AEROSPACE STANDARD

AS8049™	REV. D
Issued 1990-07 Revised 2020-11 Superseding AS8049C	

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

RATIONALE

This Aerospace Standard requires modifications, clarifications, and additions to address current industry standards for aircraft and rotorcraft seats, including consideration of current regulatory standards and guidance applicable to these seats as an industry standard.

TABLE OF CONTENTS

TO PLACE A DOCUMENT ORDER: Tel: 877-606-7323 (inside USA and Canada)
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

For more information on this standard, visit
https://www.sae.org/standards/content/AS8049D/

1. SCOPE

1.1 General

This SAE Aerospace Standard (AS) defines minimum performance standards, qualification requirements, and minimum documentation requirements for passenger and crew seats in civil rotorcraft, transport aircraft, and general aviation aircraft. The goal is to achieve comfort, durability, and occupant protection under normal operational loads and to define test and evaluation criteria to demonstrate occupant protection when a seat/occupant/restraint system is subjected to statically applied ultimate loads and to dynamic impact test conditions set forth in Title 14, Code of Federal Regulations (14 CFR) parts 23, 25, 27, or 29 (as applicable to the seat type, see Table 1).

Guidance for test procedures, measurements, equipment, and interpretation of results is also presented to promote uniform techniques and to achieve acceptable data.

While this document addresses system performance, responsibility for the seating system is divided between the seat supplier and the installation applicant. The seat supplier's responsibility consists of meeting all the seat system performance requirements and obtaining and supplying to the installation applicant all the data prescribed by this document. The installation applicant has the ultimate system responsibility in assuring that all requirements for safe seat installation have been met.

1.2 Applicability

This document addresses the performance criteria for forward and rearward facing seat systems (0 degrees to 18 degrees relative to the aircraft longitudinal axis) requiring static and dynamic testing to be used in civil rotorcraft, transport aircraft, and general aviation aircraft. For Type A-T oblique facing passenger seats greater than 18 degrees and no greater than 45 degrees relative to the aircraft longitudinal axis, additional performance criteria are found in AS6316. For side facing seats, additional performance criteria are found in AS8049/1. Seat systems greater than 45 degrees and less than 80 degrees are not addressed in this document.

1.3 Seat Types

This document covers all passenger and crew seats for use in aircraft type-certificated in the following categories shown in Table 1:

Table 1 - Seat type categories

Seat Type	Aircraft Category	Applicable Federal Regulations
A-T	Transport Airplane	14 CFR part 25
B-N	Normal Rotorcraft	14 CFR part 27
B-T	Transport Rotorcraft	14 CFR part 29
C-N	General Aviation Aircraft - Normal	14 CFR part 23
C-U	General Aviation Aircraft - Utility	14 CFR part 23
C-A	General Aviation Aircraft - Acrobatic	14 CFR part 23
C-C	General Aviation Aircraft - Commuter	14 CFR part 23

1.4 Units

In this document, U.S. customary units (in-pound) and International System of Units (SI) are provided. In all cases, the in-pound units take precedence and the SI (metric) units provided are approximate and conservative conversions. Those who routinely use SI units in practice may make the conversions more precise.

2. APPLICABLE DOCUMENTS

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 regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

2.1.1 SAE J211/1 Instrumentation for Impact Test - Part 1 - Electronic Instrumentation

2.1.2 SAE J211/2 Instrumentation for Impact Test - Part 2: Photographic Instrumentation

2.1.3 ARP5482 Photometric Data Acquisition Procedures for Impact Test

2.1.4 ARP5526 Aircraft Seat Design Guidance and Clarifications

2.1.5 AS8049/1 Performance Standards for Side-Facing Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft

2.1.6 Gowdy, V., DeWeese, R., Beebe, M., Wade, B., et al., "A Lumbar Spine Modification to the Hybrid III ATD For Aircraft Seat Tests," SAE Technical Paper 1999-01-1609, 1999, doi:10.4271/1999-01-1609.

2.1.7 ARP5475 Abuse Load Testing for In-Seat Deployable Video Systems

2.1.8 AS6316 Performance Standard for Oblique Facing Passenger Seats in Transport Aircraft

2.1.9 ARP6909 Methods for Determining the Seat Reference Point (SRP) and the Buttock Reference Point (BRP) for Seats in Transport Aircraft, Civil Rotorcraft, and General Aviation Aircraft

2.1.10 ARP5765 Analytical Methods for Aircraft Design and Evaluation

2.2 Code of Federal Regulations (CFR) Publications

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

2.2.1 Code of Federal Regulations, Title 14 Part 21 (14 CFR 21) Certification Procedures for Products and Parts

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

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

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

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

2.2.6 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

2.2.7 Code of Federal Regulations, Title 49 Part 572 (49 CFR 572) Anthropomorphic Test Devices

2.3 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

2.3.1 FAA Advisory Circular 23-2A Change 1, Flammability Tests (dated February 13, 2013)

2.3.2 FAA Advisory Circular 25.853-1, Flammability Requirements for Aircraft Seat Cushions (dated September 17, 1986)

2.3.3 FAA Policy Statement PS-ANM-25.853-01 R2, Flammability Testing of Interior Materials (dated July 3, 2013)

2.3.4 FAA Policy Statement ANM-115-07-002, Policy Statement on Certification for Flammability of Lightweight Seat Cushions (dated April 16, 2009)

2.3.5 FAA Advisory Circular 25.562-1 Change 1, Dynamic Evaluation of Seat Restraint Systems and Occupant Protection on Transport Airplanes (dated September 30, 2015)

2.4 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

2.4.1 DOT/FAA/AR-00/12 Aircraft Materials Fire Test Handbook

3. GENERAL DESIGN

The term seat reference point (SRP) is used throughout this document. Refer to ARP6909 for definition and acceptable methods for determining the SRP.

3.1 Guidance

[Intentionally left blank]

3.2 Requirements

This section provides requirements for a seat and restraint system design that are not described elsewhere in this document. The seat structure, cushions, and occupant restraint shall be considered to act as a total system. Any substitution of these elements shall be made only on the basis of additional tests or rational analysis based on test.

3.2.1 Seat systems shall be designed to provide occupant impact protection at seat adjustment positions, orientations, and locations allowed during takeoff and landing.

3.2.2 Seat elements shall be designed so that, when evaluated under the test conditions of this document, they do not generate hazardous projections that could significantly contribute to injury to occupants that are seated or moving about the airplane or that could impede rapid evacuation.

3.2.3 Quick-release type fittings, adjustment handles, and buttons shall be designed, installed, and protected such that their positions can be easily verified, and that incorrect installation or inadvertent activation is unlikely.

3.2.4 [Intentionally left blank]

3.2.5 Electrical or electronic devices incorporated in a seat shall be supplied with grounding.

3.2.6 Adjustable features (seat swivel, back recline, and stowage of movable tables, armrests, footrests, etc.) shall not deploy under the dynamic impact test conditions of this document in a manner that could significantly contribute to serious occupant injury or impede rapid egress of any aircraft occupant.

3.2.7 When an under-seat baggage restraint is incorporated in a passenger seat, it shall be designed to restrain at least 20 pounds (9.1 kg) or its placarded weight of stowed items per passenger place under the dynamic and static (forward and sideward directions only) test conditions of this document in a manner that will not significantly impede rapid egress from the seat.

3.2.8 [Intentionally left blank]

3.2.9 [Intentionally left blank]

3.2.10 Rearward-facing seats shall be designed with a back height sufficient to provide 36.5 inches (930 mm) of support for the occupant as measured from the SRP to the top of the seat back or headrest along the seat back tangent line with the seat in the position identified for taxi, takeoff and landing.

If there is a gap between the bottom of the seat back and the SRP waterline with the seat in any adjusted position, it shall be no more than 4.0 inches (100 mm).

If an adjustable headrest is incorporated into the seat back design, the evaluation of the back height shall be performed with the seat in the position identified for taxi, takeoff and landing with the headrest adjusted to its highest position.

If a headrest separate from the seat is provided, a maximum gap of 4.0 inches (100 mm) may exist between the bottom of the headrest and the top of the seat back. However, the headrest must be appropriately sized and located to provide head support for the intended range of occupant size.

3.2.11 Seat track fitting locking devices shall readily indicate positive engagement and locking when installed in the aircraft environment (carpets, track covers, etc.).

3.2.12 The use of pure static friction between two or more flat or curved surfaces in direct contact as the sole means to restrain items of mass is not acceptable. Items restrained by mechanical fasteners such as screws, bolts, nuts, hook and loop fasteners, tape, hooks, springs, clamps, detents, rivets, etc., are not considered friction restrained items.

3.2.13 Seats equipped with foldup armrests shall incorporate means to preclude any armrest from extending beyond adjacent seat backs into any ingress/egress space behind the seat.

3.2.14 [Intentionally left blank]

3.2.15 Except for rearward facing seats and seats equipped with multiple anchorage point pelvic restraints (e.g., Y-belts), the pelvic restraint system shall be designed such that the vertical angle between the pelvic restraint centerline and the SRP waterline shall range from 35 to 55 degrees. The SRP waterline is a line/plane passing through the SRP parallel to the floor waterline. The pelvic restraint centerline is formed by a line from the pelvic restraint anchorage to a point located 9.75 inches (250 mm) forward of the SRP and 7.0 inches (180 mm) above the SRP waterline. In addition, the pelvic restraint anchorage point(s) must be located no further than 2.0 inches (51 mm) forward of the SRP.

3.2.16 All hinged armrest caps installed along an aisle must close as a result of normal movement of a person along the aisle. Caps must not snag clothing or present any other impediment to egress when contacted by a person moving in either direction along the aisle.

3.2.17 Safety belt restraint systems must be equipped with a metal-to-metal latching device.

3.2.18 Seat stowage compartments shall be designed to prevent the contents from becoming a hazard by shifting under the load conditions identified in Table 4A and 5.3.1. A placard must indicate the maximum weight of the contents allowed in each stowage compartment.

3.2.19 The SRP must be determined using only one of the methods described in ARP5526. The selected method shall be documented, and must be used consistently when evaluating all variations of the seat model or future changes to the seat model design.

3.2.20 Literature pockets shall be designed as part of the seat system for a minimum content weight of 3 pounds (1.36 kg) each.

3.2.21 The design and installation of the occupant restraint system shall prevent unbuckling or detachment due to applied inertial forces or impact of the occupant hands/arms during an emergency landing through impact and rebound.

3.2.22 Type A-T, C-N, C-U, C-A, and C-C passenger seats shall be designed to accommodate a range of occupants from a two year old child to a 99th percentile male in stature. Type B-N and B-T passenger seats shall be designed to accommodate a range of occupants from a 5th percentile female to a 95th percentile male in stature.

3.2.23 Restraint systems, including their attachments and webbing lengths, shall be adjustable to function properly to safely restrain the range of occupants defined in 3.2.22. Interior surroundings that are part of the restraint system shall also be sized to accommodate this range or occupants.

3.2.24 Type B-N and B-T seats shall have an upper torso restraint.

3.3 Materials and Workmanship Requirements

3.3.1 Materials must be suitable and durable for use in aircraft seats, as established by tests or experience, accounting for the effects of environmental conditions such as temperature and humidity expected in service.

The suitability and durability of all materials used for parts, the failure of which could adversely affect aircraft and occupant safety, must:

a. Be established on the basis of experience or tests.

b. Meet specifications that the parts have the strength and other properties assumed in the design data. Suitable specifications are:

   1. Industry approved specifications.

   2. Military approved specifications.

   3. Specifications approved under the seat manufacturer's Quality Management System.

c. Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

3.3.2 The methods and processes of fabrication and assembly used must produce consistently sound structure. If a fabrication process requires close control to reach this objective, the process must be performed in accordance with a process specification. Suitable specifications are:

a. Industry approved specifications.

b. Military approved specifications.

c. Specifications approved under the seat manufacturer's Quality Management System.

3.3.3 Magnesium alloys may be used in aircraft seat construction provided they are tested to and meet the flammability performance requirements in the FAA Fire Safety Branch document: Aircraft Materials Fire Test Handbook - DOT/FAA/AR-00/12, Chapter 25, Oil Burner Flammability Test for Magnesium Alloy Seat Structure.

3.3.4 Each part of the structure must be protected against deterioration or loss of strength in service due to any cause and have provisions for ventilation and drainage where necessary for protection.

3.4 Fire Protection Requirements

NOTE: Inflatable airbag material is not required to meet the requirements of 3.4.1. Inflatable airbag material shall meet the requirement of 3.4.7.

3.4.1 All materials used on Type A-T and Type B-T seats shall meet the fire protection requirements of 14 CFR Part 25, Appendix F, Part 1 (Amendment 25-111), except where material properties, size and quantity would not create or propagate a cabin fire on or around the seat. The material's fire protection properties may also be demonstrated by following FAA Policy Statement PS-ANM-25.853-01 R2, Flammability Testing of Interior Materials (dated July 3, 2013).

All materials used on Type B-N, Type C-N, Type C-U, and Type C-A seats shall have flame-resistant properties. The materials shall be tested to and shall meet the requirements of paragraph 8.b of FAA Advisory Circular (AC) 23-2A Change 1, Flammability Tests (dated February 13, 2013).

All materials used on Type C-C seats shall be tested to the fire protection requirements of 14 CFR Part 23, Appendix F, Part 1 (Amendment 23-62) and shall meet the flammability performance requirements defined in 14 CFR 23.853(d)(3) (Amendment 23-62), except where material properties, size, and quantity would not create or propagate a cabin fire on or around the seat.

3.4.2 Cushion systems on Type A-T and Type B-T passenger, flight attendant and observer seats shall meet the fire protection requirements of 14 CFR Part 25, Appendix F, Part 2 (Amendment 25-111). The material's fire protection properties may also be demonstrated by following FAA AC 25.853-1, Flammability Requirements for Aircraft Seat Cushions (dated September 17, 1986) and, where applicable, FAA Policy Statement ANM-115-07-002, Policy Statement on Certification for Flammability of Lightweight Seat Cushions (dated April 16, 2009).

3.4.3 Insulation on electrical wire and cable on all Type A, Type B and Type C seats shall meet the fire protection requirements of 14 CFR Part 25, Appendix F, Part 1(a)(3) (Amendment 25-111).

3.4.4 If ashtrays are installed in or attached to the seat, they shall be self-contained, completely removable types. The ashtray housing shall be fire resistant and sealed to prevent burning materials from falling into seat structure in case the ashtray is missing. Ashtrays in folding armrests shall be designed to preclude release of burning material when the armrest is folded with or without the ashtray lid closed.

3.4.5 Electrical components in a seat shall have provisions to preclude initiation of a fire from overheating.

3.4.6 If oxygen generators are incorporated into a seat, provisions shall be made to preclude damage to the seat, including initiation of a fire due to the heat produced by the generator. The adequacy of the design shall be demonstrated.

3.4.7 Inflatable airbag material shall not have an average burn rate of greater than 2.5 inches/minute when tested using the horizontal flammability test defined in Part 25, Appendix F, Part I, Paragraph (b)(5).

3.5 Allowable Permanent Deformations

Seat permanent deformations for each tested seat shall be measured at all critical locations with regard to egress after static and dynamic tests. Measuring points, as described in the following subparagraphs, shall be identified and marked on the test seat, and their positions measured in the lateral, vertical, and longitudinal directions relative to fixed points on the test fixture. The following sub-paragraphs describe the minimum deformations required; however, complex seats may require many more measuring points to define their deformed envelope. These measurements shall be recorded before and after the tests. The difference between the pretest and posttest measurements shall be recorded and reported as permanent deformations.

It is assumed that the maximum seat deformation will result from the structural evaluation except for seat back deformations which are usually critical in a row-to-row HIC test. Once accomplished, it is not necessary to repeat deformation measurements for the injury criteria (e.g., multiple row) tests, unless the structural and injury criteria tests were combined into one test.

For dynamic tests, if floor deformations are applicable, consistency in pretest and posttest measurements shall be maintained. If the pretest measurements are made before floor deformations are applied, the posttest measurements shall be made after floor deformations have been removed. Conversely, if the pretest measurements are made after floor deformations are applied, the posttest measurements shall be made before removal of floor deformations.

3.5.1 Longitudinal Direction

The longitudinal measurement in the forward direction shall be made at the forward-most hard point of the seat.

Depending on the seat design, the forward-most hard point post-test may not be the forward-most hard point pre-test and multiple points may need to be measured.

If the seat exhibits longitudinal deformation in the aft direction, the maximum rearward longitudinal measurement shall be made at the aftmost point(s) of the seat and at a point where clearance with an exit path, or an undeformed seat behind is at a minimum.

If Test 1 is conducted using a horizontal (acceleration or deceleration) test facility, the required angle of the test setup to produce the load condition imposes a load on the seat back and that load is not representative of the Test 1 load condition. In this case, measurement of aft deformation on the seat back is not meaningful and is not required. If Test 1 is conducted using a vertical test facility (drop tower), deformation measurements on the seat back are meaningful and shall be recorded and reported. The Test 1 load condition is defined in 5.3.1.1.

3.5.2 Downward Direction

There is no limitation on downward permanent deformation provided it can be demonstrated that the feet or legs of occupants will not be injured or entrapped by the deformation, and that adequate clearance for that deformation can be assured by the seat design, with full consideration of the potential presence of under seat baggage or stowed items.

3.5.3 Seat Rotation

The seat bottom rotational permanent deformation shall not result in an angle that exceeds 20 degrees pitch down or 35 degrees pitch up from the horizontal plane. This rotational deformation shall be measured between the fore and aft extremities of the seat pan at the centerline of each seat bottom (Figure 1A). Rotation of the seat pan shall not cause entrapment of the occupant.

3.5.4 Sideward Direction

The maximum sideward permanent deformations towards an aisle shall be measured for heights below 25 inches (635 mm) above the floor and for heights 25 inches (635 mm) or more above the floor. The determination of which parts of the seat are at what heights is made prior to testing and before applying floor deformation.

3.5.5 Other Deformation Limits

The most forward surface of a seat back centerline must not deform to a distance greater than one half the original distance to the forward-most hard structure on the seat that supports the seat bottom cushion (see Figure 1B). The posttest measurement may be made with the seat back returned to its pretest upright or structurally deformed position using no more than a 35-pound (155-N) force applied at the centerline of the top of the seat back.

3.5.6 Stowable Seats

A stowable seat (manual or automatic) installed near exits or in exit paths must stow posttest and remain stowed without interfering with the exits or exit paths. The permanent deformation shall not exceed 1.5 inches (40 mm) from the pretest upright position. For seats that are stowed manually, a posttest stowage force not to exceed 10 pounds (45 N) per seat place above the original stowage force may be used to stow the seat prior to measurement of permanent deformation. For seats that stow automatically, a posttest stowage force no greater than 10 pounds (45 N) per seat place, applied at the centerline of the seat back (or seat pan if appropriate), may be used to assist with automatic retraction prior to the calculation of permanent deformation.

3.5.7 Deployable Items

3.5.7.1 General

Seats may be equipped with items that may be deployed in flight for passenger use and are typically required to be stowed for taxi, takeoff and landing (such as, food tray tables, leg rests, arm caps over in-arm tray tables, deployable video monitors, cup holders, personal electronic device holders, etc.).

Deployment of such items during testing defined in this document shall be reported as permanent deformation. If the item partially deploys, a load of 10 pounds (45 N) shall be applied in the inertial load direction of the test to further deploy the item before the deformation measurement is made. If normal passenger movement returns the item to its original position and it remains in that position, the deployment does not need to be reported as permanent deformation. If the item does not return to its original position, then the final position will be recorded and reported as permanent deformation.

Normal passenger movement is the act of the seated occupant getting up out of the seat and moving to egress the airplane (i.e., unbuckling their restraint, standing, turning towards the aisle and moving into the aisle). It does not include additional movements to stow or latch an item in place.

3.5.7.2 Seat Back Food Tray Tables

In row-to-row HIC tests, the primary objective is to evaluate occupant head injury. Seat back food tray table deployment is secondary to that objective. The deployment of the seat back food tray table is adequately evaluated during the structural tests (with the exception noted below). In the event that the seat back food tray table deploys, the following requirements are applicable:

3.5.7.2.1 Seats Forward of an Exit Path or Passageway

For seats forward of an exit path or passageway, any seat back food tray table deployment, including those caused by the ATD head strikes, shall be treated as permanent deformation.

3.5.7.2.2 All Other Seats

For other seats, if the seat back food tray table deploys as a result of the ATD head striking the seat back or tray table during a row-to-row HIC test, the deployment is acceptable and does not need to be considered as permanent deformation. The food tray table shall be easily pushed out of the way but is not required to remain in that position. In this situation, “easily pushed out of the way” is not required to be by normal passenger movement.

