are:

- An attendant seat automatic seat pan closure with a rate check device would receive a 4a score. A seat pan closure without a rate check device would be receive a more severe score.
- A rotating armrest that can crush but not shear would receive a 2b score.
- A rotating armrest with a shearing action would receive a 2e score.
- A seat where two sliding plates with interposing lightening holes with powered actuators would receive a 4e score.
- A scissor action on an electrically operated leg rest that operates fairly slowly with reasonably blunt edges would receive a 3c score. A faster motion with sharper edges would receive a 3e score.

3.11.2.6 Test: Test all suspect areas of the mechanism. To test the severity of a mechanism that could cause injury, use a standard #2 (HB) wood pencil (alternatively a  $7\pm 1$  millimeter (mm) diameter dowel made from California incense cedar or equivalent softwood is also acceptable) of approximately six inches (153 mm) to simulate a finger or toe. Place the pencil into the suspect portion of the mechanism (e.g., typically any acute angle that closes in a scissor or shear action mechanism, or a cavity that closes during a rotation). For a suspect cavity, insert the pencil at minimum one inch or as far as space permits for access to the shear plane not exceeding the length defined above. Hold, or fasten a holder to the pencil and firmly and deliberately operate the deployment mechanism such that the suspect area closes on the pencil or acceptable alternate.

3.11.2.7 Pass/Fail Criteria: Make certain the pencil remained in position during the test(s). If the pencil or acceptable alternate is significantly marked/crushed (e.g., less than one half the original thickness remaining post-test) from any of the tests, the mechanism is unacceptable without modification to prevent access or altering the design to improve performance.

### 3.12 Sharp Edges

#### 3.12.1 Application

##### 14 CFR Part 25.601

###### General.

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

3.12.2 Definition and Criteria: Edges that could cut skin during normal use should be eliminated and for maintenance should be minimized. A suspected sharp edge should be checked by utilizing a tool that meets the requirements of UL 1439. Edges that are accessible (ref. 3.11.2.1) during normal use and fail the test are not recommended.

In addition, the seat should not have any feature whose edges or corners are exposed when deployed, that presents a potential to impede an occupant's egress (e.g., cocktail table, seat back and in-arm video, flip-out PCU, ashtray, etc.)

Reference NASA Standard 3000 Section 6.3.3 Man-Systems Integration Standards provides design criterion which may aid in preventing a hazardous condition.

### 3.13 Delethalization of Seat Features

#### 3.13.1 Application

##### 14 CFR Part 25.601

###### General.

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

##### 14 CFR Part 25.785 Amendment 25-88

- (b) Each seat, berth, safety belt, harness, and adjacent part of the airplane at each station designated as occupiable during takeoff and landing must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in Sections 25.561 and 25.562.
- (d) Each occupant of a seat that makes more than an 18 degree angle with the vertical plane containing the airplane centerline must be protected from head injury by a safety belt and an energy absorbing rest that will support the arms, shoulders, head, and spine, or by a safety belt and shoulder harness that will prevent the head from contacting any injurious object. Each occupant of any other seat must be protected from the head injury by a safety belt and, as appropriate to the type, location, and angle of facing of each seat, by one or more of the following:
  - (1) A shoulder harness that will prevent the head from contacting any injurious object.
  - (2) The elimination of any injurious object within striking radius of the head.
  - (3) An energy absorbing rest that will support the arms, shoulders, head, and spine.

Letter TAD-96-002 Appendix A

3.13.2 Definition and Criteria: This section recommends test methods that demonstrate items on seats located within the striking radius of the head are not injurious to the occupant of a seat or a nearby seat. The component tests are defined in FAA Policy Memo ANM-03-115-31 and in this context the striking radius of the head is defined in AC 25-17A section 25.785 81.b.(3)(see Figures 13 and 14 for graphical representations).

Alternatively, row to row HIC tests per AS8049b, which include a head-strike (where head-strike meets the intent of the referenced policy memo) on the potentially injurious area, is acceptable.

