SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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AEROSPACE STANDARD

SAE AS8049

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Submitted for recognition as an American National Standard

PERFORMANCE STANDARD FOR SEATS IN CIVIL ROTORCRAFT AND TRANSPORT AIRPLANES

1. SCOPE:

1.1 This Aerospace Standard (AS) defines minimum performance standards, qualification requirements, and minimum documentation requirements for passenger and crew seats in civil rotorcraft and transport airplanes. 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 the applicable Federal Aviation Regulations (FAR) Part 25, 27, or 29.

This AS also provides guidance for design by enumerating certain design goals to enhance comfort, serviceability, and safety. Guidance for test procedures, measurements, equipment, and interpretation of results is presented to promote uniform techniques and to achieve acceptable data.

While this AS 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 AS. The installation applicant has the ultimate system responsibility in assuring that all requirements for safe seat installation have been met.

1.2 Applicability: This AS addresses the performance criteria for seat systems requiring dynamic testing to be used in civil rotorcraft and transport airplanes. These criteria do not apply to seats certified solely on the basis of static test or analysis.

1.3 Types: This AS covers all passenger and crew seats for use in aircraft type-certificated in the following categories:

SEAT TYPE	AIRCRAFT CATEGORY	APPLICABLE FAR
A	Transport Airplane	Part 25
B	Normal Rotorcraft	Part 27
B	Transport Rotorcraft	Part 29

2. REFERENCE PUBLICATIONS:

2.1 Society of Automotive Engineers (SAE):

2.1.1 SAE J211 Instrumentation for Impact Tests

2.2 Federal Aviation Regulations:

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

2.2.2 Code of Federal Regulations, Title 14 Part 25 Airworthiness Standards: Transport Category Airplanes

2.2.3 Code of Federal Regulations, Title 14 Part 27 Airworthiness Standards: Normal Category Rotorcraft

2.2.4 Code of Federal Regulations, Title 14 Part 29 Airworthiness Standards: Transport Category Rotorcraft

2.2.5 Code of Federal Regulations, Title 49 Part 572 Anthropomorphic Test Dummies

2.3 Order of Precedence: In the event of a conflict between the text of this AS and the references cited herein, the text of this AS shall take precedence. Nothing in this AS, however, shall supersede applicable laws and regulations.

3. GENERAL DESIGN:

3.1 Guidance: Section 3.1 provides the designer with information, which, experience has shown, enhances comfort, serviceability, and safety. Satisfactory designs may include features that differ from this guidance material.

3.1.1 Attention should be given to ergonomic, utility, and comfort aspects of seats commensurate with the intended use and duration of flight.

3.1.2 Comfortable support and protective retention of the occupant under all conditions throughout the aircraft performance envelope, including movement on the surface, takeoff, landing, and emergency flight maneuvers should be provided.

3.1.3 Crew seats and restraints should accommodate adult occupants encompassing the 1.57 m (5 ft 2 in) female to the 1.9 m (6 ft 3 in) male occupant.

3.1.4 Passenger seats and restraints should accommodate occupants encompassing the 2-year old child to the 99th-percentile male occupant. The restraint attachments and lengths should be adjustable to function properly in safely retaining this range of occupants.

3.1.5 The seat system should be designed to absorb energy where practical. Brittle failure should be avoided. Failures of joints and attachments should not occur first in the primary load path of the structure.

3.1.6 If the seat design incorporates energy absorbing features through deformation or stroking, shields or other means should be provided in the seat design to maintain clearances for the deformation or stroking.

3.1.7 The seat design should include provisions to minimize static electricity buildup.

3.1.8 Safety devices should be accessible without release of occupant restraints.

3.1.9 Crew restraint systems, while fastened, should neither significantly impede access to controls nor prevent crews from performing their duties.

3.1.10 The seat system should be designed so that the primary structural elements can be readily inspected to detect wear, deterioration or any other condition that would degrade safety.

3.1.11 Restraint system anchorages should provide self-aligning features. If self-aligning features are not provided, the static and dynamic tests in this AS should be conducted with the restraints and anchorages positioned in the most adverse configuration allowed by the design. The anchorage system should minimize the possibility of incorrect installation or inadvertent disconnection of the restraints.

3.1.12 All members of the primary structure should be protected to minimize deterioration from environmental factors. Members should be protected or designed to accommodate deterioration without compromise of safety or function. The design must address loss of strength caused by vibration, humidity, dissimilar metals, in-service impact damage, and other expected conditions, including spillage, exposure to cleaning agents, or dirt.

3.1.13 Materials should be selected that minimize smoke and toxic gas emissions in the presence of fire.

3.1.14 On seats which use studs or other fittings for attachment of the seat to seat tracks or fittings, anti-rattle designs or devices should be considered to reduce wear on the seat tracks or fittings.

3.1.15 All exposed portions of the seat should be free from projections and sharp edges that could catch or damage the occupant's clothing or cause injury.