If the seat back food tray table deploys as a result of the ATD head striking the seat back or tray table during the test and the food tray table is not easily pushed out of the way, the deployment shall be reported as permanent deformation per 3.5.7.1.

If the seat back food tray table deploys, not as a result of the ATD head striking the seat back or tray table, the deployment shall be reported as permanent deformation per 3.5.7.1.

Determination of the seat back food tray deploying as a result of the ATD head striking the seat back or tray table during the test shall be made by review of the high-speed film/video.

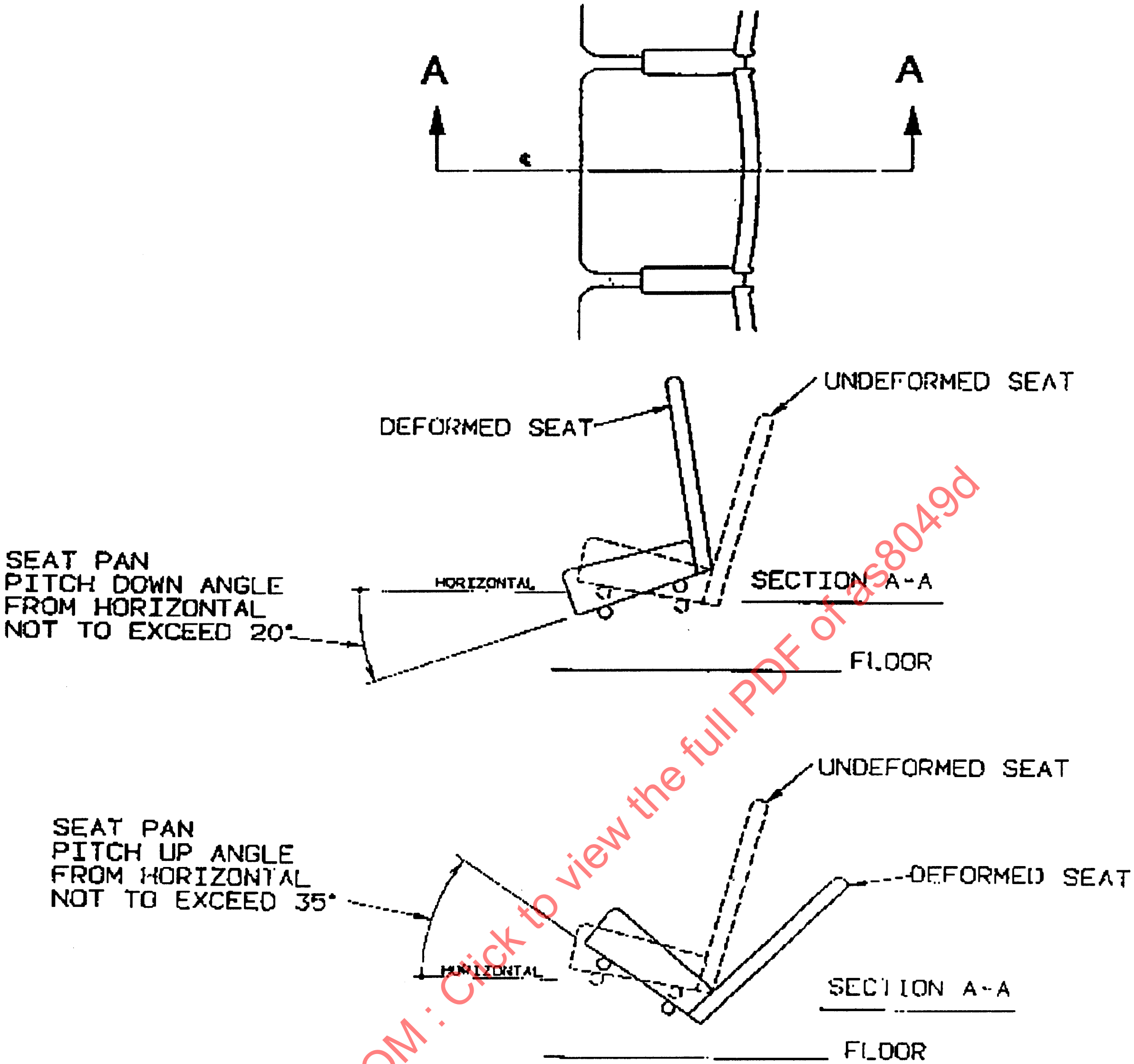


Figure 1A - Maximum posttest seat pan rotation

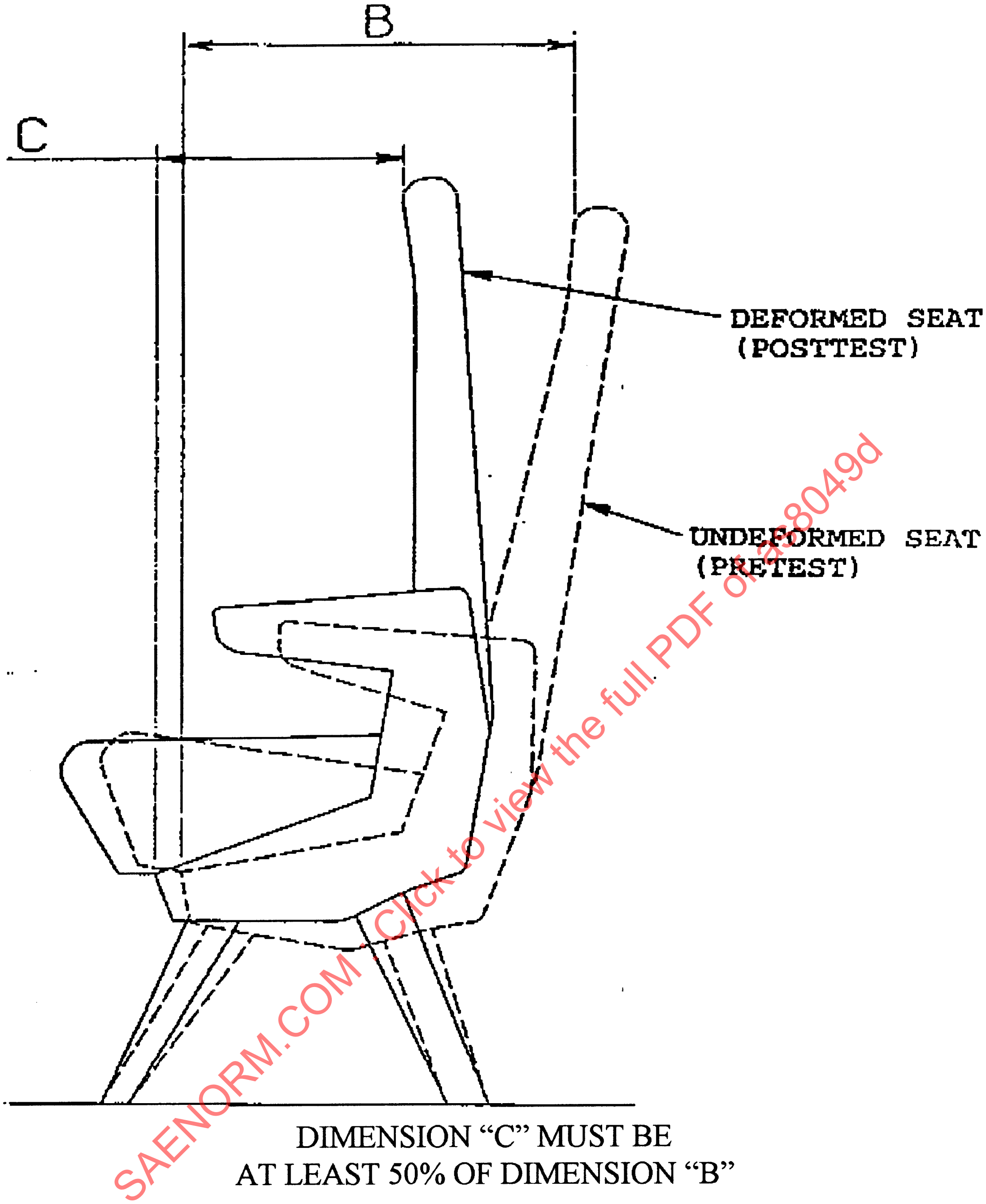


Figure 1B - Maximum seat back permanent deformation
(NOTE: Applicable for forward facing seats only)

4. STRENGTH

All seats qualified for occupancy during taxi, takeoff and landing shall be capable of withstanding, within the criteria defined below, both statically and dynamically applied loading.

4.1 Static Strength

Seats shall be designed to withstand the ultimate loads determined by using the load factors specified in Table 4A. Forces representing the sum of each occupant weight specified in Table 4A, plus the complete seat weight (including all trim and accessories), plus the total weight of any item of mass restrained by the seat (e.g., under-seat baggage, stowage compartment weight plus weight of contents, literature pocket content weight, etc.), all multiplied by the appropriate load factor from Table 4A, shall be applied to the seat (see 5.1.7 and 5.1.9). The forward, side, down, up, and aft loads shall be applied separately for at least 3 seconds without failure. Static strength shall be demonstrated under all variations of seat occupancy and positions that produce critical loading of any structural member. Ultimate loads need only be applied for allowed takeoff and landing positions.

For ultimate load conditions, the strength of fittings (a part or terminal used to join one structural member to another) in the seat and occupant restraint shall be 1.15 (if demonstrated by analysis) or 1.0 (if demonstrated by test) times the ultimate load factors specified in Table 4A, except as specified in 4.1.3 for seat attachments and occupant restraint attachments.

For flight and ground load conditions, the strength of the seat attachments to the aircraft structure and the occupant restraint attachments to the seat or aircraft structure shall be 1.15 (if demonstrated by analysis) or 1.0 (if demonstrated by test) times the airplane model specific flight and ground loads.

If a part requires more than one special factor, the highest applicable factor shall be used and not a combination of the applicable factors.

For Type A-T seats:

The seat structure, occupant restraints and their attachments must withstand the 4.0 g ultimate sideward load factor specified in Table 4A. For the seat attachments to the aircraft structure and the occupant restraint attachments to the seat or aircraft structure, the 1.33 fitting factor required in 4.1.3 is already included in the 4.0 g sideward load factor.

Any special factors (1.15 fitting factor, bearing, casting, etc.) applicable to seat structure and occupant restraint parts shall have that factor applied to the ultimate 4.0 g sideward load factor, and all other load factors specified in Table 4A (see next paragraph for seat and occupant restraint attachments).

The minimum sideward load factor applied to the seat attachments and occupant restraint attachments shall be 4.0 g. Any special factors (bearing, casting, etc.) that exceed the 1.33 fitting factor applicable to the seat attachments and occupant restraint attachments shall have that factor applied to the ultimate 4.0 g sideward load factor divided by 1.33, and all other load factors specified in Table 4A.

4.1.1 Pilot and Copilot Loads

Pilot and copilot seats shall be capable of withstanding an ultimate rearward load of 1000 pounds (4.45 kN) applied 8 inches (200 mm) above the SRP to provide for the application of pilot forces to the flight controls. Consideration must be given to any seat adjustment position or configuration that the pilot may use while controlling the aircraft.

4.1.2 Limit Loads

All seat systems shall be capable of withstanding aircraft specific limit loads without any detrimental permanent deformations. Pilot and copilot seats shall be capable of withstanding a limit rearward load of 667 pounds (3 kN) rearward limit load applied 8 inches (200 mm) above the SRP without any detrimental permanent deformation.

4.1.3 Seat and Occupant Restraint Attachments

The strength of the seat attachments to the aircraft structure and the occupant restraint attachments to the seat or aircraft structure shall be 1.33 times the ultimate loads specified in Table 4A (except as noted for Type A-T seat sideward). This requirement only applies to seats in their position(s) for taxi, takeoff, and landing.

4.1.4 Casting Factors

If castings are used in the construction of the seat or occupant restraint, the castings shall have a casting factor and related inspection requirements in accordance with Table 4B (Type A-T seats) or Table 4C (All Type B and C seats). If a fitting in the seat or occupant restraint is or contains a casting, the casting shall be substantiated to the higher of the casting factor, the 1.33 fitting factor for ultimate load conditions or the 1.15 factor for ground or flight loads, but not the combination of factors.

A casting factor must be applied to all load carrying cast structural parts. These castings can be classified as critical or noncritical as defined below, and must have the appropriate casting factor applied based on the inspection/test requirements defined for that part.

Critical castings are load carrying structural parts in the load path from the occupant to the seat attachment to the airplane, including occupant restraint hardware. Critical castings are also parts whose failure would result in uncontrolled seat motion, or would result in a seat becoming jammed in a position that impedes egress, interferes with the operation of the aircraft or prevents the seat from returning to the taxi, takeoff and landing position.

Noncritical castings are load carrying structural parts that carry load from the occupant not associated with the load path from the occupant to the seat attachment to the airplane or an item of mass retained by the seat. Such a part could be a cast part in the underseat baggage restraint or a cast part retaining an item of mass.

The orientation of the seat (forward facing, aft facing, side facing, oblique facing) or the type of occupant restraint system (lap belt only, three-point restraint, four-point restraint, etc.) must be taken into consideration as to whether the load carrying structural part is in the load path from the occupant to the seat attachment to the airplane.

Nonstructural castings are lightweight parts that only carry their own inertia load. Such parts must weigh less than 0.33 pound (0.15 kg). No casting factor need be applied to these parts.

4.1.5 Headrest Loads (Rearward Facing Seats)

When a headrest is used on a rearward facing seat, the headrest shall not deflect through an angular displacement of more than 25 degrees with respect to the backrest angle at maximum applied load. The load shall be applied through the center of gravity of the headrest for 3 seconds. The load shall be applied to the headrest in its fully extended position. The load may be applied to the headrest as part of a complete seat or to the headrest with the seat back rigidly mounted in a fixture.

The applied load is calculated by multiplying the combined weight of the head and headrest and the applicable aircraft forward load factor in Table 4A. The weight of the head shall be 13 pounds (5.9 kg), and the weight of the headrest shall include all components up to the structural interface with the seat back. The headrest load for all Type B seats shall also include a 1.33 fitting factor. The minimum applied load for Type A-T and all Type C seats shall be 200 pounds (890 N).

The weight of a headrest that is integral or a continuation of the backrest structure shall include the portion of the backrest that is 25.5 inches (648 mm) above the SRP. For these headrests, the load shall be applied 34 inches (864 mm) above the SRP or the headrest center of gravity, whichever is greater.

Table 4A - Ultimate load factors and occupant weight

		Type A-T Seat	Type B-N Seat Type B-T Seat	Type C-N Seat	Type C-U Seat	Type C-C Seat	Type C-A Seat
		Airplane (Transport Category)	Rotorcraft (Normal and Transport Category)	General Aviation (Normal Category)	General Aviation (Utility Category)	General Aviation (Commuter Category)	General Aviation (Acrobatic Category)
		Factor	Factor	Factor	Factor	Factor	Factor
Load Factors	Forward	9.0	16.0	9.0(4)	9.0(4)	9.0(4)	9.0(4)
	Sideward	4.0(1)(2)	8.0(2)	1.5(2)(4)	1.5(2)(4)	1.5(2)(4)	1.5(2)(4)
(Load Direction Relative to Aircraft)	Upward	3.0(2)	4.0(2)	3.0(2)(4)	3.0(2)(4)	3.0(2)(4)	4.5(2)(4)
	Downward	6.0(2)	20.0(2)(3)	3.0(2)(4)	3.0(2)(4)	6.0(2)(4)	3.0(2)(4)
	Aftward	1.5	1.5	N/A	N/A	N/A	N/A
Occupant Weight		170 pounds (77 kg)	170 pounds (77 kg)	170 pounds (77kg)(5)	190 pounds (86 kg)(5)(6)	170 pounds (77 kg)(5)	190 pounds (86 kg)(5)(6)

(1) The 1.33 fitting factor does not need to be applied to the 4.0 g sideward load factor (see 4.1).
(2) Increase these load factors as necessary for airplane model specific flight and ground loads. All seat adjustment positions and occupancy variations, including those used in flight, must be evaluated when using these increased load factors.
(3) Load to be applied after stroking of the seat energy absorbing system.
(4) For Type C seats, load factors may need to be increased according to 14 CFR 23.562(d).
(5) For airplane specific flight and ground loads as defined in the approved operating envelope of the airplane, an occupant weight of 215 pounds (98 kg) shall be used. The strength of the seat attachments to the aircraft structure and the occupant restraint attachments to the seat or aircraft structure shall be 1.33 times these flight and ground loads.
(6) The 190-pound occupant weight includes allowance for the weight of a parachute.

Table 4B - Casting inspection/test requirements for type A-T seats

Classification	Casting Factor	Inspection Requirements	Test Requirements
Critical Casting	1.50 or greater	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[2] and 3) Inspection of structurally significant areas and areas where defects are likely to occur using radiographic inspection methods.[2]	One casting undergoes a static test and is shown to: 1) Support 1.50 times the ultimate loads in Table 4A without failure for 3 seconds, and 2) Support 1.15 times the limit load (see 4.1.2) without detrimental permanent deformation.
	1.25 to 1.50	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[2] and 3) Inspection of structurally significant areas and areas where defects are likely to occur using radiographic inspection methods.[2]	Three castings undergo static tests and are shown to: 1) Support 1.25 times the ultimate loads in Table 4A without failure for 3 seconds, and 2) Support 1.15 times the limit load (see 4.1.2) without detrimental permanent deformation.
	1.0 to 1.25	See Note 4 below for specific process requirements. Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[2] and 3) Inspection of structurally significant areas and areas where defects are likely to occur using radiographic inspection methods.[2]	One casting undergoes a static test and is shown to: 1) Support the ultimate loads in Table 4A without failure for 3 seconds, and 2) Support the limit load (see 4.1.2) without detrimental permanent deformation.
Noncritical Casting	2.0 or greater	Each casting receives inspection of 100% of its surface using visual inspection methods.	None.
	1.50 to 2.0	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials).[2][3]	None.
	1.25 to 1.50	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[2][3] and 3) Inspection of structurally significant areas and areas where defects are likely to occur using radiographic inspection methods.[2][3]	None.
	1.0 to 1.25[1]	See Note 5 below for specific process requirements. Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[2] and 3) Inspection of structurally significant areas and areas where defects are likely to occur using radiographic inspection methods.[2]	Three castings undergo static tests and are shown to: 1) Support the ultimate loads in Table 4A without failure for 3 seconds, and 2) Support limit loads (see 4.1.2) without detrimental permanent deformation.
Nonstructural Casting	Not Required	None.	None.

(1) Alternatively, the requirements for a critical casting with a casting factor of 1.0 or greater are met.
(2) Or equivalent inspection method.
(3) The number of castings per production batch to be inspected by nonvisual methods may be reduced when an approved quality control procedure is established.
(4) It must be demonstrated, in the form of process qualification, proof of product, and process monitoring that, for each casting design and part number, the castings produced by each foundry and process combination have coefficients of variation of the material properties that are equivalent to those of wrought alloy products of similar composition. Process monitoring must include testing of coupons cut from the prolongations of each casting (or each set of castings, if produced from a single pour into a single mold in a runner system) and, on a sampling basis, coupons cut from critical areas of production castings. The acceptance criteria for the process monitoring inspections and tests must be established and included in the process specifications to ensure the properties of the production castings are controlled to within levels used in design.
(5) Castings are manufactured to approved specifications that specify the minimum mechanical properties of the material in the casting and provides for demonstration of these properties by test of coupons cut from the castings on a sampling basis.

Table 4C - Casting inspection/test requirements for all type B and type C seats

Classification	Casting Factor	Inspection Requirements	Test Requirements
Critical Casting	2.0 or greater [1]	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of the part using approved nondestructive inspection.[2]	None.
	1.50 to 2.0	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[3] and 3) Inspection of 100% of the part using radiographic inspection methods.[3]	None.
	1.25 to 1.50	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[3] and 3) Inspection of 100% of the part using radiographic inspection methods.[3]	Three castings undergo static tests and are shown to: 1) Support 1.25 times the ultimate loads in Table 4A without failure for 3 seconds, and 2) Support 1.15 times the limit load (see 4.1.2) without detrimental permanent deformation.
Noncritical Casting	2.0 or greater	Each casting receives inspection of 100% of its surface using visual inspection methods.	None.
	1.50 to 2.0	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials).[3][4]	None.
	1.25 to 1.50	Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[3][4] and 3) Inspection of 100% of the part using radiographic inspection methods.[3][4]	None.
	1.0 to 1.25	See Note 5 below for specific process requirements. Each casting receives: 1) Inspection of 100% of its surface using visual inspection methods, and 2) Inspection of 100% of its surface using penetrant inspection methods (non-ferromagnetic materials) or magnetic particle inspection methods (ferromagnetic materials),[3][4] and 3) Inspection of 100% of the part using radiographic inspection methods.[3][4]	Three castings undergo static tests and are shown to: 1) Support the ultimate loads in Table 4A without failure for 3 seconds, and 2) Support limit loads (see 4.1.2) without detrimental permanent deformation.
Nonstructural Casting	Not Required	None.	None.