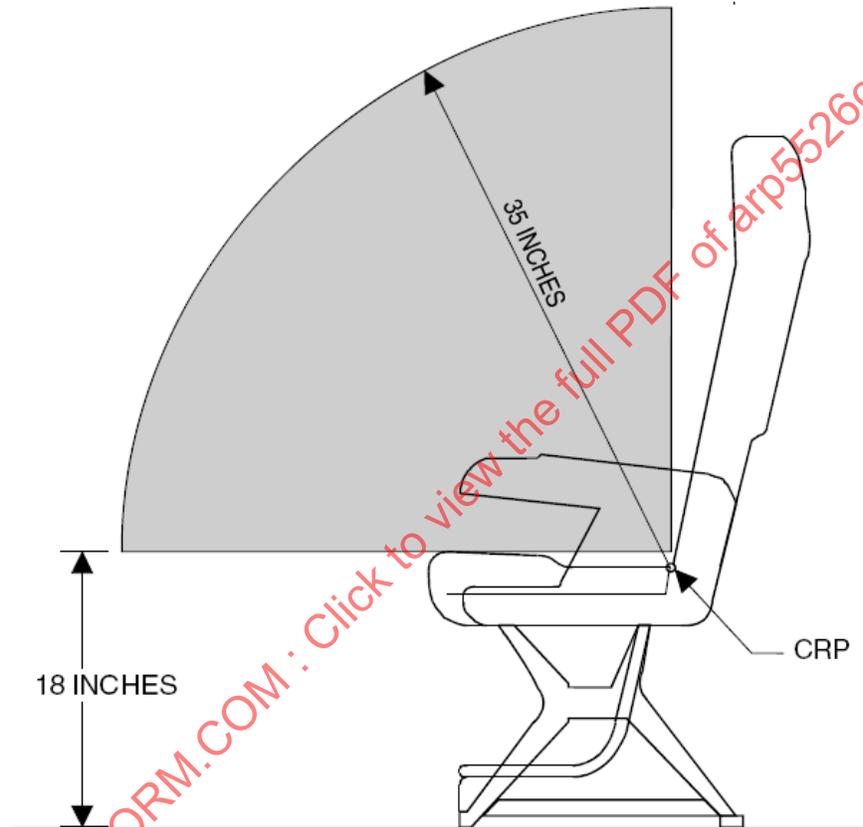


FIGURE 13 – HEAD STRIKE ARC

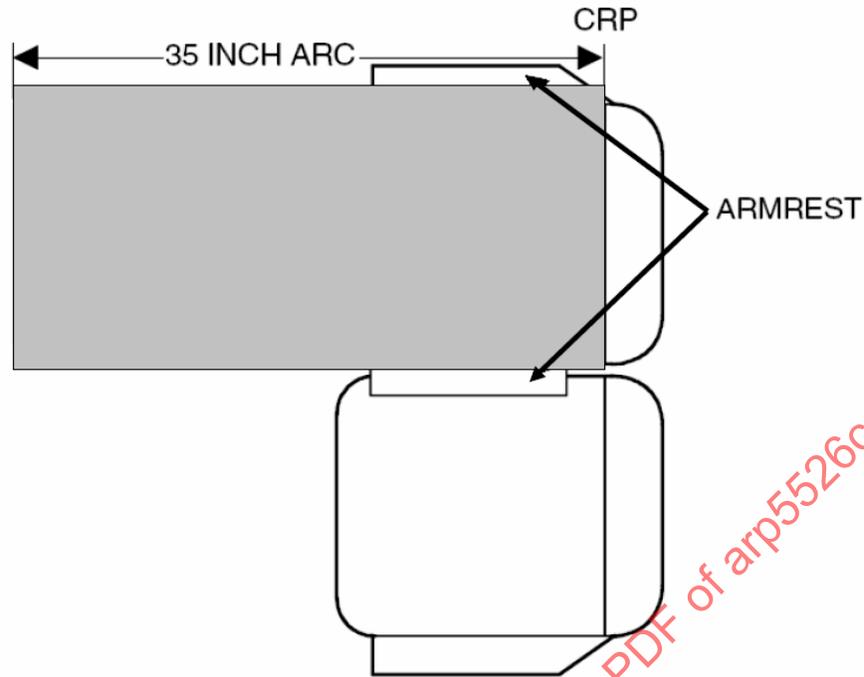


FIGURE 14 – HEAD STRIKE ARC

### 3.14 Seat Features Adjusted With/Without Tools

#### 3.14.1 Application

##### 14 CFR PART 25.561 Amendment 25-91

- (d) Seats and items of mass (and their supporting structure) must not deform under any loads up to those specified in paragraph (b)(3) of this section in any manner that would impede subsequent rapid evacuation of occupants.

##### 14 CFR PART 25.789 Amendment 25-46

- (a) Means must be provided to prevent each item of mass (that is part of the airplane type design) in a passenger or crew compartment or galley from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of Sec. 25.561(b).

##### 14 CFR Part 25.813 Amendment 25-128

- (b) There must be a passageway leading from the nearest main aisle to each Type A, Type B, Type C, Type I, or Type II emergency exit and between individual passenger areas. Each passageway leading to a Type A or Type B exit must be unobstructed and at least 36 inches wide. Passageways between individual passenger areas and those leading to Type I, Type II, or Type C emergency exits must be unobstructed and at least 20 inches wide. Unless there are two or more main aisles, each Type A or B exit must be located so that there is passenger flow along the main aisle to that exit from both the forward and aft directions. If two or more main aisles are provided, there must be unobstructed cross-aisles at least 20 inches wide between main aisles.

(c) The following must be provided for each Type III or Type IV exit--

- (1) There must be access from the nearest aisle to each exit. In addition, for each Type III exit in an airplane that has a passenger seating configuration of 60 or more
  - (i) Except as provided in paragraph (c)(1)(ii), the access must be provided by an unobstructed passageway that is at least 10 inches in width for interior arrangements in which the adjacent seat rows on the exit side of the aisle contain no more than two seats, or 20 inches in width for interior arrangements in which those rows contain three seats. The width of the passageway must be measured with adjacent seats adjusted to their most adverse position. The centerline of the required passageway width must not be displaced more than 5 inches horizontally from that of the exit.
  - (ii) In lieu of one 10- or 20-inch passageway, there may be two passageways, between seat rows only, that must be at least 6 inches in width and lead to an unobstructed space adjacent to each exit. (Adjacent exits must not share a common passageway.) The width of the passageways must be measured with adjacent seats adjusted to their most adverse position. The unobstructed space adjacent to the exit must extend vertically from the floor to the ceiling (or bottom of sidewall stowage bins), inboard from the exit for a distance not less than the width of the narrowest passenger seat installed on the airplane, and from the forward edge of the forward passageway to the aft edge of the aft passageway. The exit opening must be totally within the fore and aft bounds of the unobstructed space.
- (2) In addition to the access--
  - (i) For airplanes that have a passenger seating configuration of 20 or more, the projected opening of the exit provided must not be obstructed and there must be no interference in opening the exit by seats, berths, or other protrusions (including any seatback in the most adverse position) for a distance from that exit not less than the width of the narrowest passenger seat installed on the airplane.
  - (ii) For airplanes that have a passenger seating configuration of 19 or fewer, there may be minor obstructions in this region, if there are compensating factors to maintain the effectiveness of the exit.

### 3.14.2 Definition and Criteria

Limit stops on seat settings, such as seat back upright position, maximum recline position, etc., should be designed so that they are adjustable only with the use of tools. If such an adjustment can be made without the use of tools, the location must be inaccessible and not visible to the occupant or designed so that incorrect adjustment is conspicuous to the flight crew. For example if the adjustable element were under the bottom cushion and the seat pan/fabric, or if improper adjustment would obviously disconnect the seat back or center console from the seat assembly.

### 3.15 Legrest and Footbar Retention

#### 3.15.1 Application

#### 14 CFR PART 25.789 Amendment 25-46

- (a) Means must be provided to prevent each item of mass (that is part of the airplane type design) in a passenger or crew compartment or galley from becoming a hazard by shifting under the appropriate maximum load factors corresponding to the specified flight and ground load conditions, and to the emergency landing conditions of Sec. 25.561(b).