3.1.16 Electrical or electronic devices incorporated in a seat should be provided with appropriate shielding and provisions to minimize electromagnetic interference.

3.2 Requirements: This section provides additional requirements for a seat and restraint system design which are not described elsewhere in this AS.

3.2.1 Seats shall be designed to provide impact protection for the occupant. This protection shall be provided at all seat positions that are allowed to be occupied during takeoff and landing. Demonstration of impact protection shall be either by test or by analysis based on test of a similar type seat.

3.2.2 Seat elements shall be designed so that, when evaluated under the test conditions of this AS, they do not leave hazardous projections that could significantly contribute to occupant injury or 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 verified, and incorrect installation or inadvertent activation is unlikely.

3.2.4 Magnesium alloys shall not be used.

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 be designed so that they can be returned by the occupant to the positions required for takeoff and landing without release of occupant restraints. In addition, these items shall not deploy under the test conditions of this AS in a manner that could significantly contribute to serious occupant injury or impede rapid egress of any aircraft occupant.

3.2.7 When an underseat baggage restraint is incorporated in a seat, it shall be designed to restrain at least 90 N (20 lb) of stowed items per passenger place under the test conditions of this AS in a manner that will not significantly impede rapid egress from the seat.

3.2.8 The cushions and restraint system shall minimize submarining of the occupant or slippage of the restraint when evaluated under the dynamic test conditions of this AS.

3.2.9 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.

3.2.10 Rearward facing seats shall be designed with a back height sufficient to provide 930 mm (36.5 in) of support for the occupant as measured from the seat reference point (SRP) to the top of the seat back. If a separate headrest is provided, a maximum gap of 100 mm (4 in) can exist between the bottom of the headrest and the top of the seat back, provided that the height of the headrest is sufficient to provide hard support for the intended range of occupant size. (See Figures 1A, 1B, and 1C for the definition, determination, and use of SRP.)

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.).

3.3 <u>Materials and Workmanship Requirements</u>:

3.3.1 Materials shall be of a quality that experience or tests have demonstrated to be suitable for use in aircraft seats.

3.3.2 Workmanship shall be consistent with high-grade aircraft manufacturing practice.

3.4 <u>Fire Protection Requirements</u>:

3.4.1 The cushion system, covering and upholstery and all other exposed material used in the seat shall have self-extinguishing properties as specified in the applicable FAR.

3.4.2 Where required by the FAR, cushion systems shall be tested and shall meet the fire protection provisions of Appendix F, Part II of FAR Part 25 or shall be demonstrated by analysis (similarity) to provide equivalent protection.

3.4.3 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.

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

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

3.4.6 If in-arm food trays are installed, the bottom of the cavity should be open to prevent accumulation of waste. If it is not possible to provide an opening, the cavity shall be sealed.