(1) Applicable only to Type C-N, Type C-U, Type C-C, and Type C-A seats.
(2) When an approved quality control procedure is established and an acceptable statistical analysis supports reduction, nondestructive inspection may be reduced from 100% and applied on a sampling basis.
(3) Or equivalent inspection method.
(4) The number of castings inspected by nonvisual methods may be reduced below that specified when an approved quality control procedure is established.
(5) Castings must be procured to a specification that guarantees the mechanical properties of the material in the casting and provides for demonstration of these properties by test of coupons cut from the castings on a sampling basis.

4.2 Dynamic Strength/Occupant Protection

The seat structure, cushions, and occupant restraint, as a system, shall be designed to withstand the dynamic impact load conditions prescribed in 5.3 and meet the pass/fail criteria of 5.4.

5. SEAT QUALIFICATION

Initial static qualification of a seat shall be performed by static tests. Initial dynamic qualification of the seat shall be performed by dynamic tests or by the use of computer modeling techniques that are validated by dynamic test in accordance with ARP5765.Subsequent qualifications related to design changes to seats of a similar design may be performed by rational analysis based on existing qualification test or computer modeling data.

5.1 Static Qualification Tests

5.1.1 The test seat shall be complete to the extent that the primary structure, the occupant restraint system, and the seat attachment fittings to the aircraft are accurately represented. Items that are not part of the seat primary structure, the omission of which will not alter the test and pass/fail criteria, may be excluded from the test article, but their weight must be included when determining the static loads.

5.1.2 A body block shall be installed in each occupant place that will be loaded and shall be restrained by the occupant restraint. The body blocks shown in Figures 2, 3, 4A, and 4B are satisfactory for static test purposes. They may be refined or modified if desired; however, the resultant load application point for each static test shall comply with 5.1.6 (Table 5).

5.1.3 For the application of down loads, representative distributed loading of the seat pan (as opposed to loading rigid boundary members) must be achieved.

5.1.4 The body block shall be placed either on the actual bottom cushion or on a non-rigid foam block representative of the bottom cushion. The back cushion or a non-rigid foam block representing the back cushion shall be in place.

5.1.5 Forward loads on seat backs of rearward-facing seats and rearward loads on seat backs of forward-facing seats shall be applied by a body block as shown in Figure 2, or by a rigid block with the same back dimensions. The back cushion or an equivalent non-rigid foam block shall be placed between the body block and the back structure to distribute the load over the seat back rather than just the rigid boundary structure.

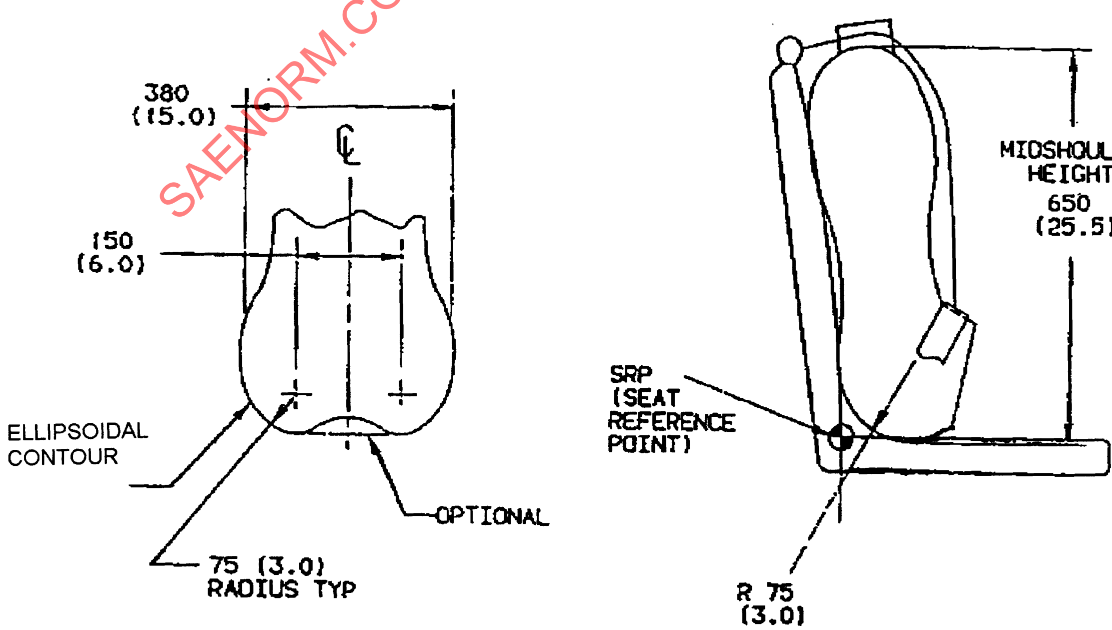


Figure 2 - Optional body block for static testing

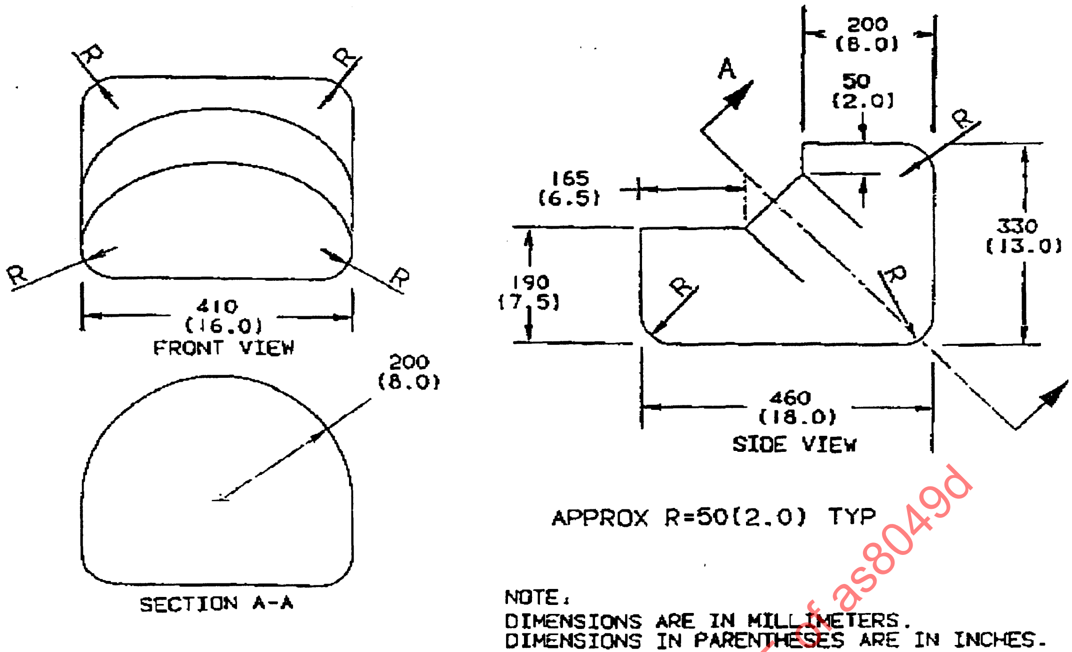
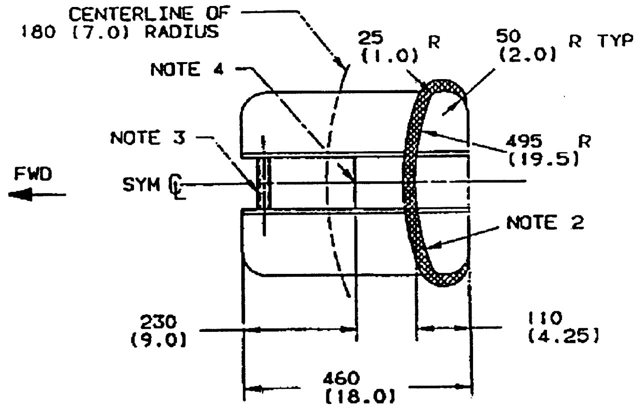
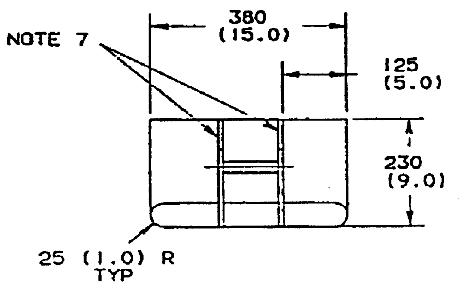
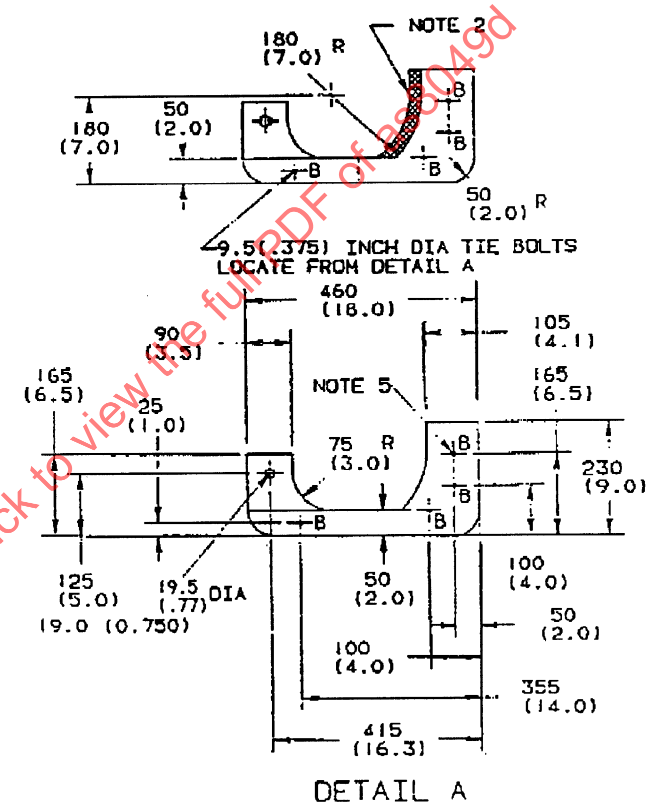


Figure 3 - Optional body block for static testing



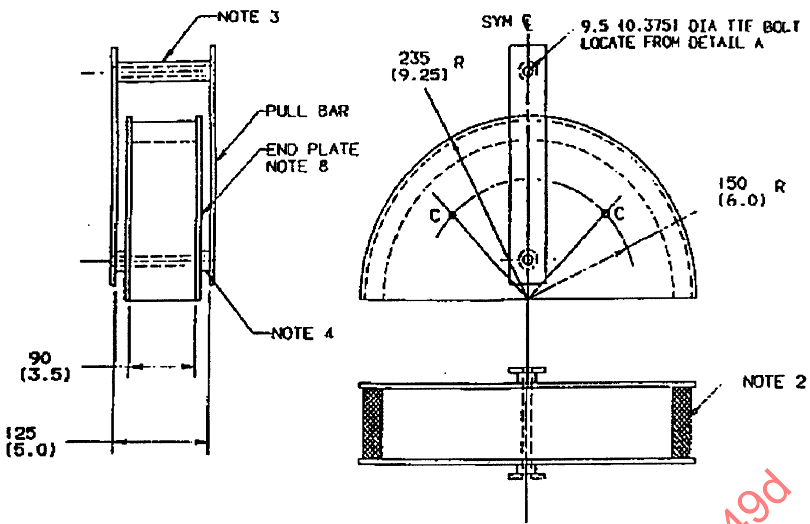


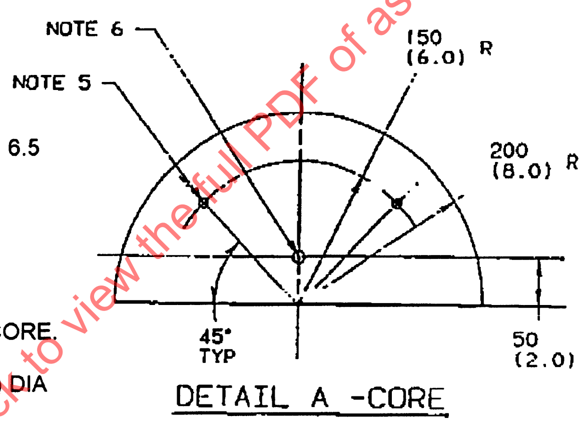


7. PULL PLATE MATERIAL: 9.5 (0.375) STEEL.
6. BLOCK MATERIAL: LAMINATED HARDWOOD
5. DRILL 10.0 (25/64) DIA HOLE AND COUNTERBORE AS REQUIRED FOR ATTACHMENT BOLTS AT LOCATIONS LABELED "B".
4. REMOVE CENTER SECTION FORWARD OF THIS LINE AS REQUIRED FOR TESTS OF RESTRAINT SYSTEM WITH NEGATIVE - G STRAP.
3. 25 (1.0) O.D. STEEL SPACER OVER 19.0 (0.75) DIA BOLT.
2. THIS SURFACE COVERED WITH NYLON OVER 25 (1.0) THICK SLOW REBOUND FOAM PAD.
1. DIMENSIONS ARE IN MILLIMETERS. DIMENSIONS IN PARENTHESES ARE IN INCHES.

NOTES:

Figure 4A - Lower torso block





8. END PLATE AND PULL BAR MATERIAL: 6.5 (0.25) STEEL
7. CORE MATERIAL: LAMINATED HARDWOOD.
6. DRILL 13 (33/64) DIA HOLE THRU END PLATE AND CORE.
5. DRILL 10 (25/64) HOLE AT LOCATIONS LABELED "C" THRU END PLATE AND CORE.
4. 13.0 (O.5) LONG X 25 (1.0) O.D. STEEL SPACER (2 PLACES) OVER A 13.0 (0.5) DIA bolt.
3. 127 (5.0) LONG X 25 (1.0) O.D. STEEL SPACER OVER A 12.5 (0.5) DIA BOLT.
2. THIS SURFACE COVERED WITH NYLON OVER 25 (1.0) THICK SLOW REBOUND FOAM PAD.
1. DIMENSIONS ARE IN MILLIMETERS. DIMENSIONS IN PARENTHESES ARE IN INCHES.

NOTES:

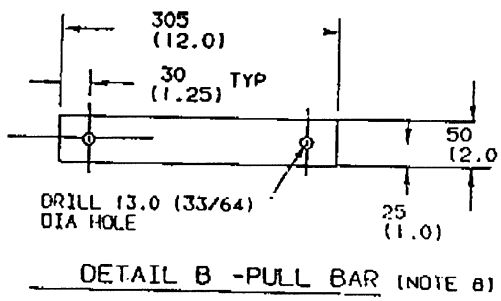


Figure 4B - Upper torso block

5.1.6 Static resultant load application points are summarized in Table 5.

NOTE: The load application points given are relative to the seat coordinate system (see Figure 5) and are independent of the seat facing direction relative to the aircraft coordinate system. The applied load direction is relative to the aircraft coordinate system (reference Table 4A).

Table 5 - Static resultant load application points

Applied Load Direction (Relative to Aircraft)	Load Application Point (Relative to Seat Coordinate System)			
	Forward Facing Seat	Oblique Facing Seat	Sideward Facing Seat	Rearward Facing Seat
Forward	10.5 inches (270 mm) up from the SRP	10.5 inches (270 mm) up from the SRP and 8.5 inches (215 mm) forward of the SRP	10.5 inches (270 mm) up from the SRP and 8.5 inches (215 mm) forward of the SRP	10.5 inches (270 mm) up from the SRP
Sideward	10.5 inches (270 mm) up from the SRP and 8.5 inches (215 mm) forward of the SRP	10.5 inches (270 mm) up from the SRP and 8.5 inches (215 mm) forward of the SRP	10.5 inches (270 mm) up from the SRP	10.5 inches (270 mm) up from the SRP and 8.5 inches (215 mm) forward of the SRP
Upward	8.5 inches (215 mm) forward of the SRP	8.5 inches (215 mm) forward of the SRP	8.5 inches (215 mm) forward of the SRP	8.5 inches (215 mm) forward of the SRP
Downward	Evenly over seat bottom	Evenly over seat bottom	Evenly over seat bottom	Evenly over seat bottom
Aftward	10.5 inches (270 mm) up from the SRP	10.5 inches (270 mm) up from the SRP and 8.5 inches (215 mm) forward of the SRP	10.5 inches (270 mm) up from the SRP and 8.5 inches (215 mm) forward of the SRP	10.5 inches (270 mm) up from the SRP

5.1.7 Loads due to stowed articles under the seat or due to other stowage compartments that are part of the seat, and their contents, shall be applied simultaneously with the loads due to the occupant and the seat.

5.1.8 Devices used for indicating applied static loads shall be calibrated by comparison with a certified standard.

5.1.9 The load due to any item of mass, including the seat, that is not restrained by the occupant restraint system may be applied in a representative manner through the cg of the mass or with a corrective factor applied in a conservative manner relative to the cg of the item of mass.

NOTE: If retention of an item of mass attached to the seat is demonstrated by the dynamic qualification tests of 5.3, no further demonstration of retention for the forward and down static conditions is required. However, demonstration of retention of items of mass for the side, up and aft static conditions is still required.

5.1.10 If occupant restraint systems are not attached to the seat structure, the occupant restraint system shall be attached to the test fixture at points that are equivalent in location to those in the aircraft. The static loads shall then be applied as specified in this section.

5.1.11 All seat positions and facing directions used for taxi, takeoff and landing shall be considered when selecting the critical test conditions for structural testing. The taxi, takeoff and landing positions that were considered and tested shall be recorded and reported. In addition, flight and ground loads shall be evaluated in all adjustable positions used in flight.

5.1.12 When testing a vertically or horizontally adjustable seat, the most critical seat position(s) shall be selected for each test condition.

5.1.13 The distribution of the forward static loads applied to a seat that uses upper torso restraint shall be 40% through the upper torso restraint and 60% through the pelvic restraint. These loads shall be applied using the body block shown in Figure 2, the test setup shown in Figure 4C, or an equivalent method.