14 CFR Part 25.813 Amendment 25-128

- (d) There must be a passageway leading from the nearest main aisle to each Type A, Type B, Type C, Type I, or Type II emergency exit and between individual passenger areas. Each passageway leading to a Type A or Type B exit must be unobstructed and at least 36 inches wide. Passageways between individual passenger areas and those leading to Type I, Type II, or Type C emergency exits must be unobstructed and at least 20 inches wide. Unless there are two or more main aisles, each Type A or B exit must be located so that there is passenger flow along the main aisle to that exit from both the forward and aft directions. If two or more main aisles are provided, there must be unobstructed cross-aisles at least 20 inches wide between main aisles.
- (c) The following must be provided for each Type III or Type IV exit--
- (1) There must be access from the nearest aisle to each exit. In addition, for each Type III exit in an airplane that has a passenger seating configuration of 60 or more
- (i) Except as provided in paragraph (c)(1)(ii), the access must be provided by an unobstructed passageway that is at least 10 inches in width for interior arrangements in which the adjacent seat rows on the exit side of the aisle contain no more than two seats, or 20 inches in width for interior arrangements in which those rows contain three seats. The width of the passageway must be measured with adjacent seats adjusted to their most adverse position. The centerline of the required passageway width must not be displaced more than 5 inches horizontally from that of the exit.
- (ii) In lieu of one 10- or 20-inch passageway, there may be two passageways, between seat rows only, that must be at least 6 inches in width and lead to an unobstructed space adjacent to each exit. (Adjacent exits must not share a common passageway.) The width of the passageways must be measured with adjacent seats adjusted to their most adverse position. The unobstructed space adjacent to the exit must extend vertically from the floor to the ceiling (or bottom of sidewall stowage bins), inboard from the exit for a distance not less than the width of the narrowest passenger seat installed on the airplane, and from the forward edge of the forward passageway to the aft edge of the aft passageway. The exit opening must be totally within the fore and aft bounds of the unobstructed space.
- (2) In addition to the access--
- (i) For airplanes that have a passenger seating configuration of 20 or more, the projected opening of the exit provided must not be obstructed and there must be no interference in opening the exit by seats, berths, or other protrusions (including any seatback in the most adverse position) for a distance from that exit not less than the width of the narrowest passenger seat installed on the airplane.
- (ii) For airplanes that have a passenger seating configuration of 19 or fewer, there may be minor obstructions in this region, if there are compensating factors to maintain the effectiveness of the exit.

### 3.15.2 Definition and Criteria

Legrests and forward mounted footbars in the stowed position should be positively restrained so that they do not deploy or become a tripping hazard when subjected to the normal flight and emergency landing loads.

### 3.16 Reserved

### 3.17 Rotating and Translating Armrests

#### 3.17.1 Application

##### 14 CFR PART 25.785 Amendment 25-88

(d) Each occupant of a seat that makes more than an 18° angle with the vertical plane containing the airplane centerline must be protected from head injury by a safety belt and an energy absorbing rest that will support the arms, shoulders, head, and spine, or by a safety belt and shoulder harness that will prevent the head from contacting any injurious object. Each occupant of any other seat must be protected from the head injury by a safety belt and, as appropriate to the type, location, and angle of facing of each seat, by one or more of the following:

- (1) A shoulder harness that will prevent the head from contacting any injurious object.
- (2) The elimination of any injurious object within striking radius of the head.

##### AC 25-17A (14 CFR PART 25.785) guidance (5) Para (c)(2)

(5) Paragraph (c)(2). Some passenger seats are designed with armrests that pivot upward such that the armrest could protrude beyond the seatbacks resulting in a potentially hazardous condition to persons seated behind these seats. Armrests that are adequately de-lethalized or restricted such that they cannot protrude aft of either seatback in any position are acceptable.

3.17.2 Definition and Criteria: The armrest should not protrude beyond the aft most surface of the aft most adjacent seat back regardless of seat back position. Seats, when converted for accommodation of a stretcher, are excluded from this section.

If an armrest protrudes beyond the seat back it should not present an injurious condition (see section 3.13) considering the occupant sizes defined in section 3.20 and the range of approved seat pitches.

Recommended methods to avoid injurious conditions when an armrest is rotated out of the normal operating position are:

- a) The armrest should rotate out of the head strike zone when:
  - A maximum force of 1111 N (25 pounds) is applied at the most critical armrest location in the direction of likely head travel
  - The armrest is at its most critical head strike position
  - The armrest is located within the head strike zone (see section 3.13)
- b) The armrest is enveloped by one or more seat back profile
- c) The armrest is located outside the head strike zone (see section 3.13 )
- d) The armrest cannot be contacted because the spacing between adjacent seat backs is such that a head [see head Breadth contained in reference 2.1.2] cannot fit between the two seat backs when in the take-off and landing position.
- e) The exposed portion of the armrest within the head strike zone is covered by material that is not injurious as recommended in section 3.13.

### 3.18 Electrically Actuated Features

#### 3.18.1 Application

All electrically actuated seat parts (leg rests, foot rests, seat arms, seat backs and other electrically actuated accommodations) exposed to or interfacing with the passengers.

This section is applicable to occupants and operators of passenger seating only when occupants and operators are making proper use of the seats. This includes a precise working of the actuator system software. This testing should be performed using the software being delivered. This ARP is not applicable to crew seating or cabin attendant seating.

The words '*passenger*' ; '*operator*' and '*cabin crew*' are used throughout this section and are synonymous.

#### 14 CFR Part 25.601 General

The airplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

#### 14 CFR PART 25.1301 Amdt 25-123 Function and installation.

##### a) Each item of installed equipment must

- 1) Be of a kind and design appropriate to its intended function;
- 2) Be labeled as to its identification, function, or operating limitations, or any applicable combination of these factors;
- 3) Be installed according to limitations specified for that equipment;
- 4) And function properly when installed.

#### 3.18.2 Definition and Criteria

##### 3.18.2.1 Background

There is a wide variability between seat designs, seat actuation systems, airplane interior configurations and passenger body types. Seats are designed to easily accommodate all size passengers into various comfortable and required seating positions. However, the seat actuation systems which allow these easy and smooth seat movements must ensure passenger safety, while also allowing the necessary force required to move into and out of seating and lounging positions quickly and safely.

All seat / furniture electrically actuated moving parts which could potentially entrap and cause injury to passengers should be evaluated against this practice to ensure that any potentially hazardous mechanisms utilize body part safe forces.

Seats using electrically actuated moving parts should be designed to minimize the risk of passengers (adults and children) being exposed to compressive force hazards. This may be done by limiting access, limiting compressive forces that can be applied, or providing other features that reduce the risk of injury.

Designs that feature electrically actuated moving parts should be evaluated according to the criteria in the Hazard Determination section 3.18.2.4 to determine if there is a potential compression hazard. If there is, the Mitigating Factors Analysis Procedure in section D should be performed.