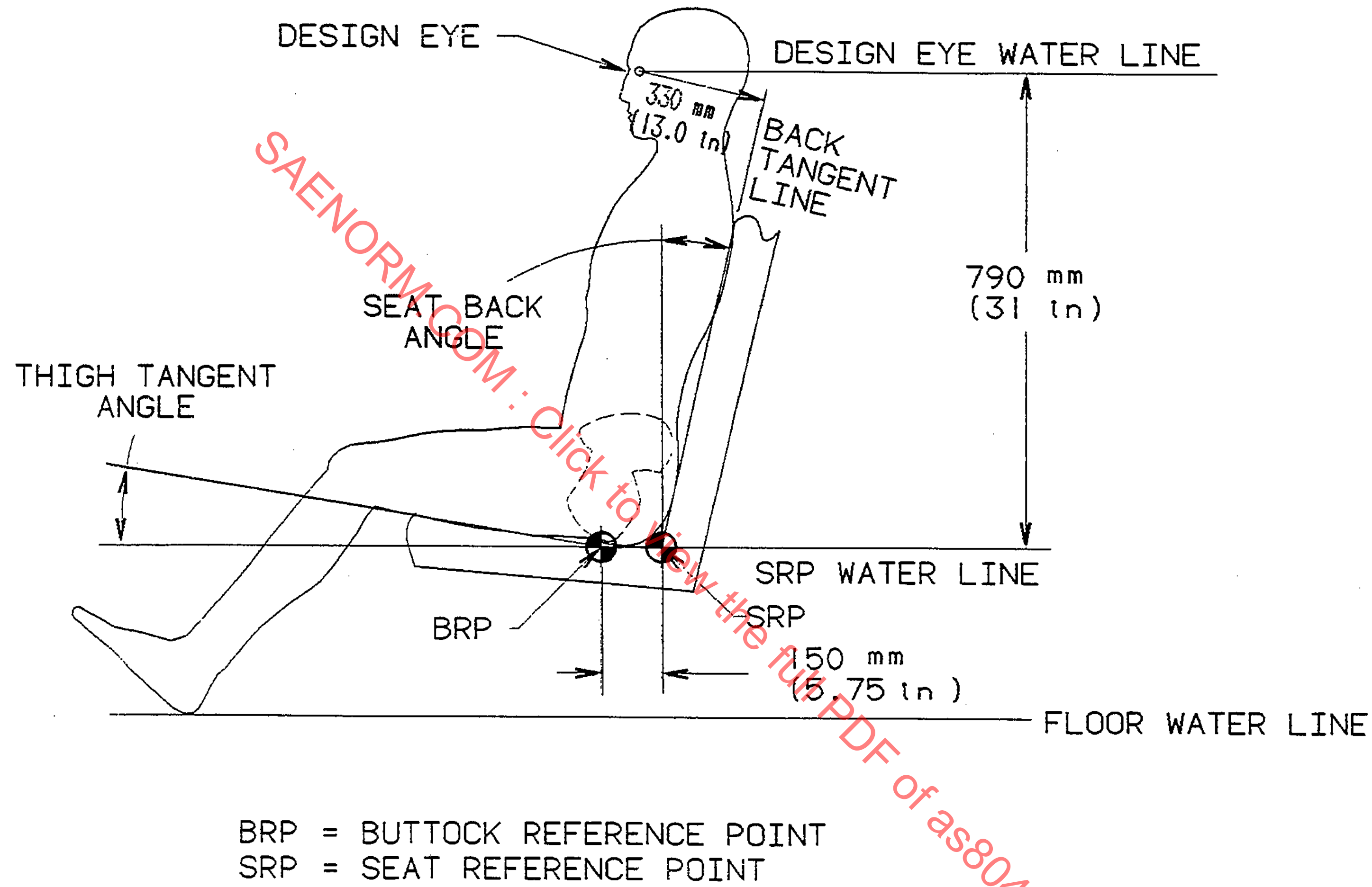


FIGURE 1A - Terminology and Dimensions for 50th Percentile Male

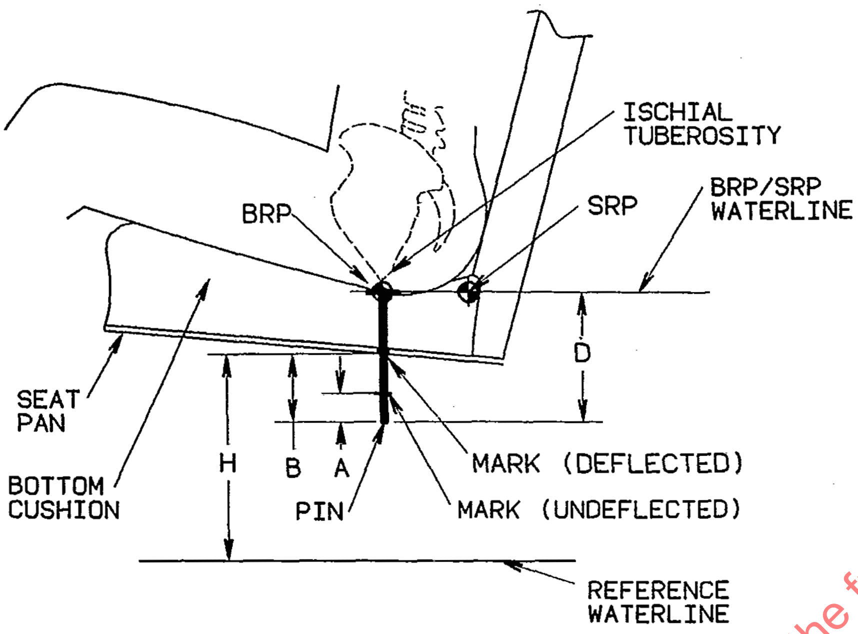


FIGURE 1B - Method for Establishing BRP/SRP

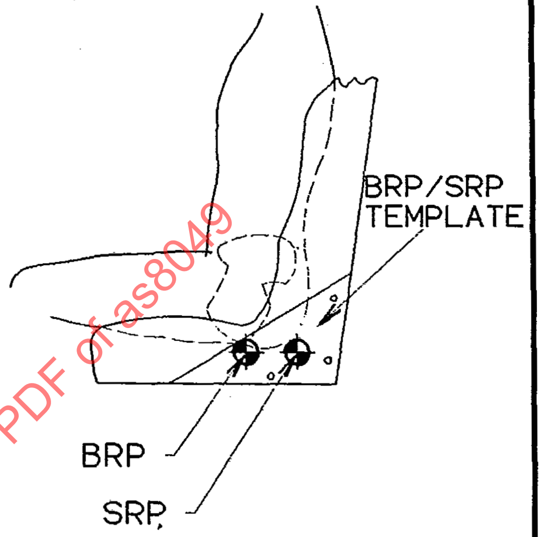


FIGURE 1C - BRP/SRP Template

PROCEDURE TO ESTABLISH BRP AND SRP:

1. PLACE A 75 TO 80 kg (160 TO 180 LB) SUBJECT OR DUMMY ON A SEAT (FIGURE 1B).
2. LOCATE AND MARK THE BUTTOCK PRESSURE POINTS ON THE CUSHION DUE TO THE ISCHIAL TUBEROSITIES.
3. DRILL A HOLE VERTICALLY AT THE MARK THRU THE CUSHION AND THE SEAT PAN AND INSERT A PIN OF LENGTH "D" (FIGURE 1B).
4. MARK THE PROTRUSION OF THE PIN WITH THE SEAT UNOCCUPIED ("A").
5. PLACE THE SUBJECT ON THE SEAT AND MEASURE HEIGHT "H" FROM A REFERENCE WATERLINE AND MEASURE PROTRUSION "B".
6. THIS ESTABLISHES THE BRP AND SRP WATERLINE: BRP/SRP WATERLINE = REFERENCE WATERLINE + H + D - B.
7. THE CUSHION DEFLECTION AT THE BRP IS B - A.
8. MEASURE 146mm (5.75 in) FROM THE BRP TOWARDS THE SEAT BACK ALONG THE BRP WATERLINE. THIS ESTABLISHES THE SRP.
9. IF DESIRED, A TEMPLATE MAY BE MADE WHICH MARKS THE POSITIONS OF THE BRP AND SRP ON A SEAT FOR CONVENIENT MEASUREMENTS AND OBSERVATION IN TESTING OR INSTALLATION (FIGURE 1C).

3.5 Allowable Permanent Deformations: Allowable permanent deformations sustained by a seat subjected to the ultimate static tests or dynamic impact tests of this AS are specified below. Permanent seat deformations shall be measured on the critically loaded seat after both static and dynamic tests. Significant measuring points 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. Measurement of the selected points shall be recorded before and after the tests. For dynamic tests, if floor deformations are applicable, consistency in pre- and post-test measurements shall be maintained. If the pre-test measurements are made before floor deformations are applied, the post-test measurements shall be made relative to the fixed points on the undeformed test fixture after the impact test. Conversely, if the pre-test measurements are made after floor deformations are applied, the post-test measurements shall be made before removal of floor deformations.

3.5.1 Longitudinal Direction: The longitudinal permanent deflection of a Type A seat model shall not exceed 75 mm (3.0 in) and a Type B seat model shall not exceed 100 mm (4.0 in). The measurement shall be made at the forward-most hard point(s) of the seat at a height up to and including the armrest.

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 entrapped by the deformation.

3.5.3 Seat Rotation: The seat bottom rotational permanent deformation shall not exceed 20 deg pitch down or 35 deg pitch up from the forward horizontal axis of the seat provided the deformation limits of 3.5.5 are not exceeded. This rotational deformation shall be measured between the fore and aft extremities of the seat pan at the centerline of each seat bottom (Figure 2A). Rotation of the seat pan shall not cause entrapment of the occupant.

3.5.4 Sideward Direction: The sideward permanent deformation, towards an aisle, of a seat shall not exceed 40 mm (1.5 in) at heights below 635 mm (25 in) above the floor, and shall not exceed 50 mm (2.0 in) at heights 635 mm (25 in) or more above the floor. Height above the floor is determined prior to imposing the floor deformation of 5.3.3.

3.5.5 Other Deformation Limits: The most forward surface of a seat back must not deform to a distance greater than one half the original distance to the forward-most hard structure on the seat (see Figure 2B). The post-test measurement may be made with the seat back returned to its pre-test upright or structurally deformed position using no more than the original seat back breakover forces.