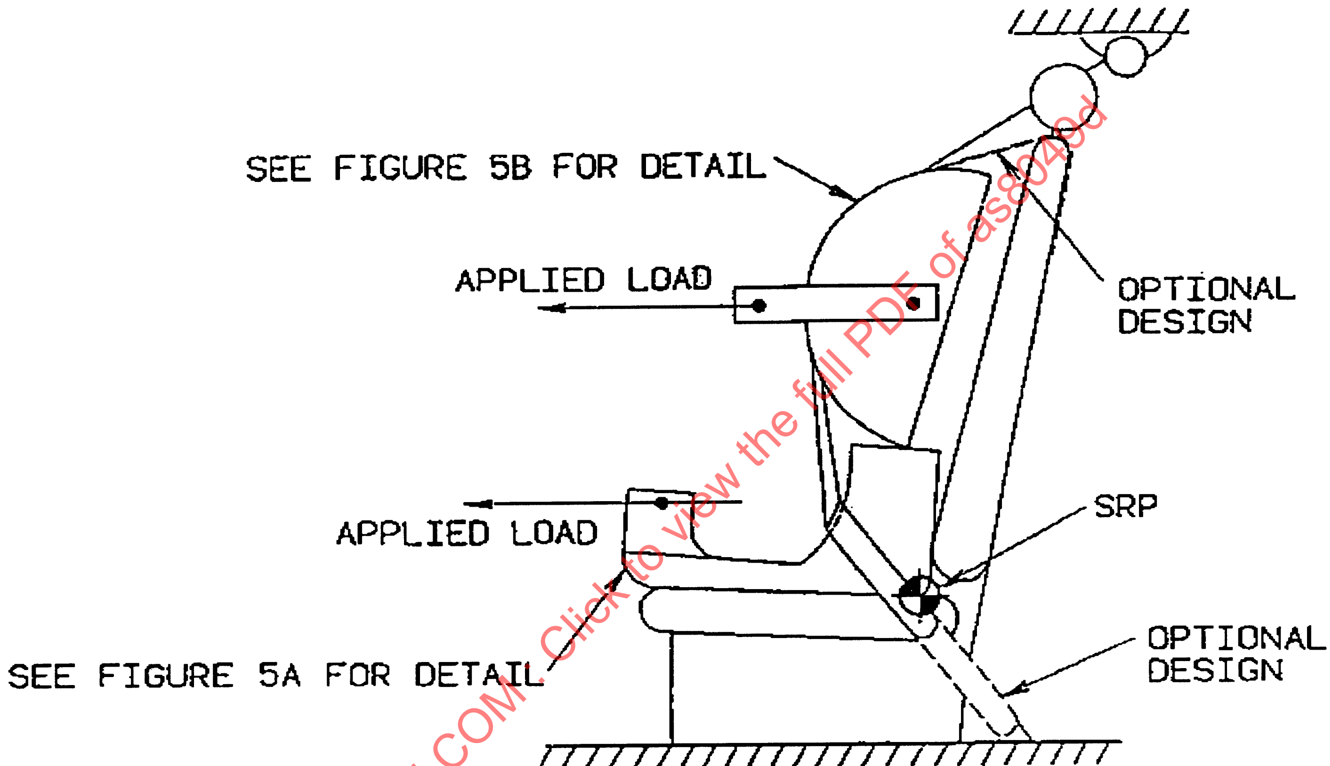


Figure 4C - Optional combined pelvic and upper torso static test

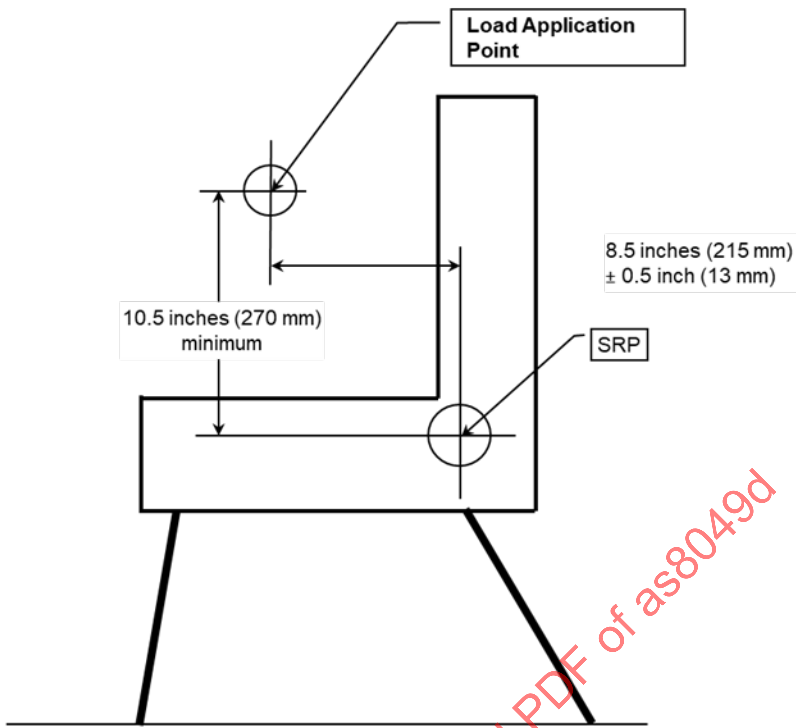


Figure 5 - Static load application point

5.1.14 When a Type B-N or Type B-T seat incorporates pelvic and upper torso restraints where the pelvic restraint is capable of being used without the upper torso restraints, static testing or rational analysis shall be performed with only the pelvic restraint effective, as well as with both pelvic and upper torso restraints effective. In both cases the load application points shall be as specified in Table 5.

5.1.15 Prior to and after the application of each test load, measurements for determination of permanent deformation shall be recorded.

5.1.16 In-arm video systems on seats shall be tested in accordance with ARP5475 Static Test Procedure.

5.2 Static Test - Pass/Fail Criteria

The static tests shall demonstrate the following:

5.2.1 The seat is capable of supporting the limit loads, as specified in 4.1.2, without detrimental permanent deformation or activating energy absorbing devices. At any load, up to limit loads, deformation may not interfere with safe operation of the aircraft.

5.2.2 The seat structure must be able to support ultimate loads without failure for at least 3 seconds. If it can be shown that failure of an armrest on a seat assembly does not reduce the degree of safety afforded the occupant(s) or become a hazard, such failure will not be cause for rejection.

NOTE: If retention of an item of mass attached to the seat is demonstrated by the dynamic qualification tests of 5.3, no further demonstration of retention for the forward and down static conditions is required. However, demonstration of retention of items of mass for the side, up and aft static conditions is still required.

5.2.3 After application and release of ultimate loads, as described in 5.2.2, the seat permanent deformation limitations of 3.5 and its subparagraphs are met.

5.2.4 In-arm video systems tested per 5.1.16 shall meet the performance criteria of ARP5475 Performance Requirements.

5.3 Dynamic Qualification Tests

This section specifies the dynamic tests to satisfy the requirements of this document.

5.3.1 Dynamic Impact Test Parameters

A minimum of two dynamic tests is required to assess the performance of an aircraft seat, restraints, and related interior system. The seat, cushions, and restraint are considered to act together as a system to provide protection to the occupant during a crash. The test facility shall provide a means of constraining the movement of the test fixture to translational motion parallel to the arrow indicating the inertial load throughout the test (Figures 6, 7A, or 7B).

5.3.1.1 Test 1 (Figures 6, 7A, and 7B), as a single row test, determines the performance of the system in a test condition where the predominant impact force component is along the spinal column of the occupant, in combination with a forward impact force component. This test evaluates the structural adequacy of the seat, critical pelvic/lumbar column forces, and permanent deformation of the structure under downward and forward combined impact loading and may yield data on Anthropomorphic Test Device or Dummy (ATD) head displacement, velocity, and acceleration time histories.

5.3.1.2 Test 2 (Figures 6, 7A, and 7B), as a single row seat test, determines the performance of a system in a test condition where the predominant impact force component is along the aircraft longitudinal axis and is combined with a lateral impact force component. This test evaluates the structural adequacy of the seat, permanent deformation of the structure, the pelvic restraint and upper torso restraint (if applicable) behavior and loads, and may yield data on ATD head displacement, velocity, and acceleration time histories and the seat leg loads imposed on the seat tracks or attachment fittings.

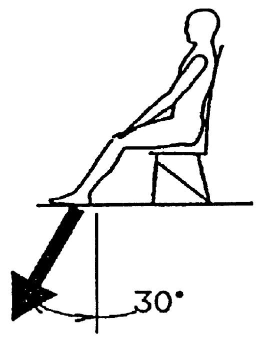
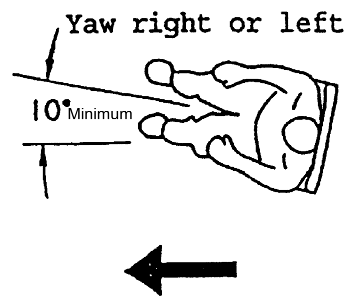
For seats intended to be installed at an angle greater than 2 degrees relative to the longitudinal axis of the airplane, the 10 degree yaw angle (left or right) required by the test condition shall be applied to the intended installation angle. For example, for a seat intended to be installed at 6 degrees to the left of the longitudinal axis of the airplane, the test angles to be considered are 16 degreesto the left and 4 degrees to the right of the longitudinal axis.

For seats intended to be installed at 2 degrees or less relative to the longitudinal axis of the airplane (left or right), the intended installation angle does not need to be included with the 10 degrees yaw angle (left or right) required by the test condition. That is, the test angles to be considered for these installation angles are 10 degrees to the left and 10 degrees to the right of the longitudinal axis (same as a 0 degrees installation).

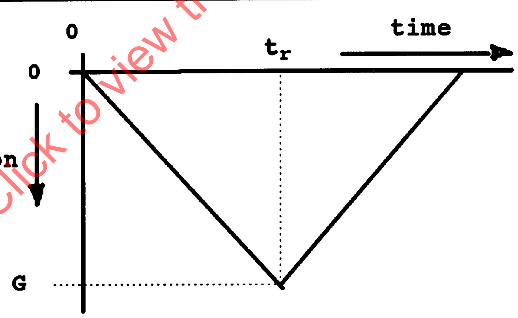
The direction of the yaw angle shall be that which increases the stress in the critically stressed seat and/or its attachments as selected per 5.3.5 and 5.3.6.1. The direction of the yaw angle shall also consider the nonsymmetrical upper torso restraint requirements per 5.3.6.3. If both yaw directions result in increasing a critical aspect of the seat and/or its attachments or having to meet nonsymmetrical upper torso restraint requirements, both directions shall be tested.

5.3.1.3 Test 2 for Type A-T and all Type C seats and Tests 1 and 2 for all Type B seats require simulating aircraft floor deformation by deforming the test fixture, as prescribed in Figures 6, 7A, and 7B, prior to applying the dynamic impact test conditions. The purpose of providing floor deformation for the test is to demonstrate that the seat/restraint system will remain attached to the airframe and perform properly even though the aircraft and/or seat may be severely deformed by the forces associated with a crash.

5.3.1.4 For seats placed in repetitive rows, an additional test condition, using seats in tandem placed at representative fore and aft distance between the seats (seat pitch), similar to Test 2 with or without the floor deformation directly evaluates head and femur injury criteria (the floor deformation is required if the test also demonstrates structural performance). These injury criteria are dependent on seat pitch, occupant location, and the effect of hard structures within the path of head excursions in the -10 to +10 degree yaw attitude range of the Test 2 conditions. The test procedure using the appropriate data obtained from Test 2 as described in 5.3.6.6 may be an alternative to multiple row testing.

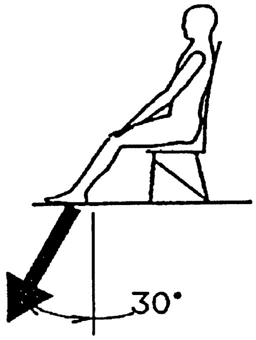
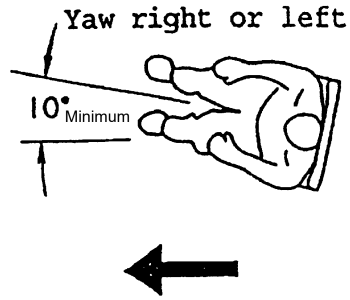
Illustration shows a forward facing seat Inertial load shown by arrow	TEST 1	TEST 2
		
Min V m/s(ft/s)	10.67 (35)	13.41 (44)
Max. t_r s	0.08	0.09
Min. G	14	16
Deform floor:		
Degrees roll	0	10 Minimum
Degrees pitch	0	10 Minimum

Test Pulse Simulating Aircraft Floor Deceleration - Time History:

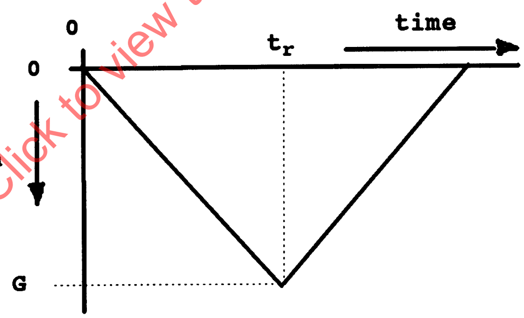


tr= Rise time
V = Impact Velocity
G = Deceleration measured on test fixture or sled near the seat position.

Figure 6 - Type A-T seat/restraint system dynamic tests

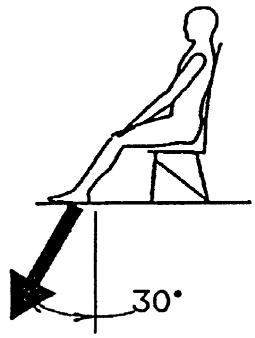
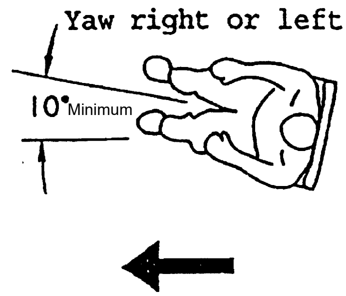
Illustration shows a forward facing seat Inertial load shown by arrow	TEST 1	TEST 2
		
Min V m/s(ft/s)	9.14 (30)	12.80 (42)
Max. t_r s	0.031	0.071
Min. G	30	18.4
Deform floor:		
Degrees roll	10 Minimum	10 Minimum
Degrees pitch	10 Minimum	10 Minimum

Test Pulse Simulating Aircraft Floor Deceleration-time History:

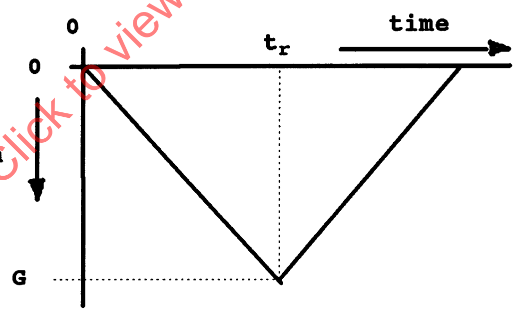


tr= rise time
V = Impact Velocity
G = Deceleration measured on the test fixture or the sled near the seat position

Figure 7A - All type B seat/restraint system dynamic tests

Illustration shows a forward facing seat Inertial load shown by arrow	TEST 1		TEST 2	
				
	CREW *	PASSENGER	CREW *	PASSENGER
Min V m/s(ft/s)	9.45(31)	9.45(31)	12.80(42)	12.80(42)
Max. t_r s	0.05	0.06	0.05	0.06
Min. G.	19	15	26	21
Deform floor:				
Degrees roll	0	0	Minimum 10	Minimum 10
Degrees pitch	0	0	10 Minimum	10 Minimum

Test Pulse Simulating Aircraft Floor Deceleration-Time History:



tr= Rise time
V = Impact Velocity
G = Deceleration measured on the test fixture or the sled near the seat position

* Refers to seats installed in the front row of the airplane

Figure 7B - All type C seat/restraint system dynamic tests

5.3.2 Occupant Simulation

An ATD representing a 50th percentile male as defined in 49 CFR Part 572, Subpart B, or an equivalent shall be used to simulate each occupant.

Since ATD development is a continuing process, provisions have been made for using "equivalent" ATDs. An equivalent ATD shall provide the same response to the test conditions of this document as the specified ATD (see 5.3.2.3).

5.3.2.1 General ATD Requirements

ATDs used in the tests defined in this document shall be maintained to perform in accordance with the requirements described in their specification. Periodic teardown and inspection of the ATD shall be accomplished to identify and correct any worn or damaged components, and appropriate ATD calibration tests (as described in their specification) shall be accomplished if major components are replaced.

ATDs shall be maintained at a temperature range between 66 to 78 °F (19 to 26 °C) and at a relative humidity from 10 to 70% for a minimum of 4 hours prior to and during the test.

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

Additional ballast weight shall not be added to the ATD. Improper or varying placement of the ballast to the ATD has the potential to invalidate the calibration. However, it is acceptable to install instrumentation, non-functioning instrumentation or similar masses of the same weight and method of attachment as the instrumentation at the locations in the ATD designed for that instrumentation (such as, head accelerometers, lumbar load cells, femur load cells, etc.) to reach a specific ATD weight.

Submarining indicators, such as electronic transducers, may be added on the ATD pelvis. If used, these indicators shall be located on the anterior surface of the ilium of the ATD pelvis without altering its contour and indicate the position of the pelvic restraint as it applies loads to the pelvis. These indicators can provide a direct record that the pelvic restraint remains on the pelvis during the test, and eliminate the need for careful review of high-speed camera images to make that determination.

5.3.2.2 Types of ATDs

The following types of ATDs are used for tests defined in this document. These have been shown to be reliable test devices that are capable of providing reproducible results in repeated testing.

5.3.2.2.1 50th Percentile Male ATD (Hybrid II)

A 50th Percentile Male ATD (Hybrid II) is an ATD representing a 50th percentile male as defined in 49 CFR part 572 subpart B.

This ATD has provisions for the installation of three accelerometers in the head (x, y, z directions) and an axial load transducer in each femur.

To measure the axial compressive load between the pelvis and lumbar column due to vertical impact as well as downward loads caused by upper torso restraints, a load (force) transducer shall be inserted into the ATD pelvis just below the lumbar column. A load cell compatible with a 49 CFR Part 572, Subpart B ATD is commercially available for this application with no ATD modification necessary except installing shims as required to adjust the ATD seated height to the ATD specifications.

To prevent failure of the clavicle used in 49 CFR Part 572, Subpart B, ATDs due to flailing, a clavicle of the same shape but of higher strength material may be substituted.

5.3.2.2.2 FAA Hybrid III ATD

A FAA Hybrid III ATD is an ATD representing a 50th percentile male as defined in 49 CFR part 572 subpart E modified per SAE Technical Paper 1999-01-1609.

This ATD has provisions for the installation of three accelerometers in the head (x, y, z direction), an axial load transducer in each femur, a lumbar spine load cell, a six-axis transducer in the neck, and accelerometers in the chest.

The FAA Hybrid III ATD has been determined to be an equivalent ATD to the 49 CFR part 572 subpart B ATD (Hybrid II).

A commercially available load cell compatible with a 49 CFR Part 572, Subpart B ATD with no ATD modification necessary has made Figure 8 obsolete (see 5.3.2.2.1). The figure numbers have not been renumbered to preserve references to figures in this document that occur elsewhere.

Figure 8 - (Intentionally left blank)

5.3.2.3 Equivalent ATDs

The continuing development of ATDs for dynamic testing of seating restraint/crash-injury-protection systems is guided by goals of improved bio-fidelity (human-like response to the impact environment) and reproducibility of test results. For the purposes of the tests discussed in this document, these improved ATDs can be considered the equivalent of the 49 CFR Part 572, Subpart B ATD if:

a. They are fabricated in accordance with design and production specifications established and published by a regulatory agency that is responsible for crash injury protection systems;

b. They are capable of providing data for the measurements discussed in this document or of being readily altered to provide the data;

c. They have been evaluated by comparison with the 49 CFR Part 572, Subpart B ATD and are shown to generate similar or improved response to the impact environment discussed in this document;

d. Any deviations from the 49 CFR Part 572, Subpart B ATD configuration or performance are representative of the occupant of a civil aircraft in the impact environment discussed in this document; and

e. They are Hybrid III ATDs (49 CFR Part 572, Subpart E) modified in accordance with SAE Technical Paper 1999-01-1609 (reference 2.1.8).

ATD drawings are available using the instructions provided in 49 CFR Part 572 (reference 2.2.7).

5.3.3 Test Fixtures

A test fixture is required to position the test article on the sled or drop carriage of the test facility and takes the place of the aircraft's floor structure. It does not need to simulate the aircraft floor flexibility. It holds the attachment fittings or floor tracks for the seat. If required for the test, it provides the floor deformation (also referred to as floor warpage or floor distortion); provides anchorage points for the restraint system; provides a floor or footrest for the ATD; and positions instrument panels, bulkheads, or a second row of seats.

5.3.3.1 Floor Deformation Fixtures

For the typical seat with two seat legs and two attachments per leg mounted in the aircraft on two parallel tracks, the floor deformation test fixture shall consist of two parallel beams: a pitch beam that pivots about a lateral (y) axis and a roll beam that pivots about a longitudinal (x) axis (see Figure 9A for a schematic representation). The beams can be made of any rigid structural form: box, I-beam, channel, or other appropriate cross section. The pitch beam shall be capable of rotating in the x-z plane up to ±10 degrees relative to the longitudinal (x) axis. The pitch axis shall be at the aft fitting of the floor attachment that is being pitched. The roll beam shall be capable of ±10 degrees roll about the centerline of floor tracks or fittings. A means shall be provided to fasten the beams in the deformed positions.

The beams shall have provisions for installing load transducers (see 5.3.3.2) that carry floor track or other attachment fittings on their upper surface in a manner that does not alter the above-floor strength of the track or fitting.