Mechanical override features shall be evaluated per section 3.11: "Pinch Hazards"

### 3.18.2.2 Definitions

**One Touch Function** - is a passenger control unit button which when depressed once, commands the seat to continuously move into or out of specific seating or bed positions until the programmed position limit is reached.

- In order for the passenger to stop the seat movement (once started), they depress any passenger controller button.
- Some examples of common One Touch function buttons are: TTL (taxi, takeoff landing), various bed, sleeping and recline positions.

**Press and Hold Function** - is a passenger control unit function button which when continuously held depressed, commands the seat to move into or out of specific seating or bed positions until the programmed position limit is reached or the passenger releases the depressed button.

- In order for the passenger to stop the seat movement, they simply lift their finger from the function button.
- Some examples of common Press and Hold function buttons are: leg rest extend/retract, seat back recline, TTL (taxi, takeoff landing), various bed, sleeping and recline positions.

**Combination One touch / Press and hold** - is a passenger control unit function button which when depressed once commands the seat to continuously move into specific seating or bed positions until a potentially hazardous area is approached and then stops. Then the passenger has to press and hold the button to reach the final position.

NOTE: PCU (Passenger Control Unit) function buttons which do not cause seat position movement (i.e. reading light, attendant call, massage, etc.) are not to be considered as part of this section because they do not initiate seat movement.

### 3.18.2.3 Introduction

This section of the ARP defines a recommended method for testing electrically actuated features associated with occupant seating area and stationary surrounding objects. Seat / furniture and their installations are to be evaluated for potential passenger injury. Examples of mitigating features to reduce the risk of occupant injuries are provided.

The evaluation of the seat should take into account the interior configuration and identify both the hazards that may be present in the installed seat and the mitigating features that reduce the severity of the hazards.

A mitigating feature is something present within the seat design, seat operation, aircraft installation which reduces the probability of injury to passengers or cabin crew.

### 3.18.2.4 Hazard Determination

Use the flow chart and guidance material to determine if hazards exist in electrically actuated seat features. Moving seat parts accessible to the occupants (e.g., leg rests, foot rests deployable video, integral tables, etc.) should have restricted motion or be shielded so that pinching and passenger entrapment hazards are minimized. In this context hazards are limited to physical injury to occupants or cabin crew due to electrically actuated features of seating areas. Use the flow chart and instructions that follow.

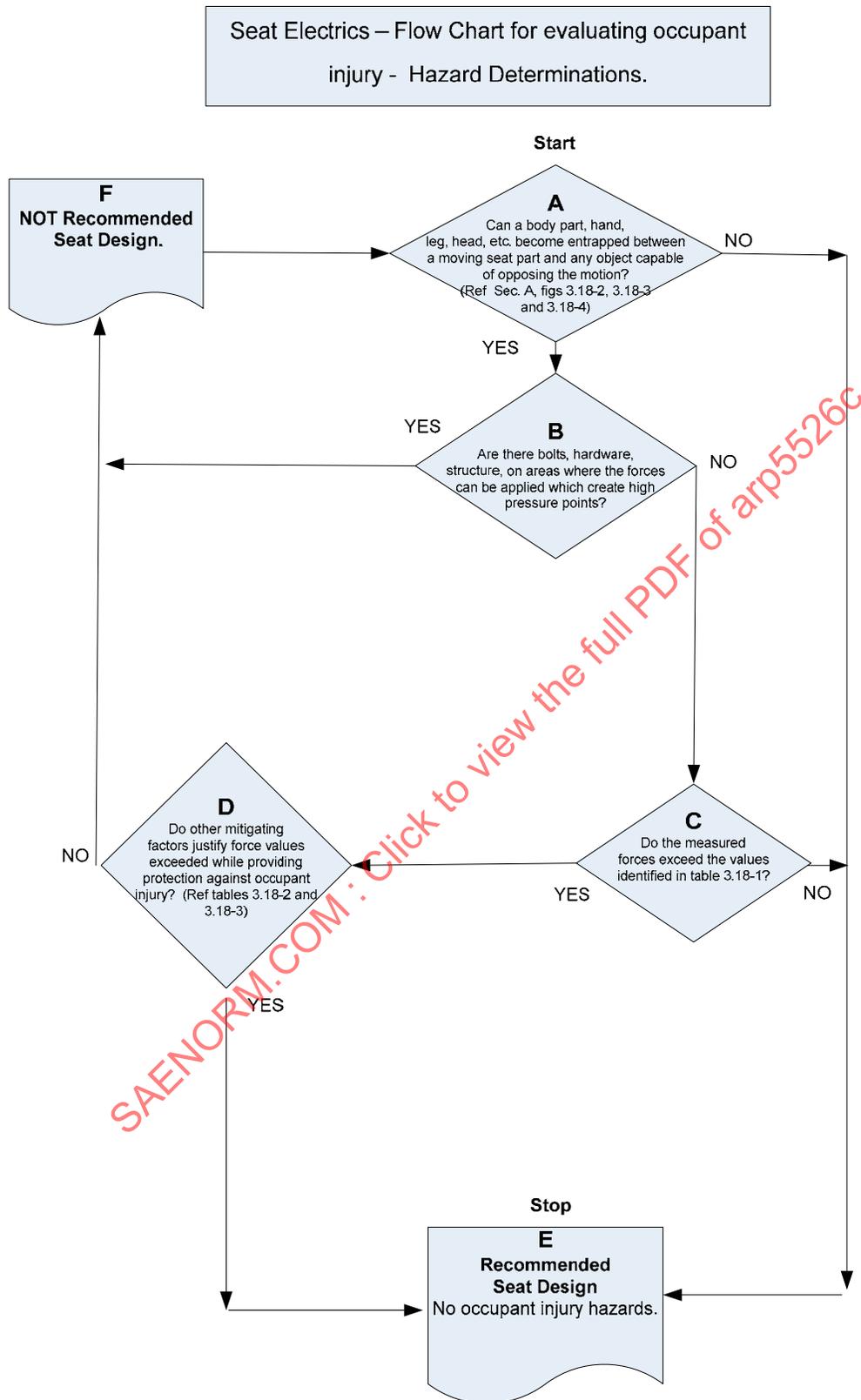


FIGURE 15 - HAZARD DETERMINATION CHART

### Section A - Can a body part, become entrapped between a moving seat / furniture part and any object capable of opposing the motion?