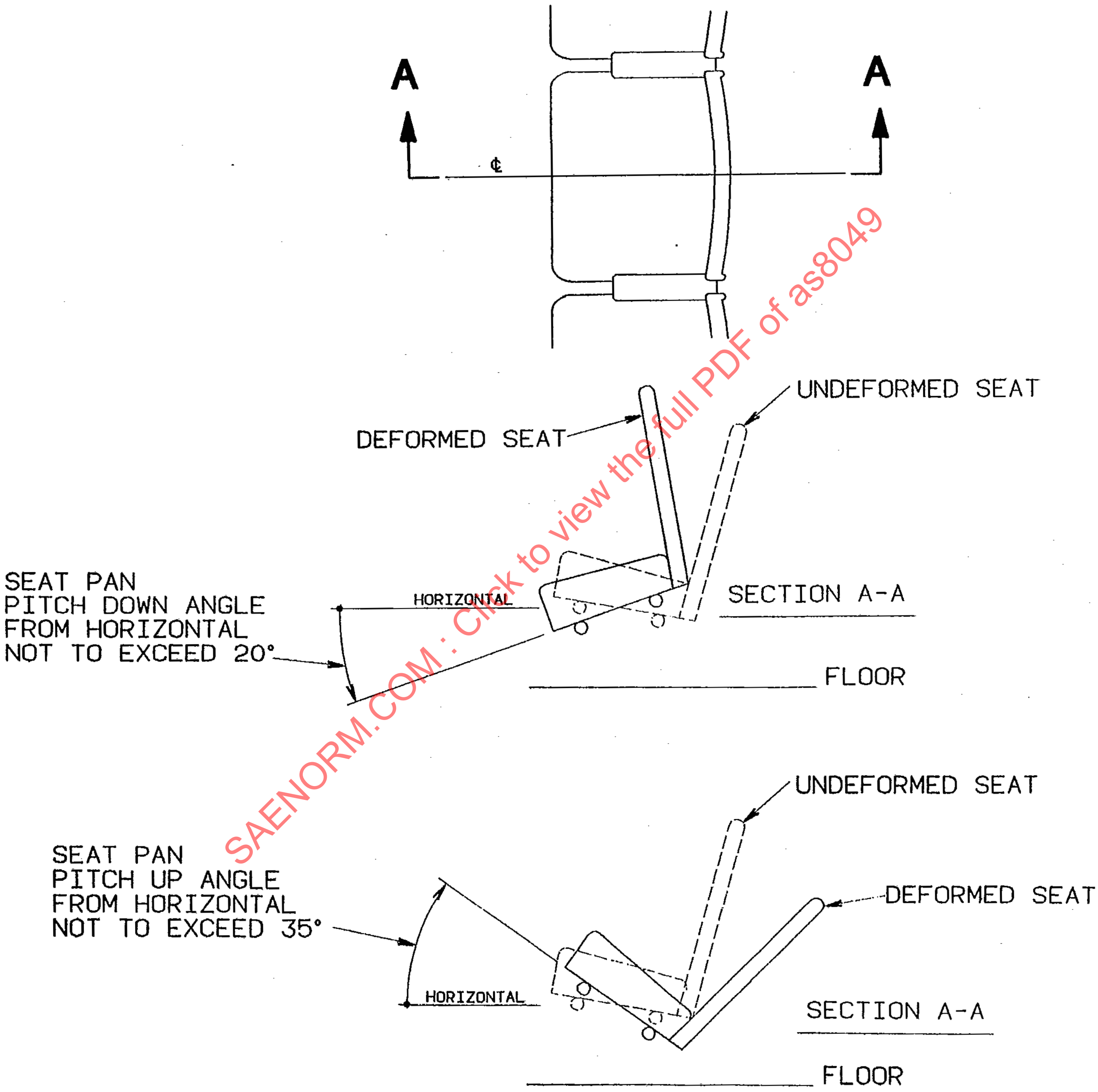
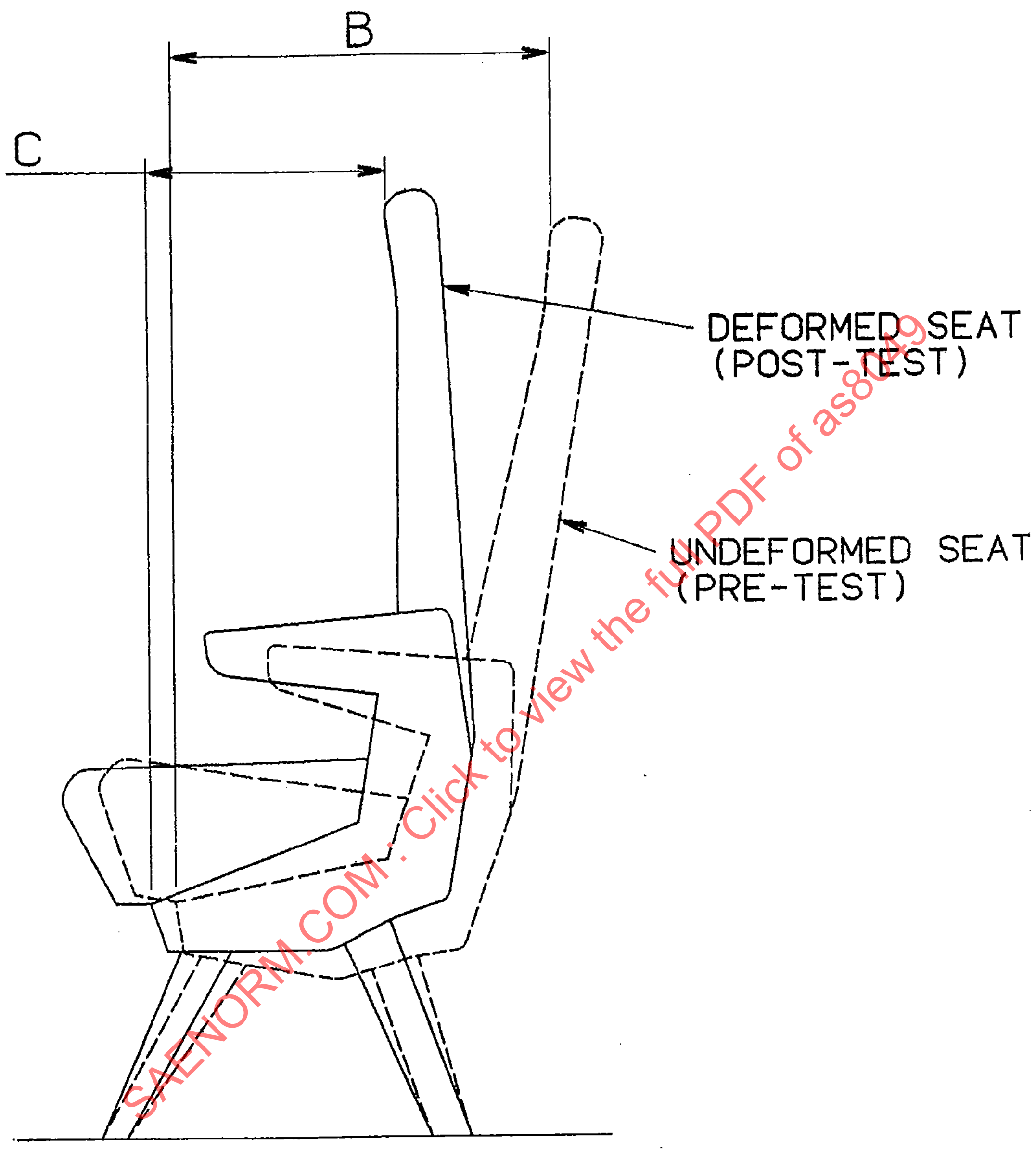