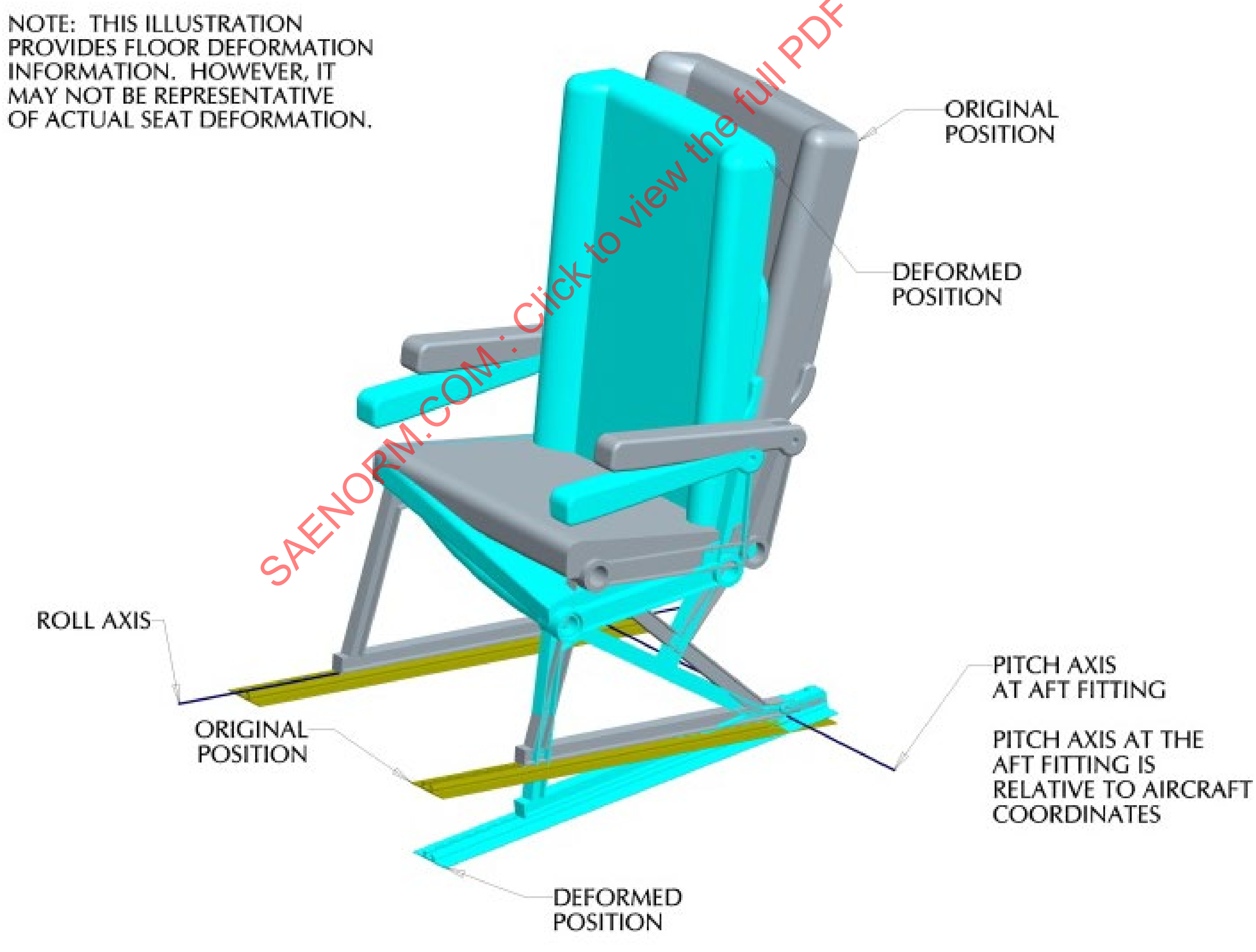


Figure 9A - Schematic of floor deformation: seat legs attached at floor level

5.3.3.2 Load Transducer Installation

The pitch and roll beams shall have provisions for installing individual load transducers at each seat leg attachment point capable of measuring three reaction forces and, if following the alternate procedure of 5.3.3.3, three reaction moments. The load transducers shall have provisions to install floor track or other attachment fittings on their upper surface in a manner that does not alter the above-floor strength of the track or fitting.

In some cases, the load cells cannot be physically centered under all the seat attachment points. For this situation, the load cells shall be centered under the critical seat attachment points that will be highest loaded during the test. For the remaining attachment points the load cells shall be positioned as close to the center of the attachment that physical space limitations allow.

5.3.3.3 Aircraft Floor Track or Attachment Fitting Simulation

The track or other attachment fittings must be representative in above-floor configuration and strength of those used in the aircraft. Structural elements below the surface of the floor that are not considered part of the floor track or seat attachment fitting need not be included in the installation. An example of the minimum required representation of a floor track is shown in Figure 9J for one type of seat track.

Alternatively, testing with seat track sections that are more critical than actual aircraft installed track is permitted. For the installation, rational analysis that takes into account material strength and section properties of the tested and installed track sections as well as any interface differences of the track and seat fitting is required at a minimum.

If representative track or attachment fittings are not used, three components of reaction forces and three components of reaction moments shall be measured during dynamic tests. These six components shall be applied simultaneously, by a separate static or dynamic test, to a track or attachment fitting used on the aircraft in which the seat is to be installed, or to a more critical track or attachment fitting than that used on the aircraft, to demonstrate that the loads measured in the dynamic impact test will not fail the track or attachment fitting used on the aircraft.

5.3.3.4 Seat Installation and Floor Deformation Procedure

The test seat shall be installed on the parallel beams of the deformation fixture so that the aft seat leg attachment point on the pitch beam (relative to aircraft coordinates) is near the pitch beam axis of rotation (see Figure 9A). The seat positioning pins or locks shall be fastened in the same manner as would be used in the aircraft, including the adjustment of anti-rattle mechanisms, if provided. The remainder of the test preparations shall then be completed (ATD installation and positioning, instrumentation installation, adjustment and calibration, camera checks, etc.).

The floor deformation shall be accomplished as the final action before the test. The roll beam shall be rotated 10 degrees and locked in place, and the pitch beam(s) shall be rotated 10 degrees and locked in place. The order in which the pitch and roll deformations are accomplished is arbitrary. Each direction of rotation shall be selected to produce the most critical loading condition on the seat and floor track or fitting (see Figure 9A).

Appropriate safety precautions should be taken while imposing floor deformation.

5.3.3.5 Other Mounting Configuration Constraints

The preceding discussion described the fixture and floor deformation procedure that would be used for a typical seat that uses four seat legs (i.e., four attachments to the aircraft floor). These test procedures are not intended to be restricted only to those seat configurations, but shall be adapted to seats having other designs. Special test fixtures may be necessary for those different configurations.

The following methods, while not covering all possible seat designs, shall be followed for the more common alternatives:

a. Aircraft seats with three legs (i.e., three floor attachment points) may have one central leg in front or back of the seat, and one leg on each side of the seat. The central leg shall be held in its undeformed position as deformation is applied to the side legs.

b. Seats that have more than two pairs of legs should be tested with the floor warpage condition that results in the most critically stressed condition. This typically involves warping adjacent pairs of legs. Seats that employ several pairs of legs, ganged together by common cross tubes, can be distorted so that one pair (the critical pair) of legs is rolled, while the remaining legs on one side of the critical leg are pitched in unison. The legs that are pitched should be selected to increase the load on the critical leg, and stress the floor or track fitting in the most severe manner as shown in Figures 9B and 9C.

c. Seats that are wall-mounted must be evaluated individually. There are several types of mounting schemes, some of which are discussed below. An important consideration is the retention of the seat under dynamic conditions, and the test setup should account for this in wall-mounted seats as well. Seats that mount solely to a wall will not be subject to deformation or warpage prior to test except as noted below. The following guidance has been established with this objective in mind.

1. Seats that are mounted to primary aircraft structure, such as a pressure bulkhead, need only be tested with the attachment fitting mounted to rigid structure, in a manner equivalent to the production installation.

2. Seats mounted to a structure such as a structural bulkhead, galley or lavatory, where integral structural members are used for attachment of the seat, need only be tested with the attachment fitting mounted to a rigid structure, in a manner equivalent to the production installation.

3. Seats mounted to a structure, such as a structural bulkhead, galley, or lavatory, where no integral structural members are used for attachment, should be tested with the seat attached to segments of the mounting surface. These segments are typically eight inch by eight inch sections of the panel. These sections can, in turn, be mounted to a rigid structure.

4. Seats that are mounted to single panel furnishings, such as class dividers or windscreens, where the panel essentially fulfills the role of the legs, should be treated the same as floor mounted seats. For the purpose of conducting tests, the entire assembly, including the panel and its attachments, should be included in the test setup. In this case, floor warpage should be applied to track-mounted furnishings.

d. Seats that are attached to both the floor and a bulkhead should be tested on a fixture that positions the bulkhead surface in a plane through the axis of rotation of the pitch beam. The bulkhead surface should be located perpendicular to the plane of the floor (the aircraft floor surface, if one were present) in the undeformed condition, or in a manner appropriate to the intended installation. Either a rigid bulkhead simulation or an actual bulkhead panel can be used. If a test fixture with a rigid bulkhead simulation is used, the seat restraint system shall attach to fittings installed in a test panel equivalent to those used in the actual installation. The seat should be attached to the bulkhead and the floor in a manner representative of the aircraft installation, and the floor shall then be deformed as described in 5.3.3.4.

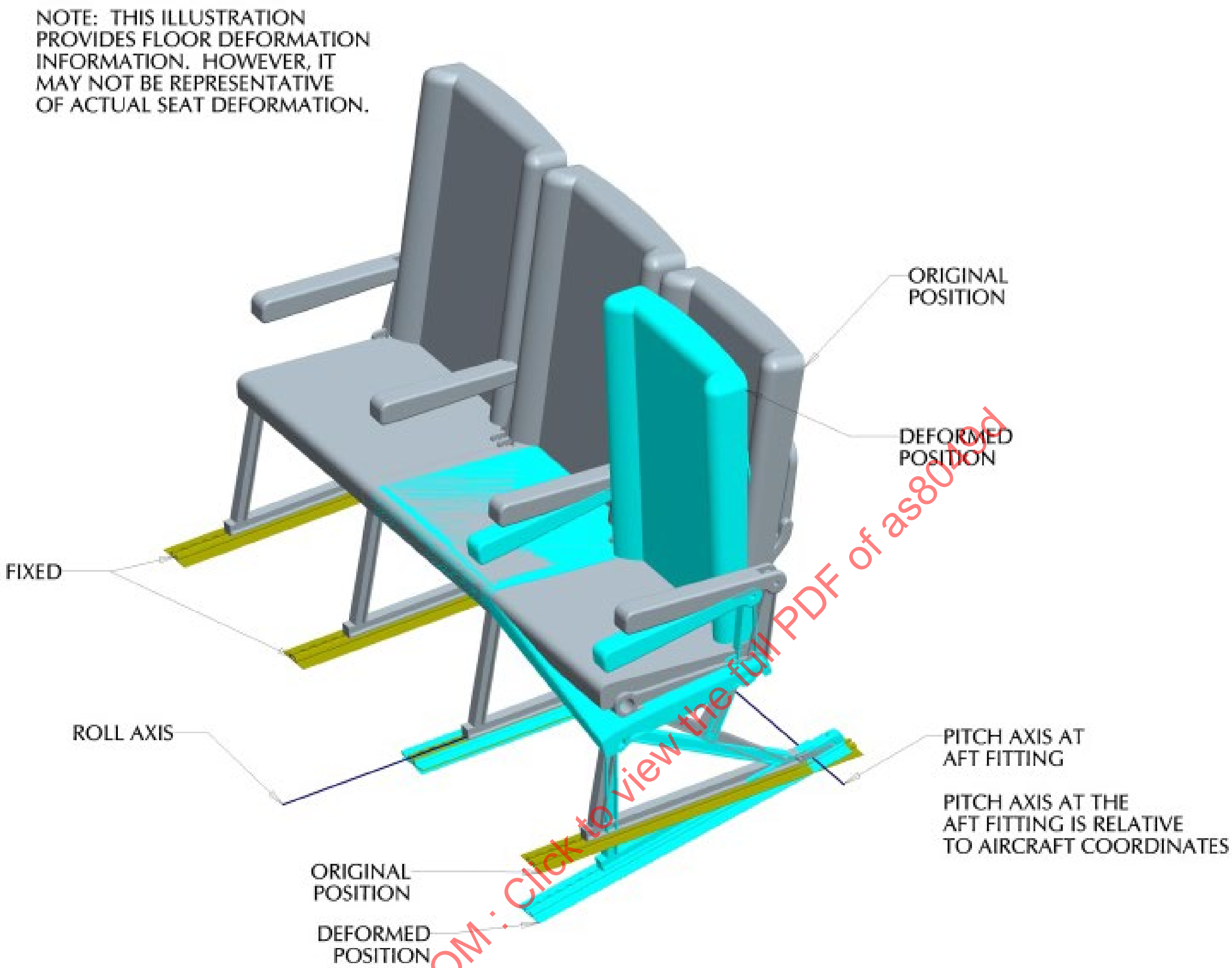


Figure 9B - Schematic of floor deformation: multiple leg seat

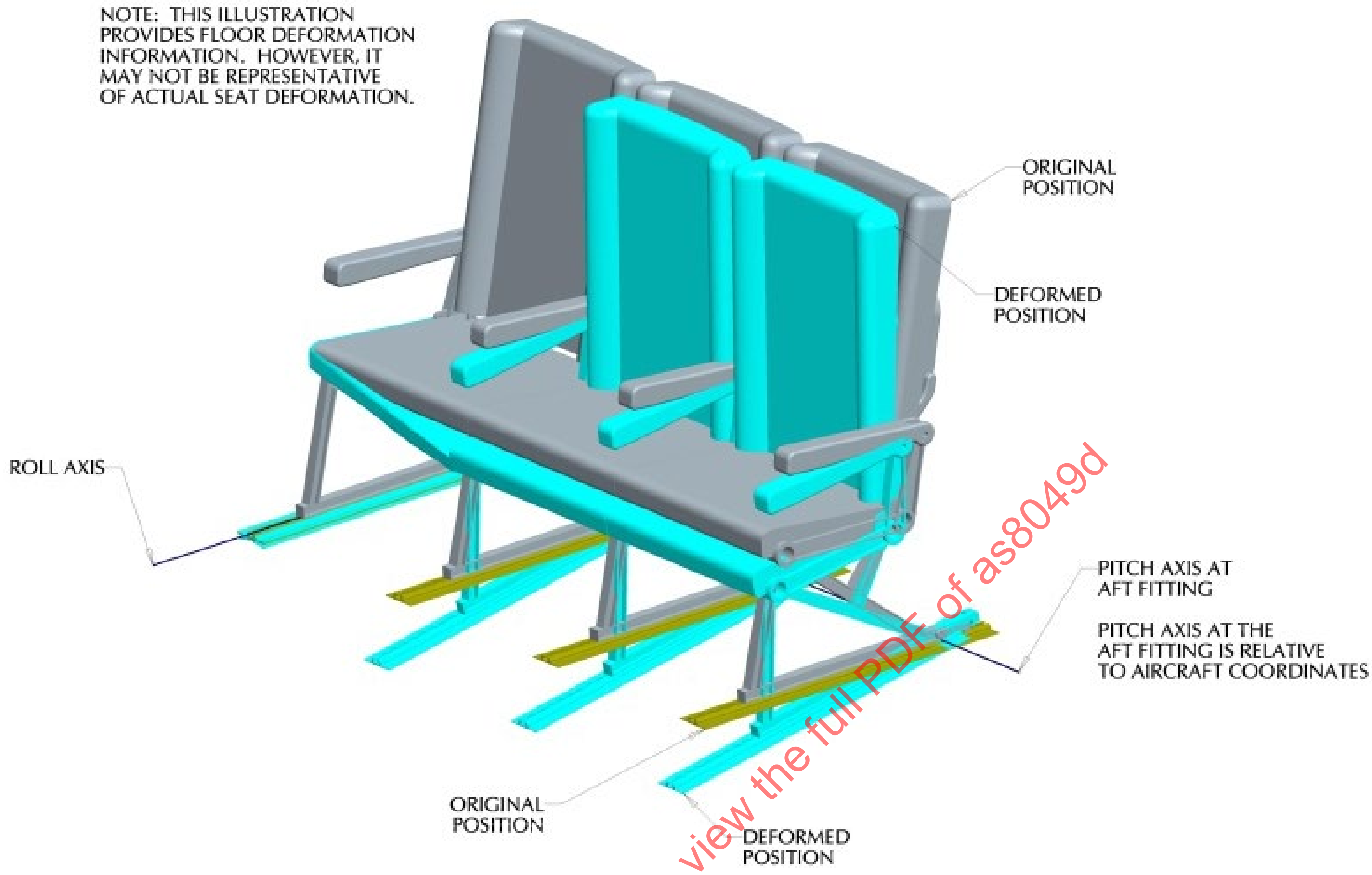


Figure 9C - Schematic of floor deformation: multiple leg seat

e. Seats that incorporate attachments to the aircraft sidewall must be evaluated taking into consideration the expected aircraft fuselage cross-section deformation during a crash. The seat could be mounted between sidewalls or to the sidewall and the floor. The test fixture shall allow either a pitch beam or a roll beam to be installed at the outboard attachment structure of the seat. The seat positioning pins or locks shall be fastened in the same manner as would be used in the aircraft, including the adjustment of anti-rattle mechanisms, if provided. The following two seat attachment cases incorporating sidewall attachment will be considered.

1. For the case where there are both sidewall and inboard floor attachments, two tests may be required.

   To substantiate the seat and sidewall attachment structure, the roll beam will be installed on the sidewall attachment and the pitch beam will be installed on the inboard floor location as shown in Figure 9D. The test shall be conducted with the roll beam rotated simulating the sidewall rotating outboard as shown in Figure 9D. The pitch beam rotation and the yaw angle direction of the seat shall be selected to produce the critical loading condition for the sidewall attachment structure.

   To substantiate the seat and inboard floor attachment structure, the roll beam will be installed on the inboard floor attachment and the pitch beam will support the sidewall attachment as shown in Figure 9E. The pitch and roll directions of the test fixture and the yaw direction of the seat shall be selected to produce the critical loading condition for the inboard attachment structure.

   Both tests are required unless it can be shown by rational analysis that testing one attachment structure in its critical condition substantiates the other attachment structure.

2. For the case where the seat is mounted between aircraft sidewalls with no floor attachment structure, the roll beam shall be installed at the critical outboard attachment structure while the pitch beam is located at the other outboard attachment structure. The test shall be conducted with the roll beam rotated simulating the sidewall rotating outboard as shown in Figure 9D. The pitch beam rotation and the yaw angle of the seat shall be selected to produce the critical loading condition for the outboard attachment structure.

f. Seats that are cantilevered from one sidewall without connection to other structure are not subject to floor deformation. A determination shall be made whether sidewall deformations could be expected that could generate a condition critical for seat performance in a crash. If sidewall deformation is likely, the entire sidewall attachment plane, or the attachment points, shall be deformed in a manner to represent the sidewall deformation. Either a rigid sidewall simulation or an actual sidewall panel may be used. If a test fixture with a rigid sidewall simulation is used, the seat/restraint system shall be attached to fittings installed in a test panel equivalent to those used in the actual installation.

g. Floor mounted adapter plates that have single seat assemblies (whether single or multiple place) attached to them should be considered part of the seat assembly. The adapter plate and its attached seat should be deformed as described in 5.3.3.4. Any items of mass attached to the adapter plate need to be included in the dynamic testing and must be representative with regards to mass, center of gravity, stiffness, and method of attachment.

h. Adapter plate installations involving multiple seat assemblies may be considered part of the floor structure of the airplane, but delineating factors have not been established at the time of this document.

i. Side-Facing Seats (Intentionally left blank).

j. For Type A-T seats, seat designs with a single attachment on any track shall be pitched with the pitch axis located at the aftmost attachment of the seat irrespective of whether the aftmost attachment is on the pitch or roll beam. See Figure 9F.

k. For Type A-T seats, seat designs with two attachments on the pitch beam, if the distance between the forward most stud on the front attachment and the aftmost stud on the aft fitting on the pitch beam is less than 18.0 inches (45.7 cm), then the pitch axis of the pitch beam shall be located at the aftmost attachment of the seat irrespective of whether the aftmost attachment is on the pitch or roll beam. If the distance between the forward most stud on the front attachment and the aftmost stud on the aft fitting on the pitch beam is equal to, or greater than, 18.0 inches (45.7 cm), then the pitch axis of the pitch beam shall be located at the aftmost attachment on the pitch beam. See Figures 9G and 9H.

5.3.3.6 Multiple Row Test Fixtures

In tests of passenger seats that are normally installed in repetitive rows in the aircraft, head and knee impact conditions are best evaluated through tests that use at least two rows of seats. These conditions are usually critical only in Test 2. This test allows direct measurements of the head and femur injury data.

a. The fixture shall be capable of setting the aircraft longitudinal axis at a yaw angle of -10 degrees and +10 degrees. The fixture should also allow adjustment of the seat pitch.

b. To allow direct measurement of head acceleration for head injury assessment for a seat installation where the head of the occupant is within striking distance of structure, a representative impact surface may be attached to the test fixture in front of the front row seat at the orientation and distance from the seat representing the aircraft installation.

c. Seats designed for seat tracks that are not in-line and parallel (track-break seats) typically require special floor attachment fittings. The installation of the seat tracks on the test fixture for these seats is unique, and depends on the intended seat location in the airplane. The test setup must represent the seat track orientation on the airplane (that is, angles, offsets, forward/aft distance, and so forth) of seat tracks under the aft attachments versus the forward attachments).