A potential compression hazard exists if an electrically actuated part approaches another part capable of opposing the motion with a resulting accessible gap of 5 inches or less. [1], [2]

NOTE: If the minimum resulting distance between the electrically actuated parts and the opposing parts is 5 inches or greater, it can be assumed that there is no hazard. This should be evaluated for opposing parts on or off the seat / furniture, in all adjustable positions of the parts.

#### Entrapment Evaluation

- The 5" criterion must be determined using electrically driven components only. Manually adjustable features (i.e. tray tables, video arms, foot rests) may act as obstructions and should be considered.
- All gaps must be evaluated for the closest spacing.
- For each potential entrapment area, establish which body part is likely to be involved (arm, leg, hand, foot, neck, etc.)

### Section B - Are there bolts, hardware, structure on areas where the forces can be applied which create high pressure points?

#### Identify high pressure points.

- Are there exposed objects, edges, bolts, hardware, structure, etc?
- Both the moving and stationary surfaces must be evaluated.

### Section C - Do the measured forces exceed the values in Table 2? Yes or No

#### Body Part Force Levels (Max) (Adult data except where noted)

TABLE 2 - MAXIMUM FORCE VALUES

Arm/Leg [3]	267 N	60 Lbf
Skull (child) [1], [2], [3]	156 N	35 Lbf
Hand/Foot [4], [5], [6]	156 N	35 Lbf
Neck (child-adult) [3] [7] [8]	100- 156 N	22.5 - 35 Lbf

NOTE: References to research data which are the basis for these values can be found in this section 3.18.3 in Appendix C. Neck force value limits estimated, based on similarly vulnerable body areas, as well as the desire to include the neck as a risk area for both bone crushing, as well as for asphyxiation (due to wind pipe blockage/compression).

#### Maximum Body Part Force Limits

The seat designs should not have hazardous areas which expose passenger and cabin crew body parts to excessive force levels which exceed the maximums shown in Table 2. Those positions where potential compression hazards are identified should be tested. Reference Figures 16, 17 and 18 for recommended starting measurement points. Add measurement points as appropriate for each specific potential hazard.