FIGURE 2A - Maximum Posttest Seat Pan Rotation



DIMENSION "C" MUST BE
AT LEAST 50% OF DIMENSION "B"

FIGURE 2B - Maximum Seat Back Permanent Deformation

3.5.6 Stowable Seats: A stowable seat (manual or automatic) must stow post-test and remain stowed without interfering with the exit. The permanent deformation shall not exceed 40 mm (1.5 in) from the pre-test upright position. A post-test stowage force not to exceed 45 N (10 lb) may be used to stow the seat prior to measurement of permanent deformation.

4. STRENGTH:

All seats qualified for occupancy during 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 and demonstrated by test or appropriate analysis that they will withstand, without primary load path failure or deformations exceeding the allowable permanent deformations defined in 3.5, the ultimate load factors specified in Table 1. Forces representing the sum of each occupant weight of 750 N (170 lb), plus the complete seat weight which includes all trim and accessories, plus the total weight of any item of mass (e.g., underseat baggage, stowage compartment weight plus weight of contents, etc.) restrained by the seat, all multiplied by the appropriate load factor from Table 1, shall be applied to the seat. 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 adjustments which produce critical loading of any structural member.

TABLE 1 - ULTIMATE LOAD FACTORS

Direction (Relative to Aircraft)	Type A Seat (Transport Airplane) Factor	Type B Seat (Rotorcraft) Factor
Forward	9.0	16.0
Sideward	4.0(1)(2)	8.0
Upward	3.0(2)	4.0
Downward	6.0(2)	20.0(3)
Rearward	1.5	

(1) Includes 1.33 fitting factor
(2) Increase these load factors as necessary for reduced weight gust/ flight loads or landing requirements.
(3) Load to be applied after stroking of the seat energy abosrbing system.

4.1.1 Pilot and Co-Pilot Loads: Pilot and co-pilot seats shall be designed to withstand the ultimate rearward load of 4.45 kN (1000 lb) applied 200 mm (8 in) above the SRP to provide for the application of pilot forces to the flight controls.

4.1.2 Limit Loads: The seat shall be capable of withstanding limit loads in the upward and downward directions, defined as 2/3 of the ultimate loads of Table 1 except that the downward limit load factor for Type B seats shall be the larger of 4 or the flight or landing limit load factor. Pilot seats shall also be capable of withstanding a 3 kN (670 lb) aftward limit load. These loads shall not cause any detrimental permanent deformation.

4.1.3 Attachments: The strength of the seat attachments to the aircraft structure and the pelvic restraint or upper torso restraint attachments to the seat or aircraft structure shall be 1.33 times the ultimate loads specified in Table 1 (except as noted for Type A seat sideward) or 4.1.1, as applicable.

4.1.4 Casting Factors: If castings are used in the construction of the seat, the castings shall have a factor of safety and related inspection requirements in accordance with the applicable portions of FAR Section 25.621, 27.621, or 29.621.

4.2 Dynamic Strength/Occupant Protection: The seat and occupant restraint, as a system, shall be designed and demonstrated by test or appropriate analysis based on test of a similar type system to withstand the dynamic impact conditions prescribed in 5.3 without primary load path failure, deformations that exceed the limitations specified in 3.5, or exceeding injury criteria of 5.4.

5. QUALIFICATION TESTS:

Initial qualification of a seat shall be performed by static and dynamic tests. Subsequent qualifications related to design changes to seats of a similar type may be performed by rational analysis based on existing qualification test 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 3, 4, 5A, and 5B 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 2).

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.