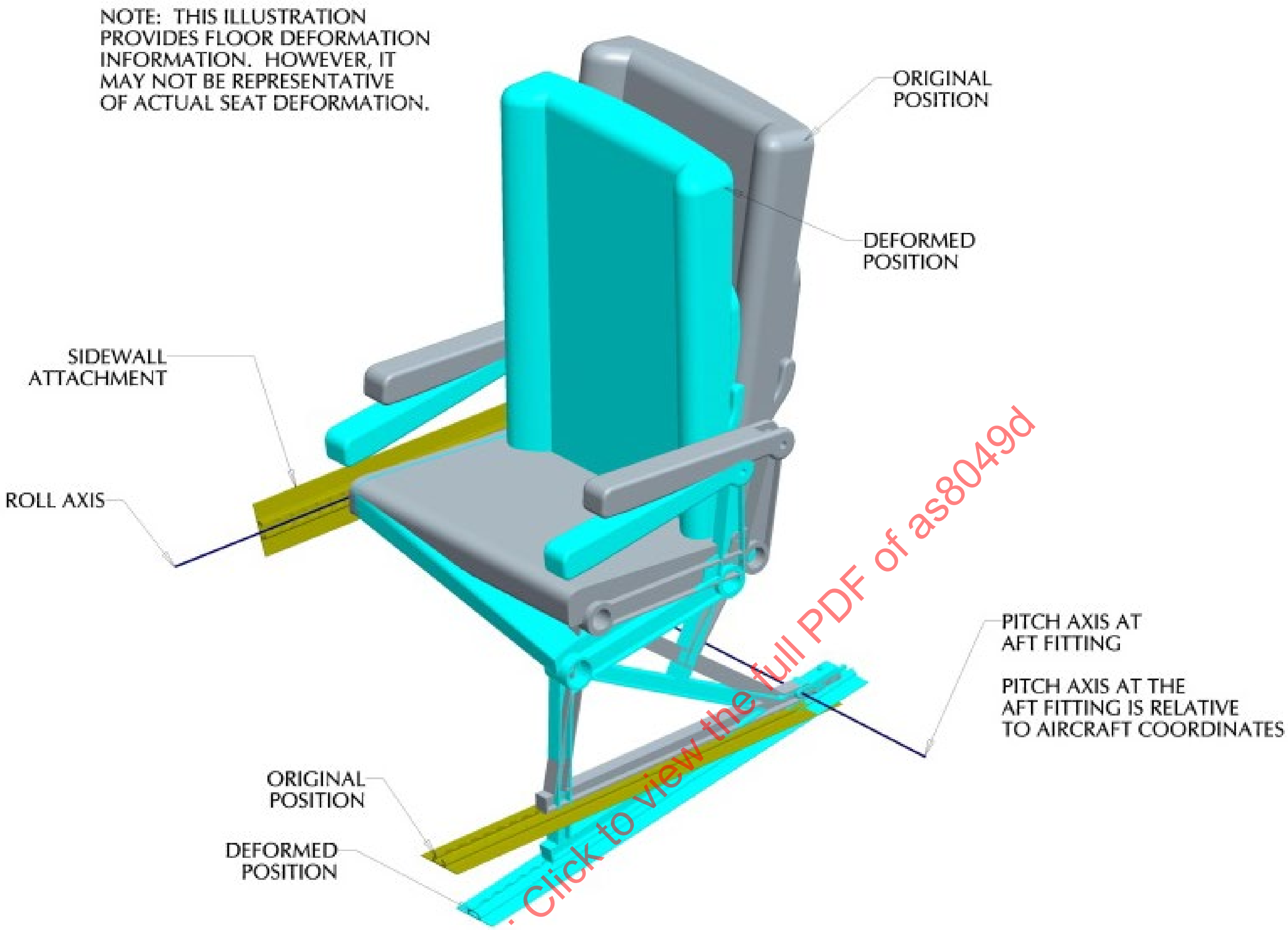


Figure 9D - Schematic of floor deformation: side wall mounted seat

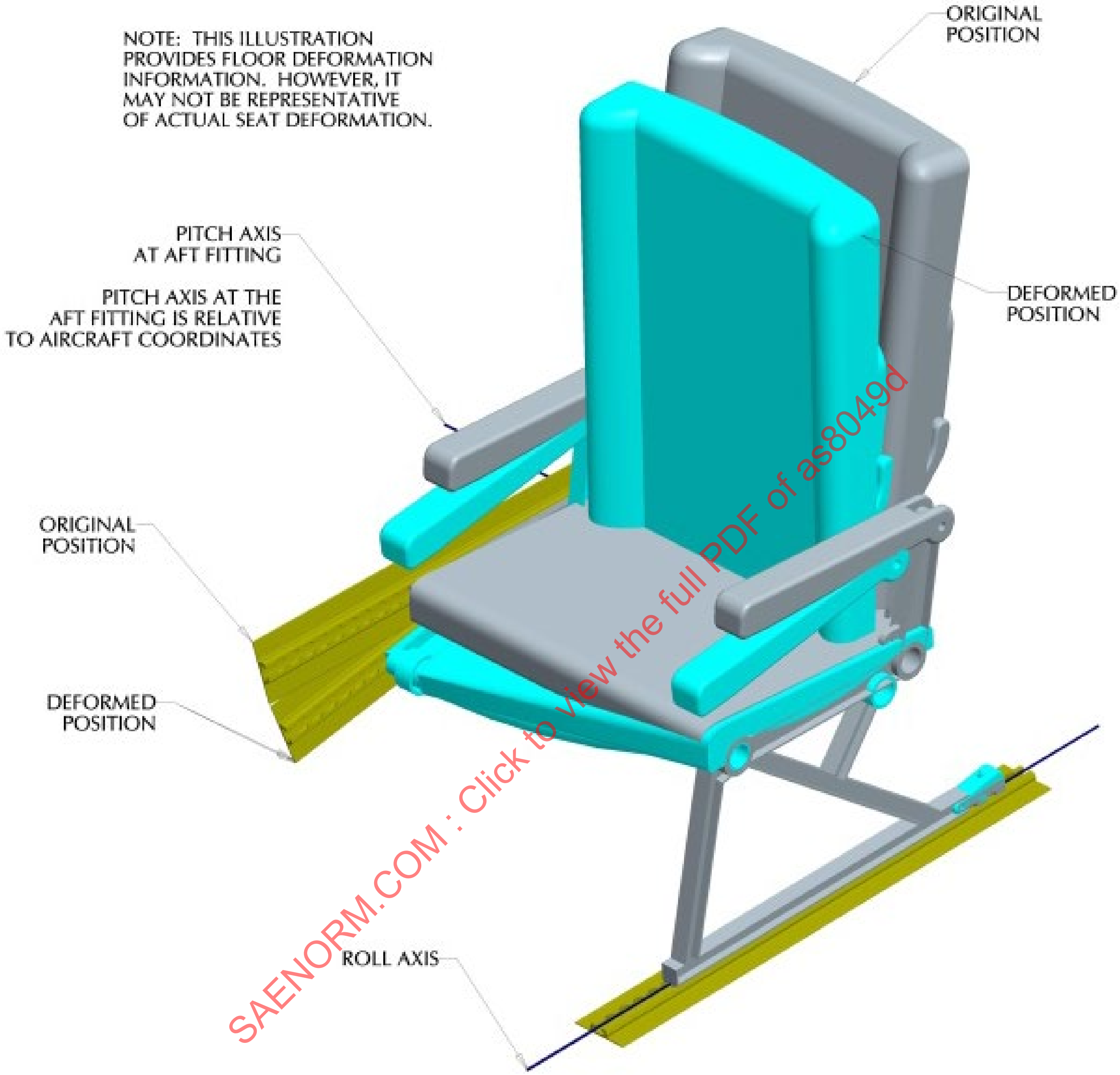


Figure 9E - Schematic of floor deformation: side wall mounted seat

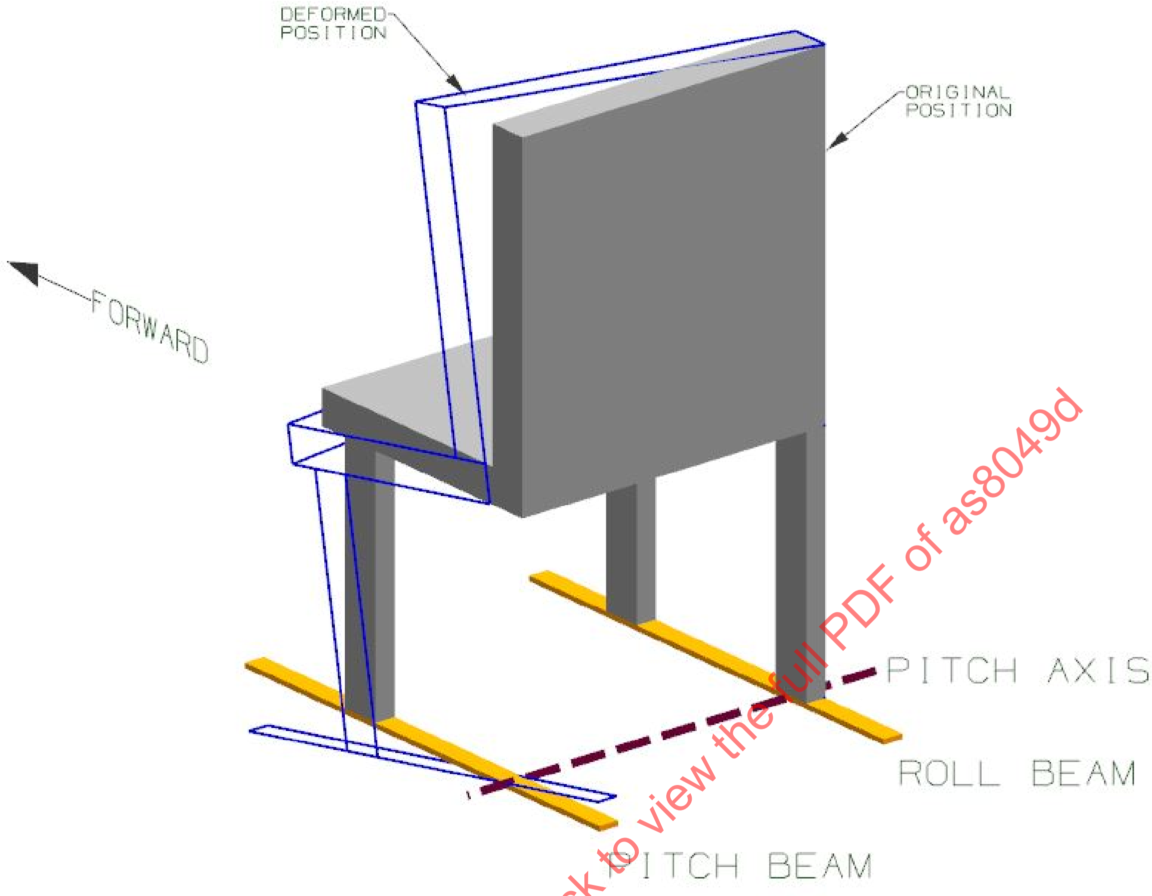


Figure 9F - Schematic of floor deformation: single floor attachment on pitch beam - pitch axis location

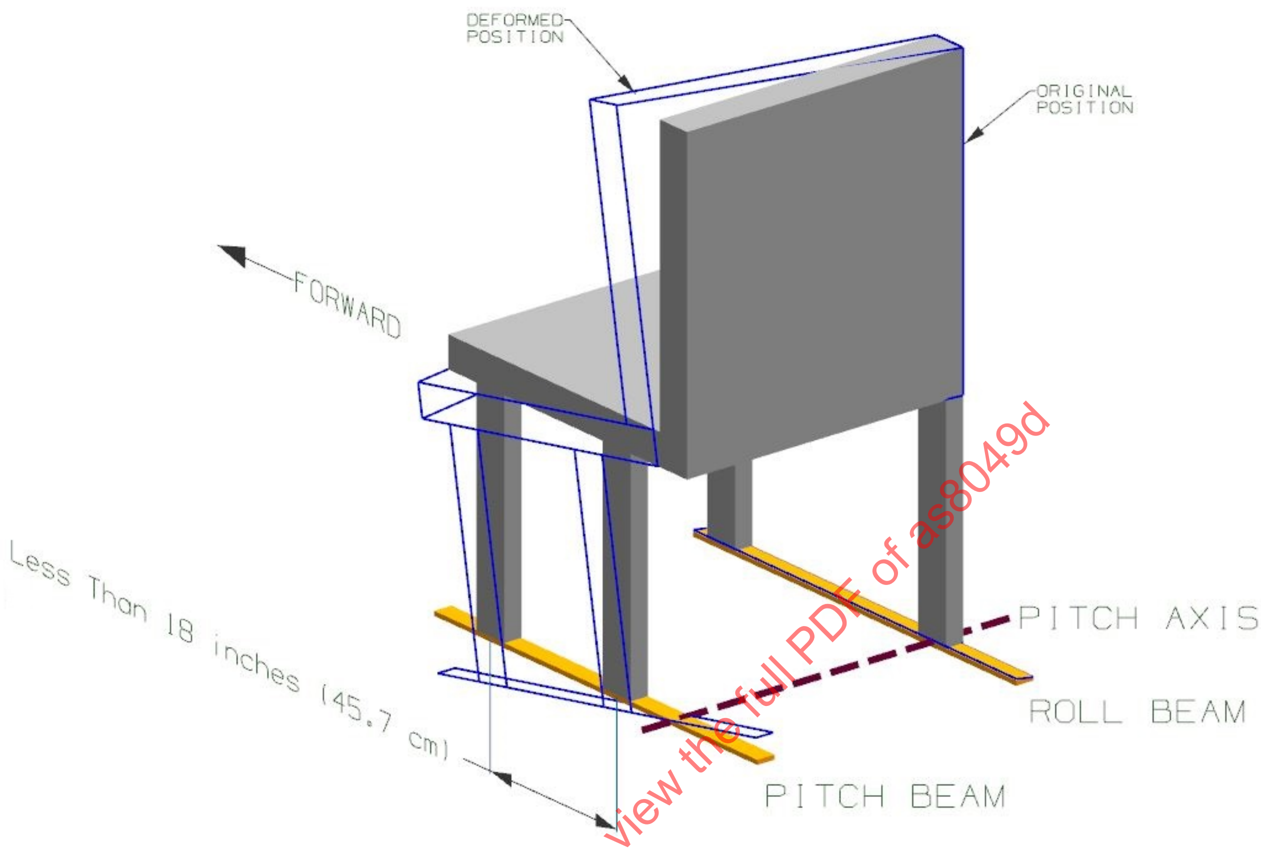


Figure 9G - Schematic of floor deformation: two floor attachments on pitch beam less than 18 inches (45.7 cm) - pitch axis location

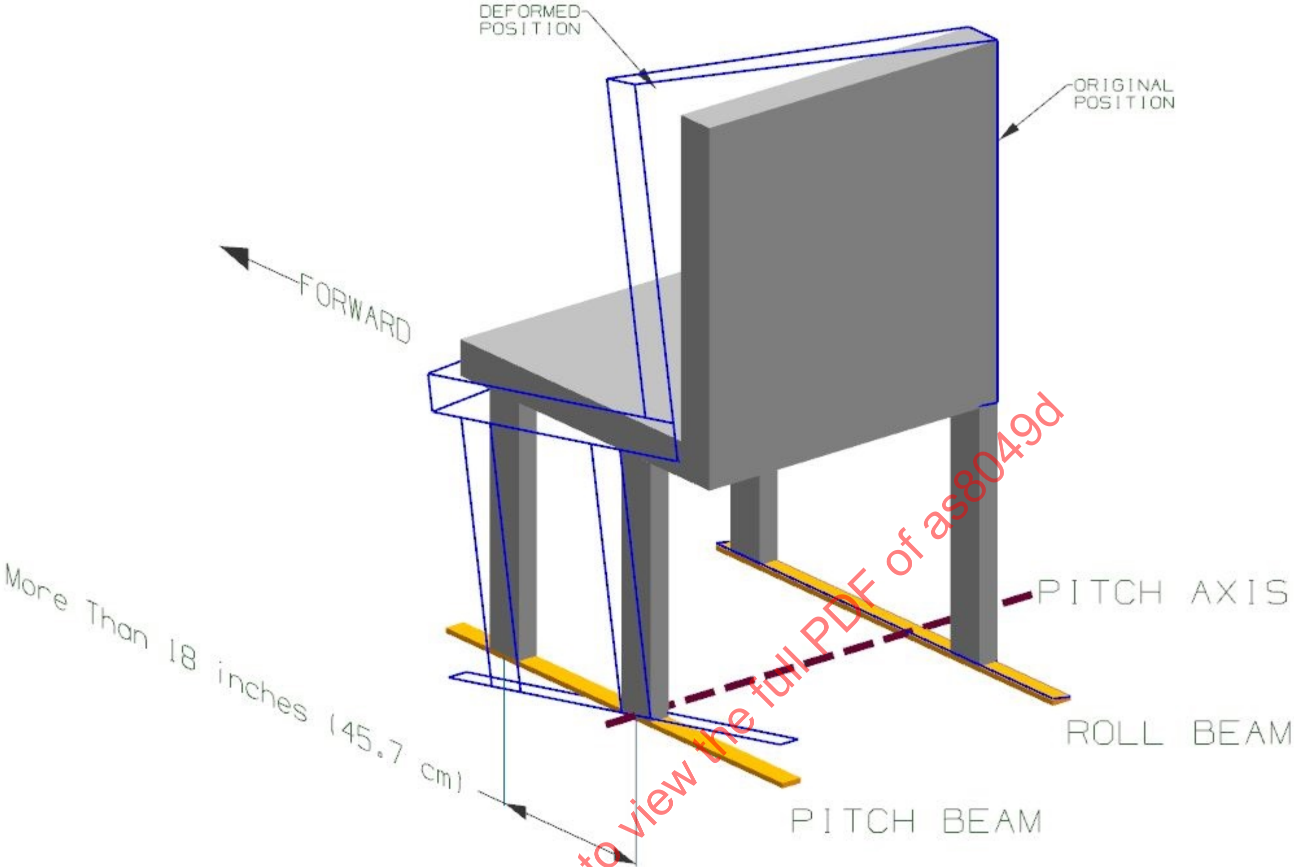


Figure 9H - Schematic of floor deformation: two floor attachments on pitch beam equal to or greater than 18 inches (45.7 cm) - pitch axis location

Figure 9J - Example of minimum seat track for testing

5.3.3.7 Other Fixture Applications

Test fixtures shall provide a flat floor for positioning the ATD's feet in tests using passenger seats and crewmember seats that are not provided with special foot rests or foot operated controls. The floor shall be at a position representative of the undeformed floor in the aircraft installation. Floors should not influence the behavior of the seat or unduly restrict the movement of the ATD's feet, especially when floor distortion is applied. A floor is not required when Test 2 is conducted only for the purpose of providing structural evaluation of the seat. Test fixtures used for evaluating crew seats that are normally associated with special foot rests or foot operated controls shall simulate those components. Test fixtures may also be required to provide guides or anchors for restraint systems or for holding instrument panels, sidewalls, or bulkheads if necessary for the planned tests. If these provisions are required, the installation shall represent the configuration of the aircraft installation and be of adequate structural strength.

5.3.4 Instrumentation

Electronic and photographic instrumentation systems shall be used to record data for qualification of seats.

Electronic instrumentation shall measure the test environment, and measure and record data required for comparison of performance to pass/fail criteria.

Photographic instrumentation shall document overall results of tests, confirming that the pelvic restraint remains on the ATD's pelvis, that the upper torso restraint strap(s) remain on the ATD's shoulder(s) during impact, that the seat does not deform as a result of the test in a manner that would impede rapid evacuation of the aircraft by the occupants, and that the seat remains attached at all points of attachment.