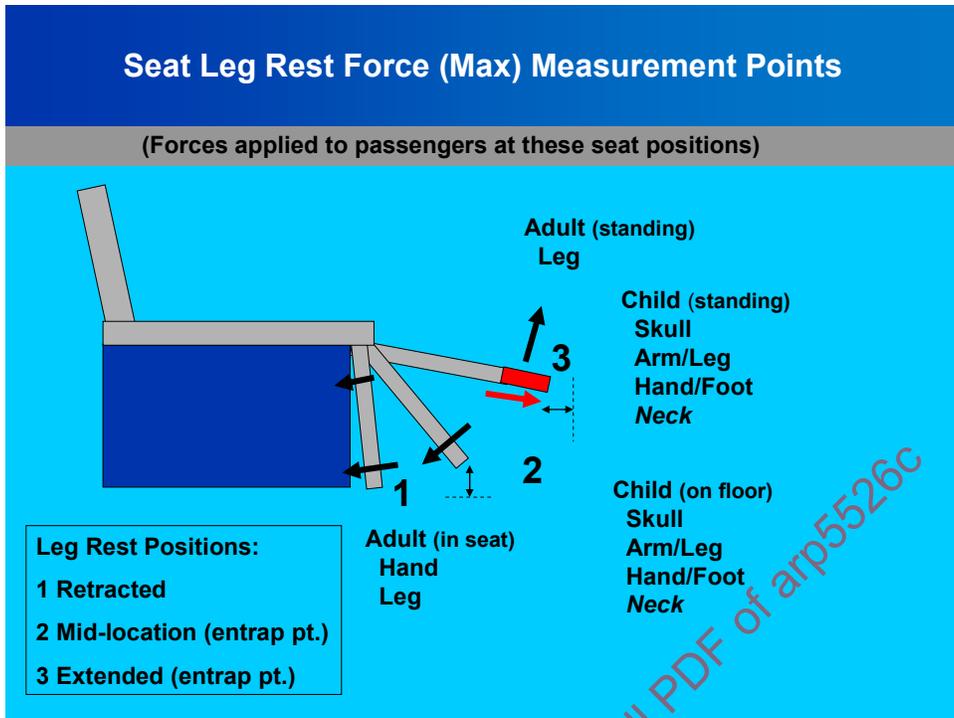


FIGURE 16 - LEG REST MEASUREMENT POINTS FOR MOVING PARTS

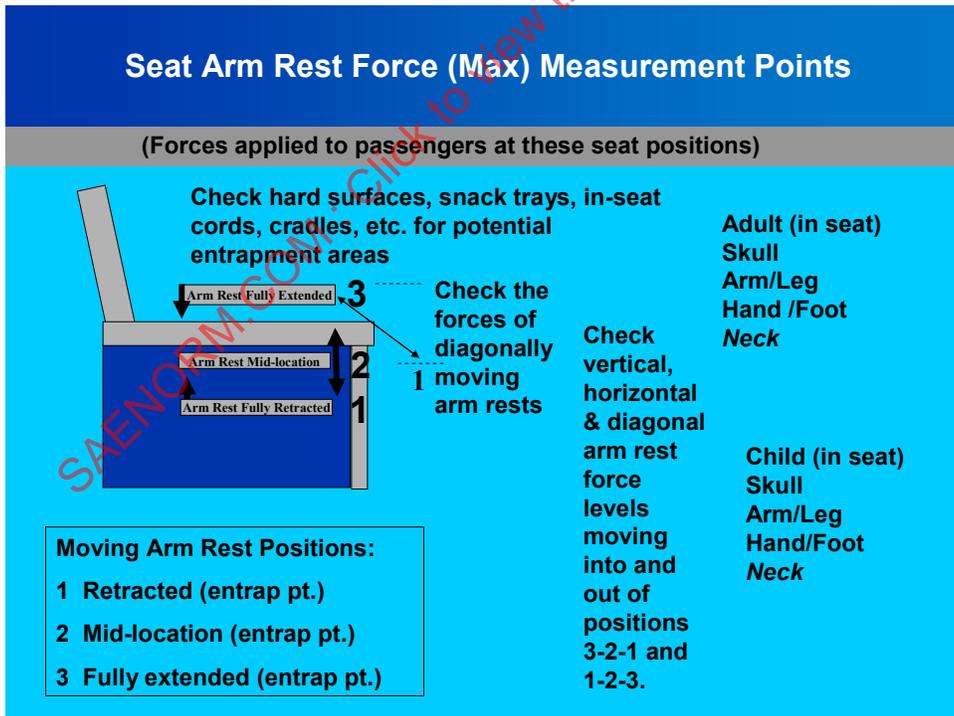


FIGURE 17 - ARM REST MEASUREMENT POINTS FOR MOVING PARTS

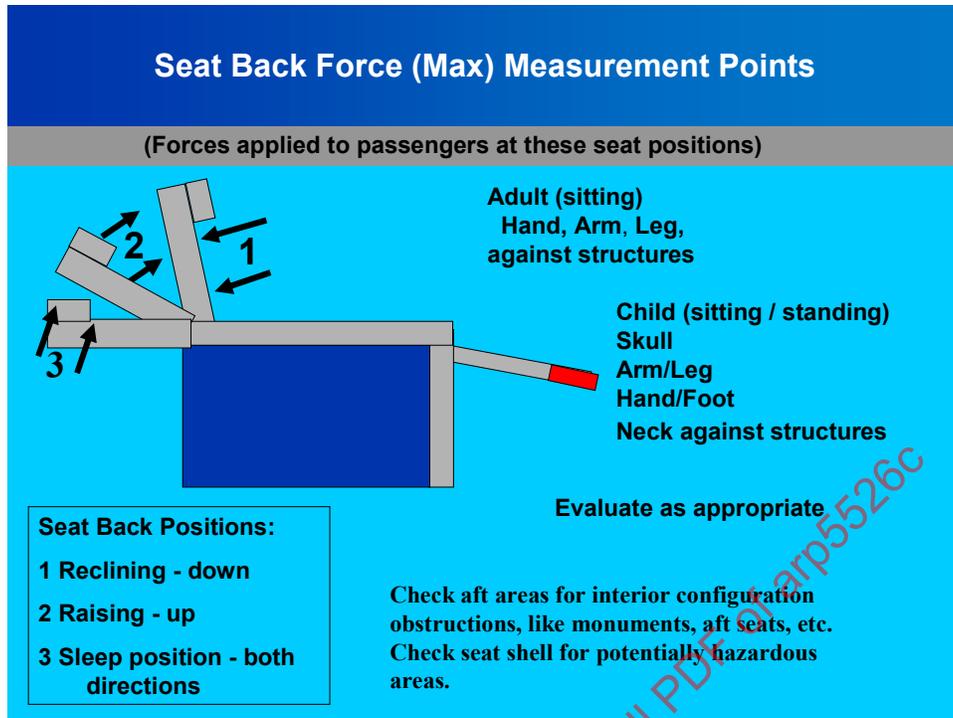


FIGURE 18 - SEAT BACK MEASUREMENT POINTS FOR MOVING PARTS

**Record the following test information.**

- 1) The location and body part(s) for each entrapment area identified in section A.
  - 2) For each potential entrapment point, take all necessary measurements according to the specific seat kinematics. This means, press and hold each seat motion button, while monitoring the seat kinematics to identify if each and every sequenced movement is safety tested and no hazardous areas exist.
  - 3) Test method and equipment used. For consistent measurements recommend using fixed test equipment and set ups (Handheld test equipment may be used).
  - 4) Take at least 3 (three) readings for each area of concern identified and evaluate the average of the readings.
- 4a) Measurements should be taken perpendicular to the reaction surface as shown in Figure 19. (for example, the floor is a reaction surface).

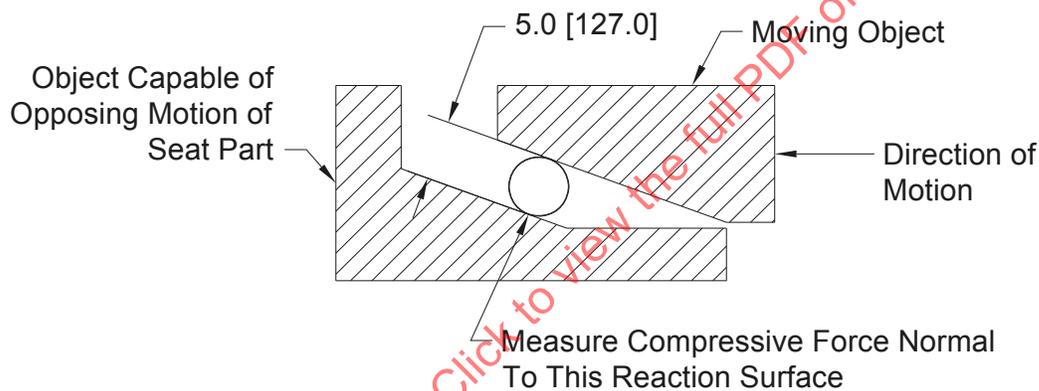
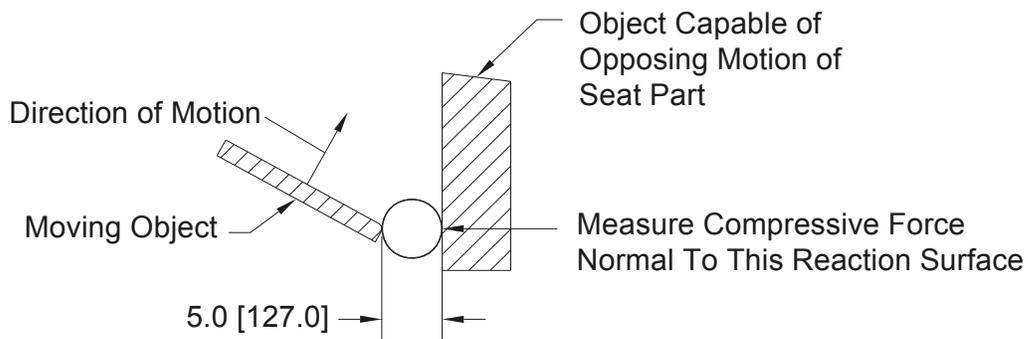


FIGURE 19 - FORCE MEASUREMENT EXAMPLE

- 4b) Ensure that seat upholstery (representative of production) is installed before taking measurements.
- 5) Verify that the actuation system controller has standard production software. (Actuation system controller part number, software part number(s), software version, data table part number(s), etc, as tested)
- 6) Test result data to include actual physical measurements of the forces measured and present at each potential entrapment location. (Calculations alone provide inaccurate information and are NOT recommended.)
  - Record if compressive or shear forces are exerted on body parts.

NOTE: For shearing hazards also see Finger Pinch section 3.11.