5.3.4.1 Electronic Instrumentation

Electronic instrumentation shall be accomplished in accordance with SAE J211/1. In this practice, a data channel is considered to include all of the instrumentation components from the transducer through the final data measurement, including connecting cables and any analytical procedures that could alter the magnitude or frequency content of the data. Each dynamic data channel is assigned a nominal channel class that is equivalent to the high frequency limit for that channel addressed in SAE J211. For the dynamic tests discussed in this document, the dynamic data channels shall comply with the following Channel Class characteristics:

a. Sled or drop tower vehicle acceleration data measurements shall be in accordance with Channel Class 60 requirements.

b. Belt-restraint system and seat attachment reaction loads (when required) shall be measured in accordance with the requirements of Channel Class 60. Loads in restraint systems that attach directly to the test fixture can be measured by three-axis load cells fixed to the test fixture at the appropriate location. These commercially available load cells measure the forces in three orthogonal directions simultaneously, so that the direction as well as the magnitude of the force can be determined. If desired, similar load cells can be used to measure forces at other boundaries between the test fixture and the test item, such as the forces transmitted by the legs of the seat into the floor track. It is possible to use independent, single axis load cells arranged to provide similar data, but care should be taken to use load cells that can withstand significant cross axis loading or bending without causing errors in the test data.

c. ATD head accelerations used for calculating the Head Injury Criterion (HIC) shall be measured in accordance with the requirements of Channel Class 1000.

d. ATD femur forces shall be measured in accordance with Channel Class 600.

e. ATD pelvic/lumbar column force shall be measured in accordance with the requirements of Channel Class 600.

f. ATD neck forces shall be measured in accordance with the requirements of Channel Class 1000.

g. ATD neck moments shall be measured in accordance with the requirements of Channel Class 600.

h. ATD chest accelerations shall be measured in accordance with the requirements of Channel Class 180.

NOTE: The relevant accelerometer for measuring chest accelerations is mounted to the spine box, not the sternum. For this mounting location of the instrumentation, Channel Class 180 is in accordance with SAE J211/1.

i. The full-scale calibration range for each channel shall provide sufficient dynamic range for the data being measured.

j. Digital conversion of analog data shall provide sample resolution of not less than 1% of full scale input.

5.3.4.2 Photographic Instrumentation

Photographic instrumentation shall be used for documenting the response of the ATDs and the test items to the dynamic test environment. Both high speed and still image systems should be used. ARP5482 provides recommended practices for photometric data acquisition.

a. Photographic instrumentation shall be in accordance with SAE J211, Part 2. High speed cameras that provide data used to calculate displacement or velocity shall operate at a minimum nominal speed of 500 frames per second. Photo instrumentation methods shall not be used for determination of acceleration. The locations of the cameras and targets or targeted measuring points within the field of view shall be measured and documented. Targets shall be at least 1/100 of the field width covered by the camera and shall be of contrasting colors or shall contrast with their background. The center of the target shall be easily discernible. The ATD clothing shall be removed locally where targets are attached to the ATD. Sufficient clothing shall be removed around the target to prevent obstruction of the target during the test.

   A description of photographic calibration boards or scales within the camera field of view, the camera lens focal length, and the make and model of each camera and lens shall be documented for each test. Appropriate digital or serial timing shall be provided on the image media. A description of the timing signal, the offset of timing signal to the image, and the means of correlating the time of the image with the time of electronic data shall be provided.

Rectilinearity of the image shall be documented in accordance with SAE J211, Part 2. If the image is not rectilinear, as indicated by an Overall Error in excess of 1%, appropriate correction factors shall be used in the data analysis process. A rigorous, verified analytical procedure shall be used for data analysis. The accuracy of the procedure is considered adequate if the difference between the measured and derived distance separating the Validation Target Pair, as defined in SAE J211, Part 2, is not greater than 0.4 inch (1.0 cm).

b. Cameras operating at a nominal rate of 200 frames per second or greater may be used to document the response of ATDs and test items if measurements are not required. For example, actions such as movement of the pelvic restraint system webbing off of the ATD's pelvis can be observed by documentation cameras placed to obtain a "best view" of the anticipated event. These cameras should be provided with appropriate timing and a means of correlating the image with the time of electronic data.

c. Still image cameras shall be used to document the pretest installation and the posttest response of the ATDs and the test items. At least four pictures shall be obtained from different positions around the test items in pretest and posttest conditions. Where an upper torso restraint system is installed, posttest pictures shall be obtained before moving the ATD. For additional posttest pictures, the ATD's upper torso may be rotated to its approximate upright seated position so that the condition of the restraint systems may be better documented, but no other change to the posttest response of the test item or the ATD shall be made. The pictures shall document that the seat remained attached at all points of attachment to the test fixture.

   Still pictures may also be used to document posttest yielding of the seat for the purpose of showing that it would not impede the rapid evacuation of the aircraft occupants. The ATD should be removed from the seat in preparation for still pictures used for that purpose. Targets or an appropriate target grid should be included in such pictures, and the views should be selected so that potential interference with the evacuation process can be determined. For tests where the ATD's head impacts a fixture or another seat back, pictures shall be taken to document the head contact areas.

5.3.5 Selection of Test Articles

Many seat designs comprise a family of seats that have the same basic structural design but differ in detail. For example, a basic seat frame configuration can allow for several different seat leg locations to permit installation in different aircraft. If these differences are of a nature that their effect can be determined by rational analysis, then the analysis can determine the most critical configuration. As a minimum, the most critically stressed configuration(s) shall be selected for the dynamic tests so that the other configurations could be accepted by comparison with that configuration.

There are two factors that must be considered in selecting the critical structural test configurations. First, the seat to aircraft interface loads (undeformed seat) can be determined by rational analysis for the seat design and load configurations. The rational analysis can be based on static or dynamic seat/occupant analytical methods. The rational analysis can form the basis for selecting the most highly stressed critical configuration based on load. Additionally, the effects of seat deformation should be considered. As noted, a family of seats typically includes seat models with varied seat leg locations. The effects of floor deformation are more critical for narrowly spaced legs. Thus, a test or rational analysis of the seat model with the minimum seat leg spacing must be conducted to evaluate the most highly stressed critical configuration based on deformation.

5.3.5.1 In all cases, the test article must be representative of the final production article in all structural elements, and shall include the seat, seat cushions, restraints, and armrests. It must also include a functioning position adjustment mechanism and correctly adjusted break over (if present).

Weights simulating luggage carried by luggage restraint bars [20 pounds (9.1 kg) per passenger place] need only be representative masses.

Items 0.33 pounds (0.15 kg) or greater carried by the seat that affect the dynamic performance of the seat, including occupant injury and egress, must be representative of the production item and production means of attachment on the test article.

Items 0.33 pounds (0.15 kg) or greater carried by the seat that do not affect the dynamic performance of the seat may be representative masses, but the production means of attachment must be on the test article.

Items less than 0.33 pounds (0.15 kg) and their means of attachment are not required to be on the test article. However, the mass of the item must be included on the test article as ballast.

Wiring harnesses, regardless of weight, may be represented on the test article by ballast weights. The production means of attachment need not be included in the test.

Life vests must be installed on the test article, if provisions are provided, but are not required to be the production life vest. Any life vest of equivalent weight, or greater, may be included on the test article. The life vest may be ballasted to substantiate heavier life vests. The life vest must represent the size and configuration of the production life vest if its size or configuration could affect retention of the life vest.

For Type A-T seats only, if an item of mass that does not affect the dynamic performance of the seat fails during a test that is otherwise acceptable, then you may validate the design for retention by a 24 g static test. The failed test article must be redesigned unless the failure is attributable to test setup or non-representative test article. The certified gross weight of the test article must be adjusted to account for any separation of mass due to failure. Apply the load for the 24 g test in the same direction as the load vector in the dynamic test where the failure occurred. Any preload, such as due to floor warpage, of the failed article must be represented in the static 24 g test.

In any case, the separation of an item of mass should not leave any sharp or injurious edges. Function of equipment or subsystems after the test is not required. Once it has been demonstrated that an item can be retained in its critical loading case, subsequent tests may be conducted with the item secured for test purposes.

5.3.5.2 The following additional items shall be considered in choosing test articles and the manner of loading:

a. If a multiple place seat incorporates energy absorbing or load limiting features that are necessary to meet the test criteria or other requirements, a partially occupied seat may adversely affect the performance of that seat. In such a case, it shall be shown, by rational analysis or additional testing, that the seat will continue to perform as intended even with fewer occupants.

b. If different configurations of the same basic design incorporate load-carrying members, especially joints or fasteners, which differ in detail design, the performance of each detail design shall be demonstrated in a dynamic test. Experience has shown that small details in the design often cause problems in meeting the test performance criteria.

c. Additional dynamic impact testing may be required for a seat with features that could affect its performance even though the test may not be the most critical case based on structural performance; e.g., if in one of the design configurations the restraint system attachment points are located so that the pelvic restraint is more likely to slip above the ATD's pelvis during the impact, that configuration shall also be dynamically tested even though the structural loading might be less than the critical configuration in a family of seats.

d. Typical dress cover materials, including synthetic and natural fabrics, and leather, can be used on a seat without testing more than one material, or substituted on an already certificated seat. Evaluation of such materials has shown that their effect on test results is small, particularly considering other factors such as occupant clothing. Unusual seat surfaces, such as hard plastics that exhibit very low friction coefficients, may require some additional substantiation.

5.3.5.3 For structural dynamic testing, each literature pocket shall include a minimum of 3 pounds (1.36 kg) ballast and may be taped closed. When following the guidance for HIC testing contained in FAA AC25.562-1b, Appendix 4, literature pocket ballast is not required for either row.

Retention of literature pocket contents does not need to be demonstrated.

5.3.6 Selection of Test Conditions

The tests shall evaluate all critical conditions.

5.3.6.1 For multiple place seats, a rational structural analysis shall be used to determine the number and seat location for the ATDs and the direction for seat yaw in Test 2 to provide the most critical seat structural test. This will usually result in unequally loaded seat legs. The floor deformation procedure shall be selected to increase the load on the highest loaded seat leg and to load the floor track or fitting in the most severe manner. Section 5.3.3.5(b) provides a procedure for use with seats having more than two pairs of legs.

5.3.6.1.1 For Test 2 structural conditions, the occupancy that produced the highest calculated seat leg resultant tension reaction in the aft fitting is used for the test, unless the load of the fully occupied seat is within 10% of the highest seat leg load. In such cases, test the fully occupied seat.

5.3.6.1.2 For Test 1 conditions, full occupancy shall be used for the test. This is to ensure that the maximum compressive load is put on the structure.

5.3.6.2 If multiple row testing is used to gather data to assess head injury protection in passenger seats, the seat pitch shall be selected so that the head would be most likely to contact a hard structure in the forward seat row. The effect of the 10 degree yaw in Test 2, the seat back break over, and front seat occupancy shall be considered. Results from previous tests or rational analysis may be used to estimate the head strike path of similar seats in similar installations. The front row may be unoccupied. This test methodology may also be used to assess femur injury protection.

5.3.6.3 If a nonsymmetrical upper torso restraint system (such as a single diagonal shoulder belt) is used in a seat system, including restraint systems not attached to the seat, it shall be installed on the test fixture in a position representative of that in the aircraft. For a forward-facing seat equipped with a single diagonal shoulder belt, the Test 2 yaw direction should be selected such that:

a. The greatest possible load is introduced into the seat structure.

b. The greatest likelihood of the upper torso restraint moving off the occupant's shoulder occurs. This condition may be met by running Test 2 with a yaw that positions the shoulder restraint over the trailing shoulder, or by presenting a rational analysis based on test data from a similar seat.

5.3.6.4 All adjustable seat positions and facing directions that can be used during taxi, takeoff and landing shall be considered when selecting the critical tests for evaluating the seat structure, occupant injury and occupant egress. The taxi, takeoff and landing positions that were considered and tested shall be recorded and reported.

Seat adjustments that do not have a significant effect on structural loading (e.g., thigh support angle, lumbar support, armrest, and headrest positions) shall be tested in the design positions for the 50th percentile male occupant, unless special requirements dictate the positions allowed for takeoff and landing.

Height adjustment should be relative to the interior envelope as it relates to the upper contour (ceiling) of the aircraft whenever a specific seat design is approved in a particular aircraft. Therefore, the seat need not be raised to a position that causes a 50th percentile male occupant to extend outside the confines of the aircraft interior.

5.3.6.5 Floor deformation need not be considered in assessing the consequence of seat deformation relative to the possible impairment of rapid evacuation of the aircraft. After a test, the pitch and roll floor beams may be returned to their neutral positions and the necessary measurements made to determine possible impairment of the evacuation process.

5.3.6.6 In some cases, it may not be possible to measure data for head impact injury during the basic test of the seat and restraint system. The design of the surrounding interior may not be known to the designer of the seat system, or the system may be used in several applications with different interior configurations. In such cases, the head strike path and the head velocity along the path shall be documented. This will require careful placement of photo instrumentation cameras and location of targets on the ATD representing the ATD's head center of mass so that the necessary data can be obtained. The test set-up requirements, general analysis procedures and test report documentation should follow those given in ARP5482. These data can be used by the interior designer to ensure either that head impact with the interior will not take place or that potential head strike surfaces can be evaluated using HIC measurements in subsequent subsystem tests.

5.3.6.7 Test 2 (Figures 6, 7A, and 7B) conducted solely to collect head/knee path data should be conducted with 0 degree yaw and without floor deformation. The test must be conducted on the seat with the greatest overhang among the seats selected for the applicable forward longitudinal dynamic structural test. It is acceptable to use the opposite-hand part for this seat. The occupancy used in the applicable forward longitudinal dynamic structural test must be used for this test. For consistency, a floor should be used for tests used to gather head path data. It is acceptable to collect ATD head path data in the applicable forward longitudinal dynamic structural test.

5.3.6.8 For Type A-T passenger seats, selection of tests to evaluate injury potential shall consider the range of occupant sizes from 5th percentile female to 95th percentile male.

5.3.7 Installation of Instrumentation

Professional practice shall be followed when installing instrumentation. Care shall be taken when installing the transducers to prevent deformation of the transducer body which could cause errors in data. Transducer lead-wires shall be routed to avoid entanglement with the ATD or test article, and sufficient slack shall be provided to allow motion of the ATD or test article without breaking the lead-wires or disconnecting the transducer. Cables and wires shall be sufficiently secured to inhibit the introduction of cable whip errors. Calibration procedures shall consider the effect of long transducer lead-wires. When needed, head accelerometers and femur load cells shall be installed in the ATD in accordance with the ATD specification and the instructions of the transducer manufacturer. The load cell between the pelvis and the lumbar column shall be installed in a manner that will provide equivalent data (5.3.2.1).

5.3.7.1 If an upper torso restraint is used, the tension load shall be measured in a segment of webbing between the ATD shoulders and the first contact of the webbing with hard structure (the anchor point or a webbing guide). Restraint webbing shall not be cut to insert a load cell in series with the webbing, since that will change the characteristics of the restraint system. Load cells that can be placed over the webbing without cutting are commercially available. They shall be placed on free webbing to minimize contact with hard structure, seat upholstery, or the ATD during the test. They shall not be used on double-reeved webbing, multiple-layered webbing, locally stitched webbing, or folded webbing unless it can be demonstrated that these conditions do not cause errors in the data. These load cells shall be calibrated using a length of webbing of the type used in the restraint system. If the placement of the load cell on the webbing causes the restraint system to sag, the weight of the load cell can be supported by light string or tape that will break away during the test. If a shoulder belt incorporating an airbag is used, care shall be taken when placing the webbing load cell to ensure that an accurate measurement is made and that the load cell does not affect the performance of the airbag.

5.3.7.2 Since load cells are sensitive to the inertial forces of their own internal mass, to the mass of fixtures located between them and the test article, as well as to forces applied by the test article, it may be necessary to compensate the test data for that inaccuracy if the error is significant. Also, if the load cell cannot be placed between the ATD shoulder and first contact with hard structure (web guide) the friction between the web and guide may introduce significant error. Data for such compensation will usually be obtained from an additional dynamic test that replicates the load cell installation but does not include the test article.

5.3.8 Procedure to Set-Up the Test

Preparation for the tests will involve positioning and securing the ATD, the ATD restraint system, the seat, and the instrumentation. This will be done for the specific critical condition being tested. Preparations that pertain to the normal operation of the test facility, such as safety provisions and the actual procedures for accomplishment of the tests, are specific to the test facility and will not be addressed in this document.

5.3.8.1 The test fixture shall be oriented as required for the given test conditions.

5.3.8.2 Each seat shall be installed in the test fixture and secured in a manner representative of its intended use.

5.3.8.3 Each ATD shall be placed in the seat in a uniform manner to enhance reproducible results. The following suggested procedures have been found to be adequate by previous experience.

a. Prior to seating the ATD, all seat adjustments and controls to the extent that they influence the injury criteria, shall be set as indicated in 5.3.6.4. Otherwise, seat adjustments and controls should be in the design position intended for the 50th percentile male occupant. For seats intended for flight crew, the seat should be set to the design eye point and the controls adjusted appropriately for the ATD position. If seat restraint systems are being tested that are to be used in applications where special requirements dictate their position for landing or takeoff, those positions should be used in the tests.

b. The friction in each limb joint shall be set so that it barely restrains the weight of the limb when extended horizontally.

c. When seating the ATD for horizontal tests or determining the nominal position for 60 degree tests, lower the ATD vertically into the seat while simultaneously (see Figure 10):

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

   2. Applying a horizontal X-direction (in the ATD coordinate system) force of approximately 20 pounds (89 N) to the torso at the intersection of the midsagittal plane and the lower sternum of the Hybrid-II or FAA Hybrid-III, to compress the seat back cushion.

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

d. Once all lifting devices have been removed from the ATD, it should be rocked slightly to settle it in the seat.

e. The ATD's knees should be separated approximately 4 inches (100 mm).

f. The forward-aftward position of the Hybrid II ATD and FAA Hybrid III ATD hands will vary depending on the taxi, take-off, and landing position of the seat back. The placement of the ATD hands should not change the seated position of the ATD accomplished in 5.3.8.3c and 5.3.8.3d. The Hybrid II ATD hands and the FAA Hybrid III ATD hands should be positioned as follows:

   1. For Test 1, the Hybrid II ATD and the FAA Hybrid III ATD hands should be placed on top of the upper legs. The hands should be as far forward on the legs as possible with the elbows slightly bent (see Figures 11 and 12). The hands may be moved inward toward the center of the ATD to prevent the elbows from contacting the armrest (see Figure 13).

   2. For Test 2, the Hybrid II ATD and the FAA Hybrid III ATD hands should be placed on the side of the thigh with the thumb on a forward-aftward line that passes through the upper leg-to-lower leg attachment bolt with the elbows bent (see Figures 14). The hands may be moved inward toward the top of the leg to prevent interaction with the ATD itself or the cabin interior that results in an invalid or null test (see Figure 15). The forward-aftward position of the hands must not cause the arms to dig into the legs during the test and not flail.

   3. If tests on crew seats are conducted in a mockup that has aircraft controls, Hybrid II ATD or FAA Hybrid III ATD hands should be lightly tied to the controls.

g. The feet shall be in the appropriate position for the type and usage of a seat being tested (flat on the floor, on control pedals or on an approximate 45 degree angled footrest for flight crew systems). The feet shall be placed so that the centerlines of the lower legs are approximately parallel, unless the need for placing the feet on aircraft controls dictates otherwise.

h. If the system is tested in other than a “horizontal floor” orientation, it is recommended that the ATD be placed such that the hip joints are in nominally the same position relative to the seat as when seated with a 1 g pre-load as shown in Figure 16. Achieving this position may require the lap belt be very tight and insertion of a shim behind the ATD’s back and pelvis.

i. Auxiliary restraints may be required to ensure that each ATD will be in its proper position prior to the impact. The auxiliary restraint(s) must not interfere with the results of the test.

j. If application of floor deformation causes the ATD to move out of its nominal position with respect to its seat place, prior to conducting the test it shall be returned to that approximate nominal position.

k. If the movement of the ATD out of position or the act of returning the ATD to its nominal position causes an upper torso belt to become slack or fall off an ATD shoulder, then the upper torso belt may be replaced and/or readjusted in accordance with 5.3.8.5 prior to test.

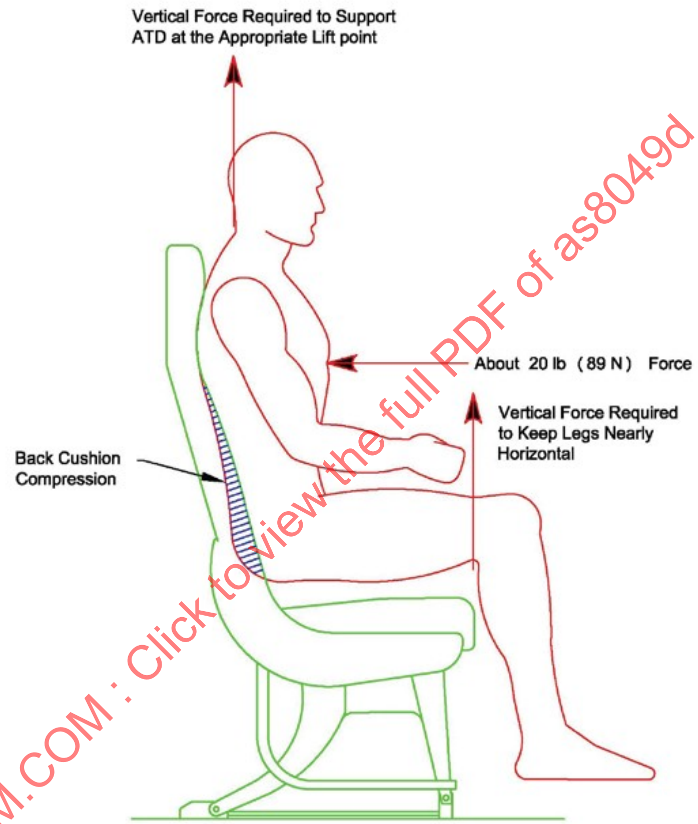


Figure 10 - ATD placement

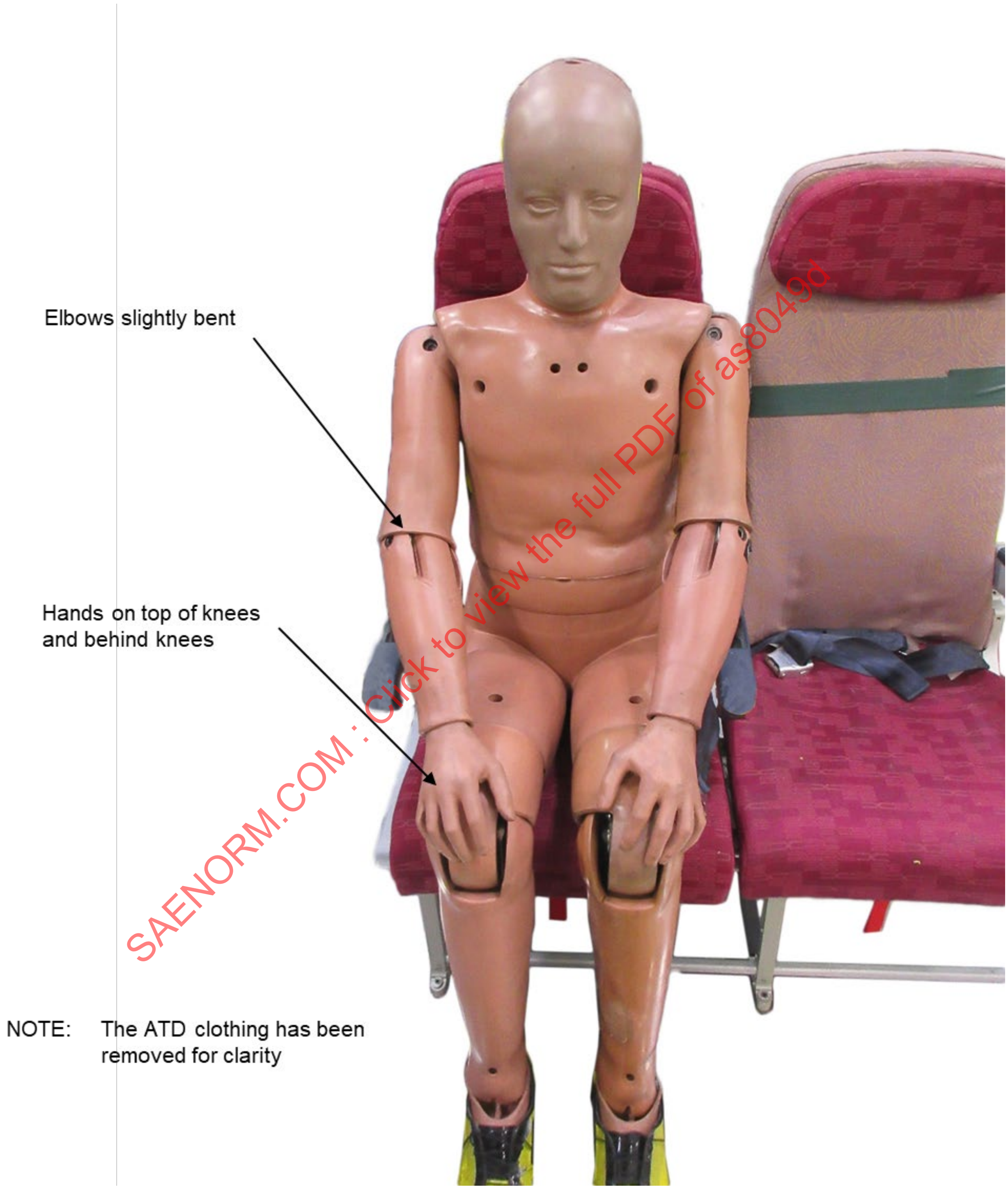


Figure 11 - Test 1 ATD hand placement - acceptable

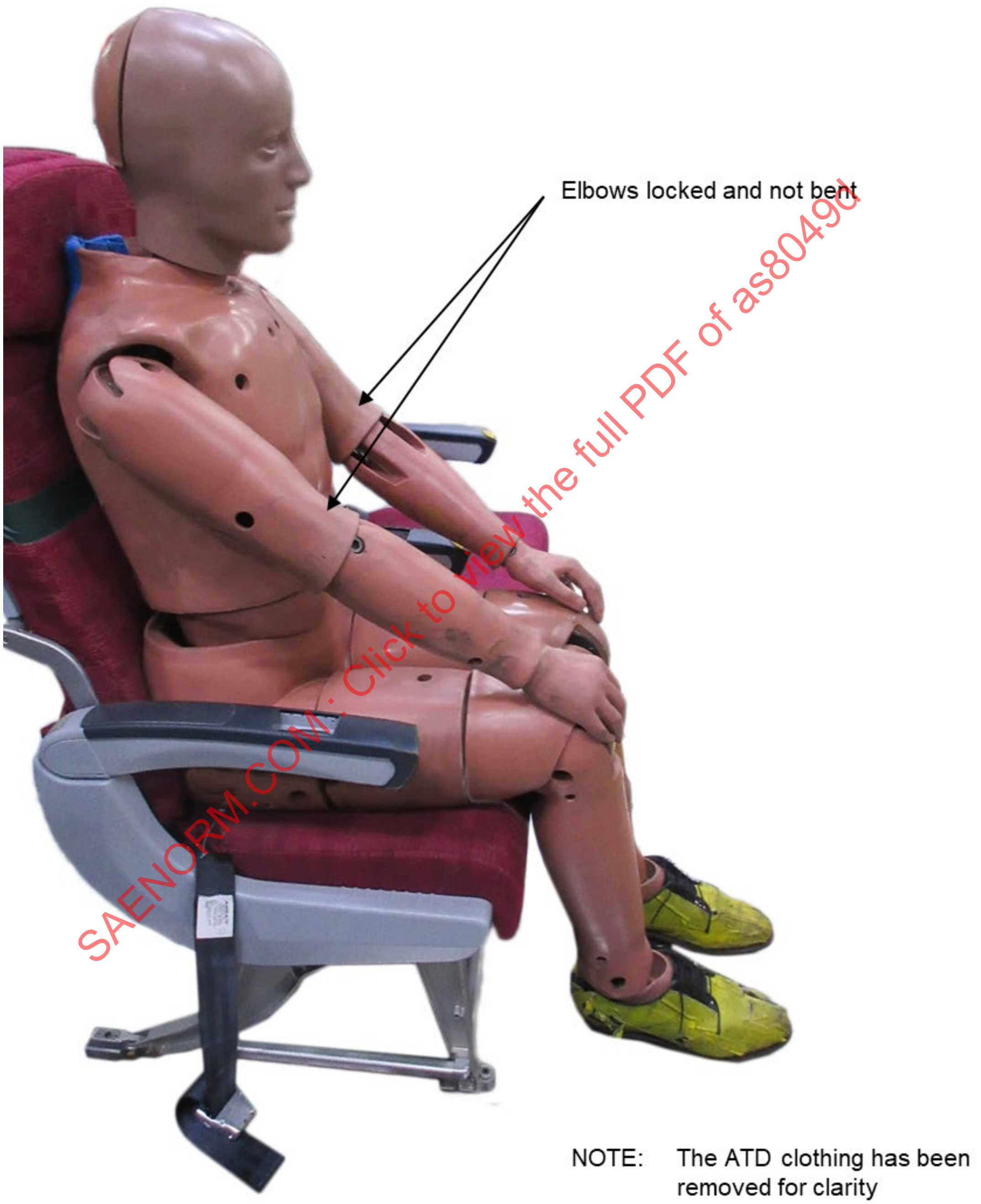


Figure 12 - Test 1 ATD hand placement - unacceptable

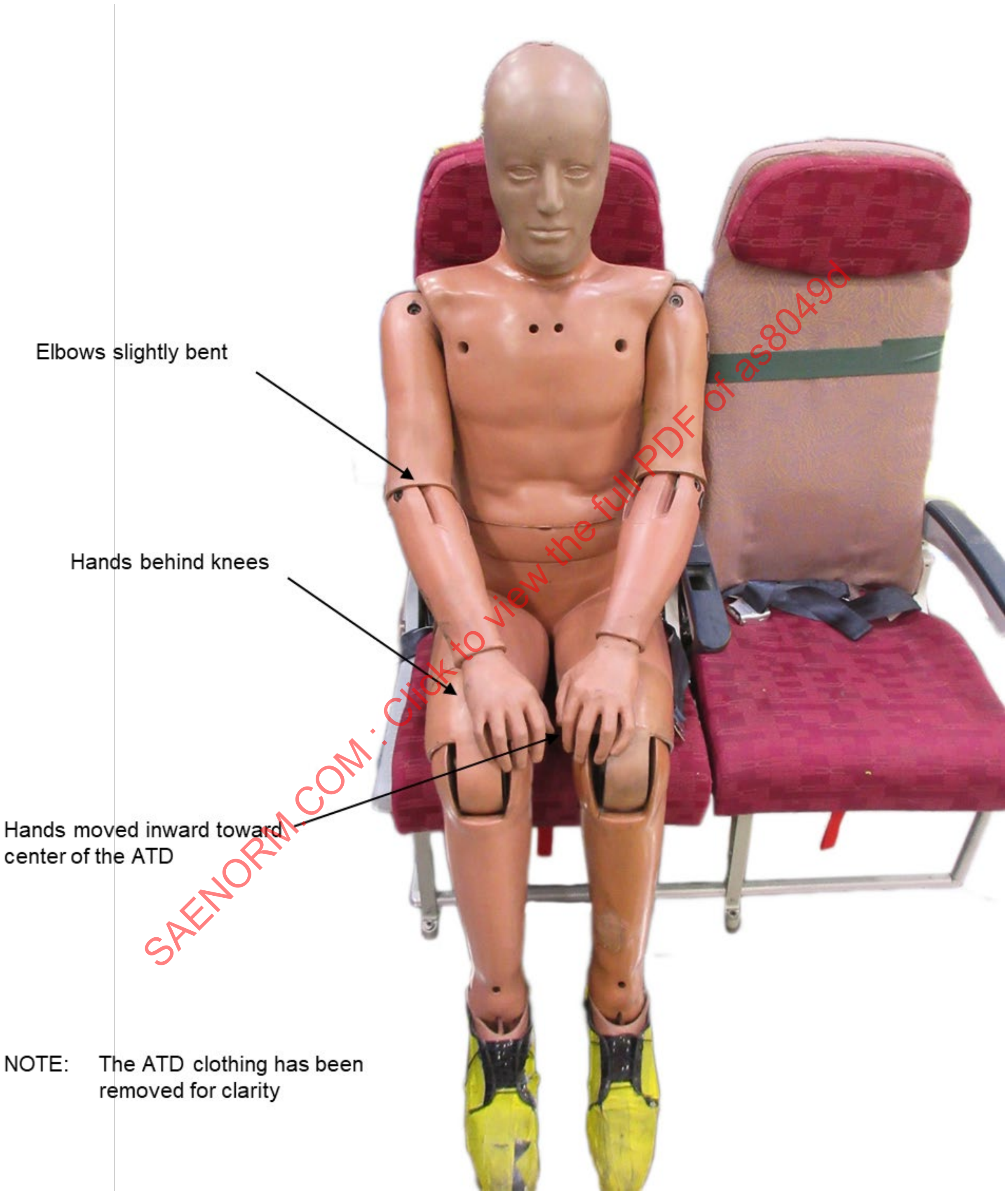


Figure 13 - Test 1 ATD hand placement - acceptable

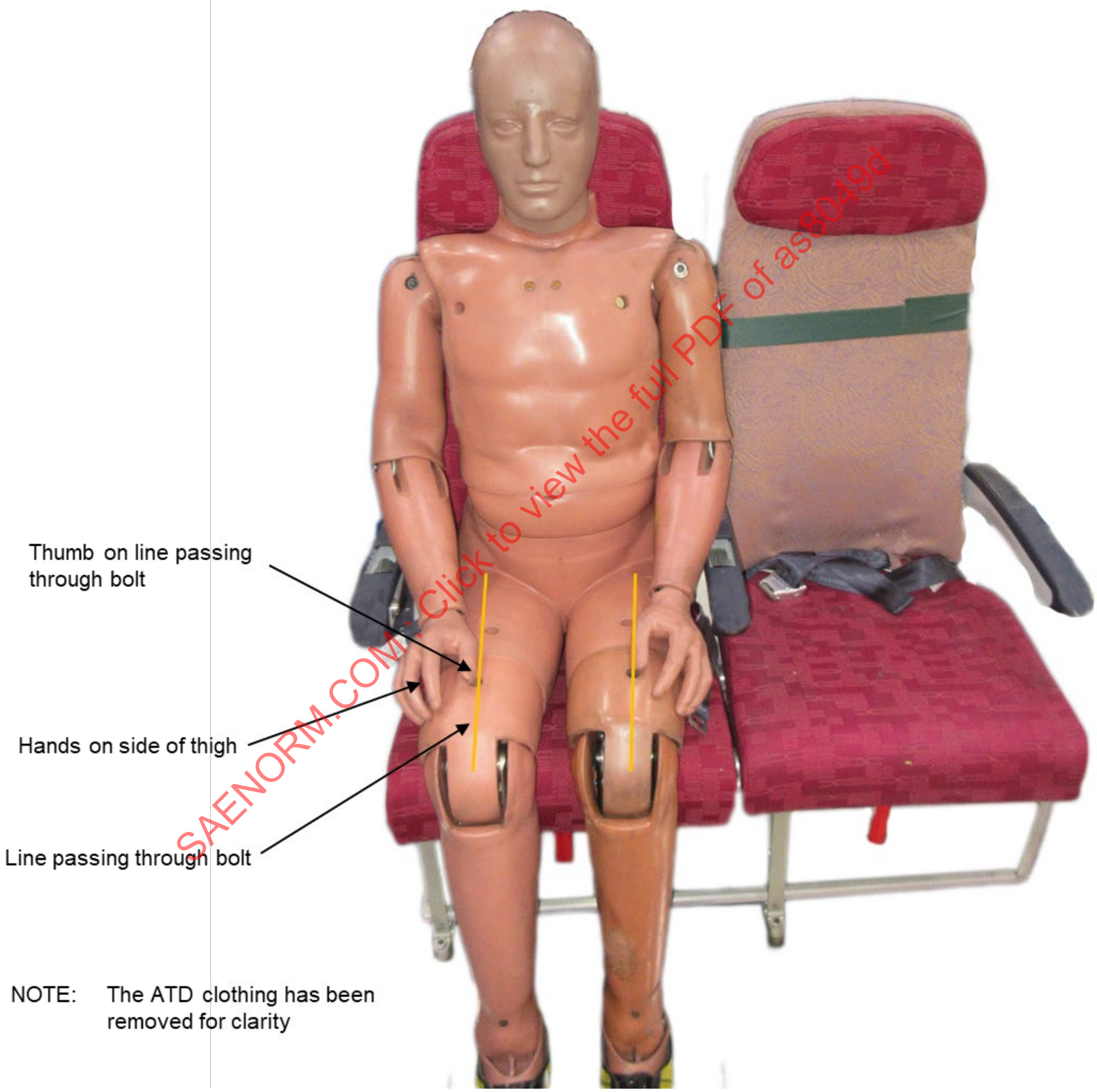


Figure 14 - Test 2 ATD hand placement - acceptable

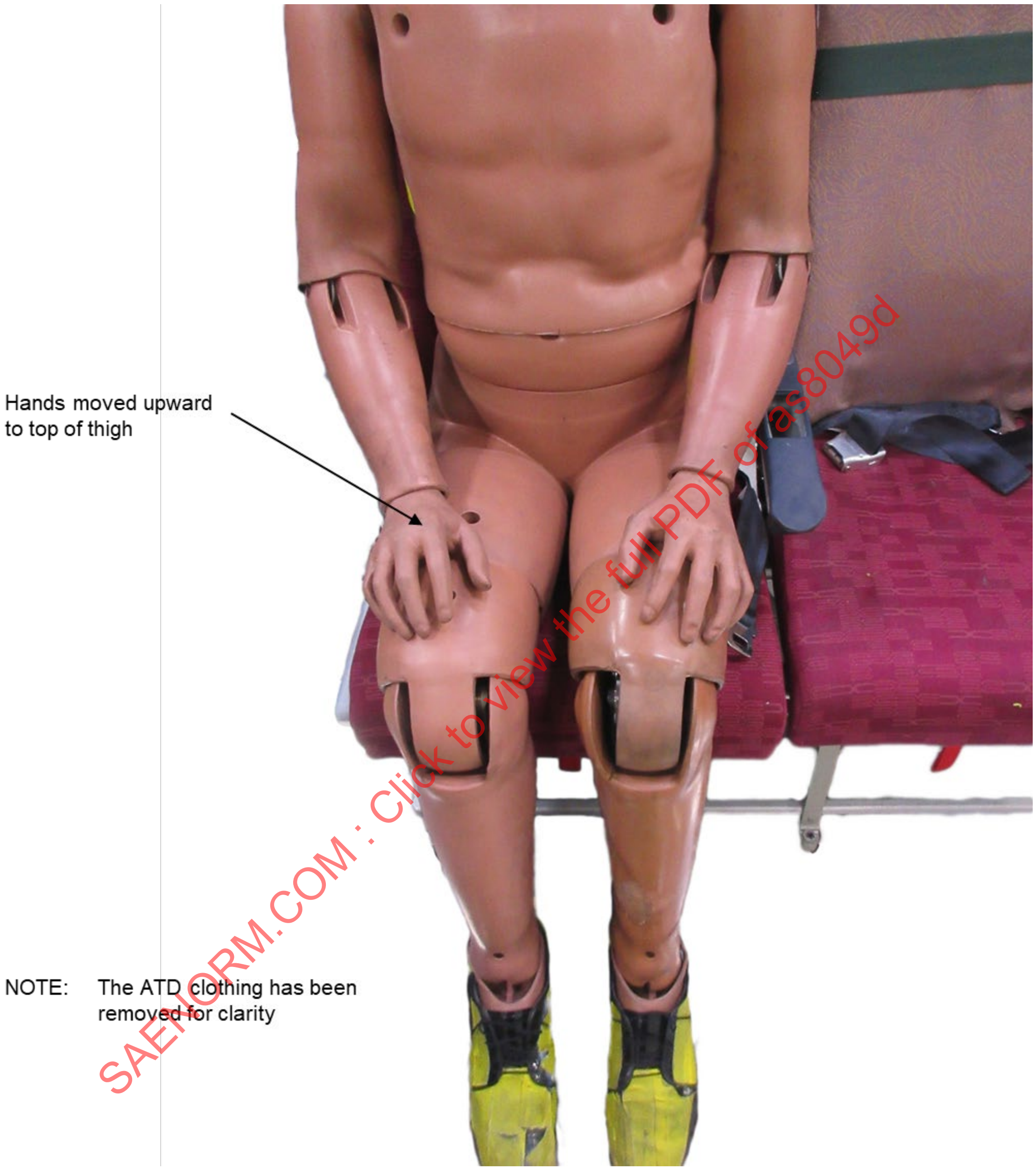


Figure 15 - Test 2 ATD hand placement - acceptable