- Load the values in a table for each mechanism evaluated and compare with table 3 for hazard level evaluations.

TABLE 3 - HAZARD LEVEL EVALUATION  
N = NEWTONS ( ) = LBF

Body Part	Hazard Levels				
	0	1	2	3	4
<b>Arm</b>	F < 267N (F < 60)	267N < F < 311N (60 < F < 70)	311N < F < 356N (70 < F < 80)	356N < F < 423N (80 < F < 95)	423N < F < 533N (95 < F < 120)
<b>Leg</b>	F < 267N (F < 60)	267N < F < 311N (60 < F < 70)	311N < F < 356N (70 < F < 80)	356N < F < 423N (80 < F < 95)	423N < F < 533N (95 < F < 120)
<b>Hand</b>	F < 156N (F < 35)	156N < F < 222N (35 < F < 50)	222N < F < 334N (50 < F < 75)	334N < F < 423N (75 < F < 95)	423N < F < 533N (95 < F < 120)
<b>Foot</b>	F < 156N (F < 35)	156N < F < 222N (35 < F < 50)	222N < F < 334N (50 < F < 75)	334N < F < 423N (75 < F < 95)	423N < F < 533N (95 < F < 120)
<b>Neck</b>	F < 156N (F < 35)	156N < F < 222N (35 < F < 50)	222N < F < 334N (50 < F < 75)	334N < F < 423N (75 < F < 95)	423N < F < 533N (95 < F < 120)
<b>Child skull</b>	F < 156N (F < 35)	156N < F < 222N (35 < F < 50)	222N < F < 334N (50 < F < 75)	334N < F < 423N (75 < F < 95)	423N < F < 533 N (95 < F < 120)
<b>Child neck</b>	F < 100N (F < 22,5)	100N < F < 156N (22,5 < F < 35)	156N < F < 222N (35 < F < 50)	222N < F < 334N (50 < F < 75)	334N < F < 444 N (75 < F < 100)

NOTE: Columns 0 and 1 are based on the human studies data referenced in the appendix. The values shown in columns 2, 3 and 4 are based on seat actuation system historical force values and are not recommended unless properly mitigated.

7) Deviations to this process.

#### Section D - Do other mitigating factors justify force values while providing protection against occupant injury?

##### Highlight the mitigating safety design features

Mitigating and aggravating factors will affect the hazard severity. Evaluate the mitigating and aggravating factors to help understand and minimize the potential pinching, shearing and passenger entrapment hazards. These factors are cumulative. You should subtract (or add) the mitigating (or aggravating) factors to determine the total hazard value.

Table 4 provides examples of hazard modifying factors which if applicable, could be used to evaluate the resulting hazard value and interpret the total hazard value. (see Table 5).

The interpretation of whether the exceeded area has 1, 2 or X number of identifiable mitigating factors, then total hazard value (severity level) should be reduced by 1, 2, or X (-1, -2, -X).

If the exceeded area has 1, 2, or X number of identifiable aggravating factors, the total hazard value (severity level) should be increased by 1, 2 or X (+1, +2, +X).

A limit of three (3) mitigating factors is recommended for each potentially hazardous area. More than two (2) aggravating factors is an automatic failure.

Some examples of mitigating factors are design features like:

- **Method of control of motion.**

The control of the actuation system may require that the operator press a button or other control for motion to continue (press-and-hold). Alternatively, the motion may continue after the operator releases the control button (one-touch). Since the method of stopping motion once it is started in a one-touch system may not be intuitively obvious, and quick action may be required to avert a hazard, one-touch systems have a higher hazard level (+1) than press-and-hold control button (-1)

- **Speed of closing between the parts**

A slower motion speed (less than ½ inch per second) allows time for the operator to react to the developing hazard and time for a person to move out of the hazard area (-1).

- **Shape and compliance of surfaces**

If the shape and compliance of the surfaces under consideration result in the force of the actuation system being applied uniformly over the largest possible area, the hazard level is decreased (-1). Conversely, hard surfaces with protruding objects will result in concentration of force in a small area and an increase in the hazard level (+1).

- **Other safety design features**

- Obstruction detection with auto reverse and or stop feature
- Audible or visual alerting system (-1)
- Sufficient padding or spacing to protect against injury or provide warning
- Location and accessibility of hazard area
  - Is the area easily accessed?
    - If No, the hazard level is decreased (-1).
  - Is the area where some part of a passenger is likely to be?
    - If No, the hazard level is decreased (-1).
  - Is it an area that a person other than the operator can be in?
    - If No, the hazard level is decreased (-1)
  - Is the area visible to the operator of the actuation system?
    - If yes, the hazard level is decreased (-1).

### **Force produced by actuation system**

The maximum force is that which is needed to stop the motion, when measured as shown in Figure 19. Since different parts of the body are more vulnerable to compression forces than others, the maximum recommended force will depend on the parts of the body that could possibly be placed in that area.

The maximum force may be generated with or without the seat being occupied. A 95 percentile male occupant is recommended for the seat-occupied tests.

During normal seat operations and within these maximum values, it should be highly unlikely that the specific body parts would become injured.

When the values in Table 2 are exceeded, evaluate the initial hazard level using Table 3 for each entrapment area and body part affected. This practice recommends to provide appropriate mitigating factors and justifications. (Refer to Table 4 for examples of mitigating factors) The evaluation should identify the body part, mechanism (and or area), measured force value which was exceeded and why this exceeded value is acceptable and therefore the seat forces are compliant with this section.

### Factors Modifying Hazard Level

The initial hazard level for each compression area is zero. When the measured force exceeds the maximum force values in Table 2, compare the force values with those in Table 3 and identify the hazard level (0 – 4) for the mechanism(s) and body part(s).

When evaluating the effects of the modifying factors, consideration should be given to the possibility of passengers being subject to compression in the area in question.

- The factors increasing hazards are assigned positive numbers (+ 1).
- Factors reducing hazard are assigned negative numbers (-1).

TABLE 4 - EXAMPLES OF HAZARD MODIFYING FACTOR VALUES

Hazard Modifying Factor	Value
PCU One-touch feature / button control	+ 1
PCU Press and hold feature	- 1
Combination One touch / Press and hold	-1
Slow rate of approach allows time to avoid compression (less than ½ " per second)	- 1
Hard surfaces on moving part and opposing part	+ 1
Shape and compliance of parts allows force to be distributed over contact area	-1
Hazard area is visible	-1
Motion can be triggered by another person other than the user of the seat	+1
Hazard area is not easily accessible. It is not likely that a body part will be placed in the area.	- 1

### Additional Actions

After taking the sum of all appropriate Hazard Modifying (Mitigating / Aggravating) Factors, the results should be compared to the Table 5 below to determine what, if any additional actions are recommended for the installation.

- Each mechanism (area) and body part evaluated to this practice is to be reviewed to identify if any one reaches or exceeds the Total Hazard Value of 2 or greater.  
If yes, the design is not recommended.
- If multiple mechanism hazards are identified each needs to be individually and properly evaluated.

TABLE 5 - HAZARD VALUE AND RECOMMENDED ACTIONS

Total Hazard Value	Recommended Action
0, 1	Design recommended
2 or greater	Design not recommended

NOTE: Mitigating factors do not positively prevent injury but reduce the probability of injury.

**Specific test data detail to include in hazard determination:**

- Identification of the areas where potential hazardous areas exist.
- For each identified area:
  - Explain why any exceeded force value(s) are acceptable.
  - Justify why the protection provided will prevent occupant injury.
  - State why the mitigating factors make the electrically activated aspects of the seat safe.
- Prepare the seat force limit test summary information which should be used in making the determination that the seat is safe.
- Further analysis with justification to show that the hazard level is not significant to potentially cause injury, may be required.

NOTE: The above mitigating factors analysis procedure is a method, but not the only way to assess hazard level and system safety.

**Section E Recommended Seat Design  
No occupant injury hazards.****Section F - Not Recommended Seat Design**

Perform additional analysis as appropriate.  
Perform seat redesign or modification to correct the hazard area(s).  
Perform re-evaluation of this hazard determination.

**3.18.2.5 Rationale**

All safety features, mitigating factors, measured force values and engineering justification statements should be performed per this ARP section 3.18. This section was created to address the need for a more objective method for evaluating the possibility of passenger injury due to Electrically Actuated seat components. These objective criteria reduce the possibility of late seat evaluations and potential redesign.

**3.18.3 Appendix C References**

- [1] Coats, B. "Mechanics of Head Impacts in Infants" University of Pennsylvania Dissertation, 2007. <http://proquest.umi.com/pqdlink?Ver=1&Exp=01-28-2013&FMT=7&DID=1331401281&RQT=309&attempt=1&cfc=1>
- [2] Coats, B. & Margulies, S. "Material Properties of Human Infant Skull and Suture at High Rates" J.of Neurotrauma, V23, #8, 2006. <http://www.liebertonline.com/doi/pdfplus/10.1089/neu.2006.23.1222>
- [3] International Organization for Standardization, ISO 13856-3 "Safety of machinery — Pressure sensitive protective devices — Part 3: General Principles for the design and testing of pressure-sensitive bumpers, plates, wires and similar devices", 2006. [http://www.iso.org/iso/iso\\_catalogue/catalogue\\_tc/catalogue\\_detail.htm?csnumber=42846](http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=42846)
- [4] Mewes, D. & Mauser, F. "Safeguarding Crushing Points by Limitation of Forces" Int J of Occupational Safety and Ergonomics, V9, #2, 2003. <http://www.ciop.pl/757.html>
- [5] British Standards Institution, British Standard BS EN 12453 "Industrial, commercial and garage doors and gates - Safety in use of power operated doors - Requirements", 2000. <http://www.bsi-global.com/en/Search-Results/?q=12453>

[6] Underwriters Laboratories, Inc., UL 325 - "UL Standard for Safety for Door, Drapery, Gate, Louver, and Window Operators and Systems", 2002. [http://www.comm-2000.com/productdetails.aspx?sendingPageType=BigBrowser&CatalogID=Standards&ProductID=UL325\\_5\\_S\\_20020607\(ULStandards2\)](http://www.comm-2000.com/productdetails.aspx?sendingPageType=BigBrowser&CatalogID=Standards&ProductID=UL325_5_S_20020607(ULStandards2))

[7] US Code of Federal Regulations - 16CFR1211.13 – Consumer Product Safety Commission Safety Standard for Automatic Residential Garage Door Operators

[8] US Code of Federal Regulations - 49CFR571.118 – Department of Transportation MVSS 118: Power- Operated window, partition, and roof panel systems

### 3.19 Crew Size

#### 3.19.1 Application

#### 14 CFR Part 25.771 Amendment 25-4

Pilot compartment.

- (a) Each pilot compartment and its equipment must allow the minimum flight crew (established under Sec. 25.1523) to perform their duties without unreasonable concentration or fatigue.
- (b) The primary controls listed in Sec. 25.779(a), excluding cables and control rods, must be located with respect to the propeller so that no member of the minimum flight crew (established under Sec. 25.1523), or part of the controls, lies in the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub making an angle of five degrees forward or aft of the plane of rotation of the propeller.
- (c) If provision is made for a second pilot, the airplane must be controllable with equal safety from either pilot seat.

#### 14 CFR Part 25.777 Amendment 25-46

- (a) Each cockpit control must be located to provide convenient operation and to prevent confusion and inadvertent operation.
- (b) The direction of movement of cockpit controls must meet the requirements of Sec. 25.779. Wherever practicable, the sense of motion involved in the operation of other controls must correspond to the sense of the effect of the operation upon the airplane or upon the part operated. Controls of a variable nature using a rotary motion must move clockwise from the off position, through an increasing range, to the full on position.
- (c) The controls must be located and arranged, with respect to the pilots' seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flight crew (established under Sec. 25.1523) when any member of this flight crew, from 5'2" to 6'3" in height, is seated with the seat belt and shoulder harness (if provided) fastened.

#### AC 25-785-1a (14 CFR PART 25.785) guidance 6. c. (3)

Occupant height. General anthropometric data indicates that adult occupant sitting height to the mid-shoulder can range from about 20 inches for a small female (2.5 percentile) to 25 inches for a large male (97.5 percentile). A mid-shoulder height of 23.3 inches approximates a large female and an average male. Locating the shoulder strap attach point at this height, allowing for seat cushion compression, would accommodate both the large and small occupant, and allow the trailing length of upper torso restraint straps to remain close to the +30, -5 degree guidelines. It should be noted that it may be impossible to accommodate extremely large and extremely small people in a given seat location. Installation of upper torso restraint may require certain tradeoffs to assure the best installation, given the limitations of the space available.