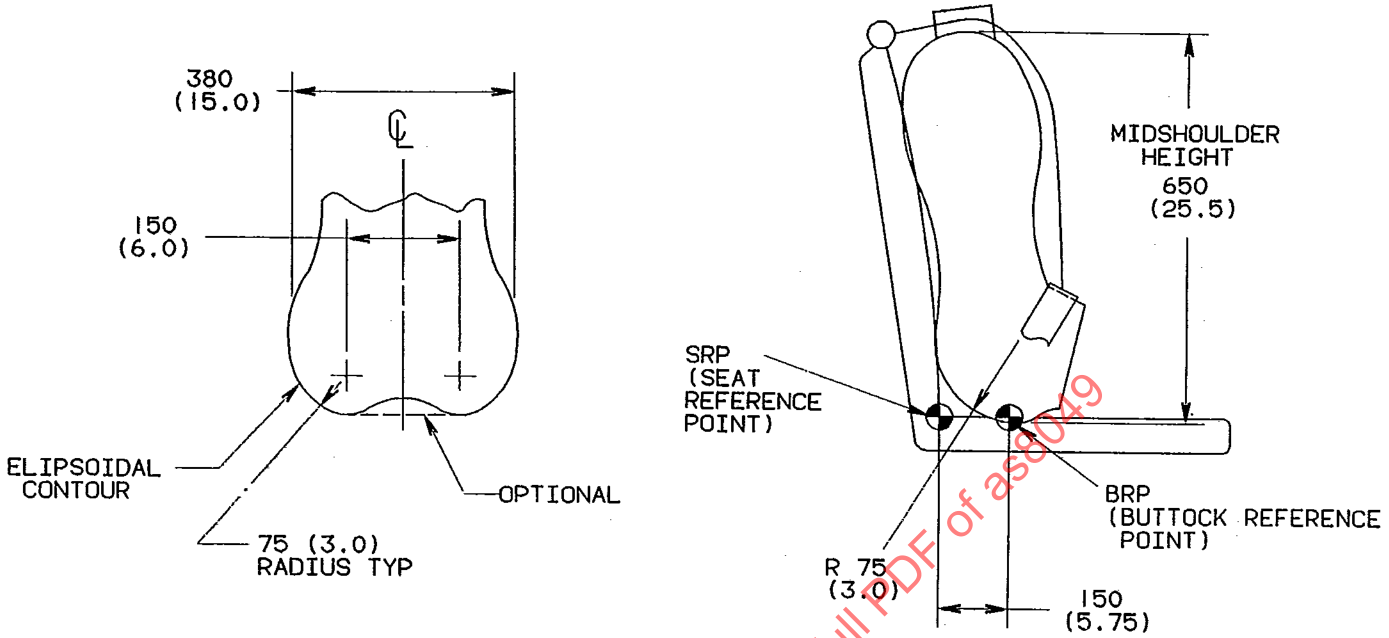
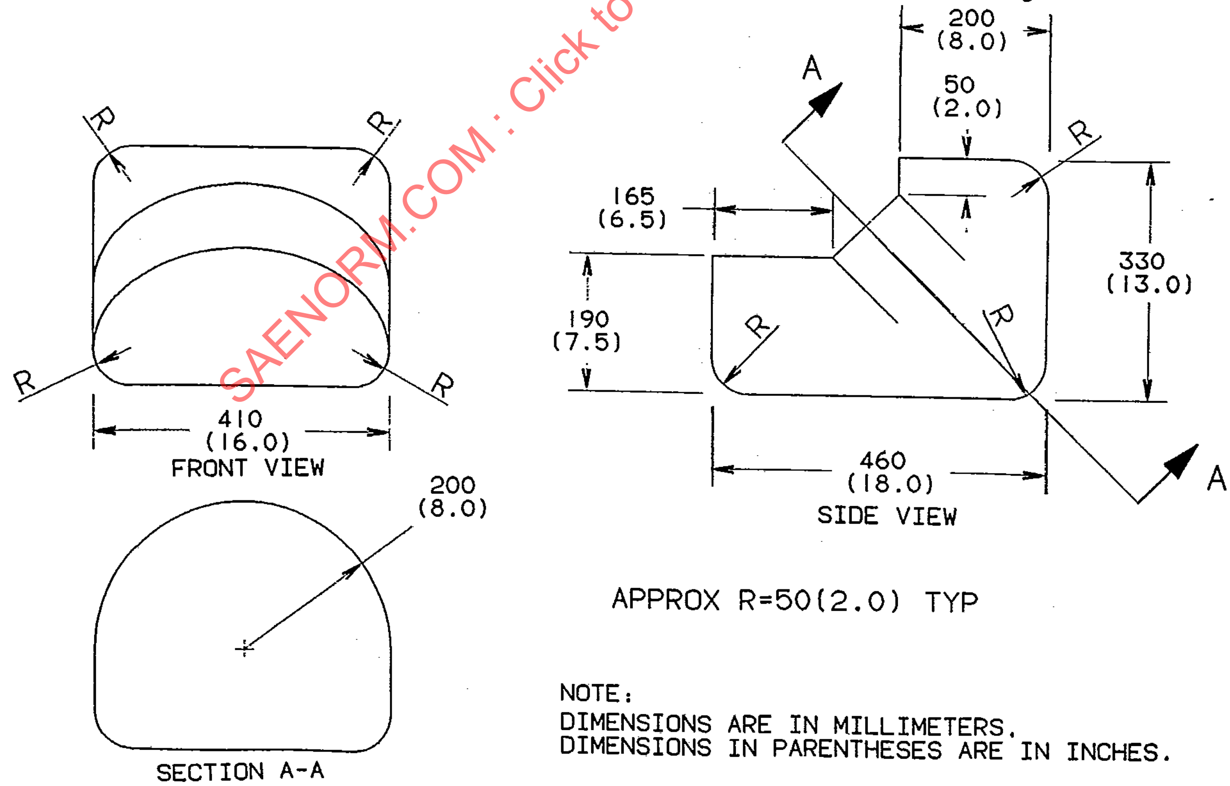
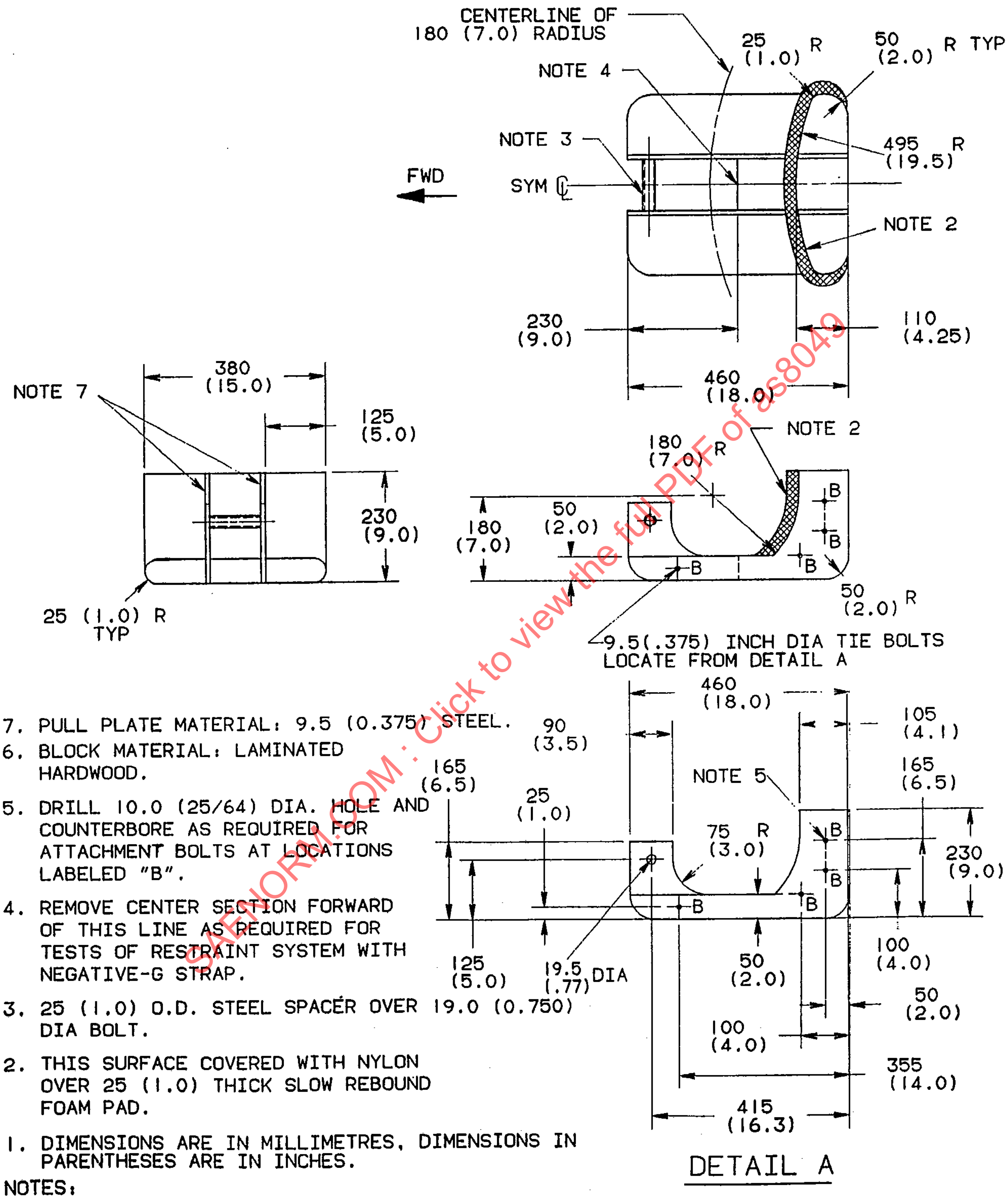


FIGURE 3 - Optional Body Block for Static Testing



NOTE:
DIMENSIONS ARE IN MILLIMETERS.
DIMENSIONS IN PARENTHESES ARE IN INCHES.

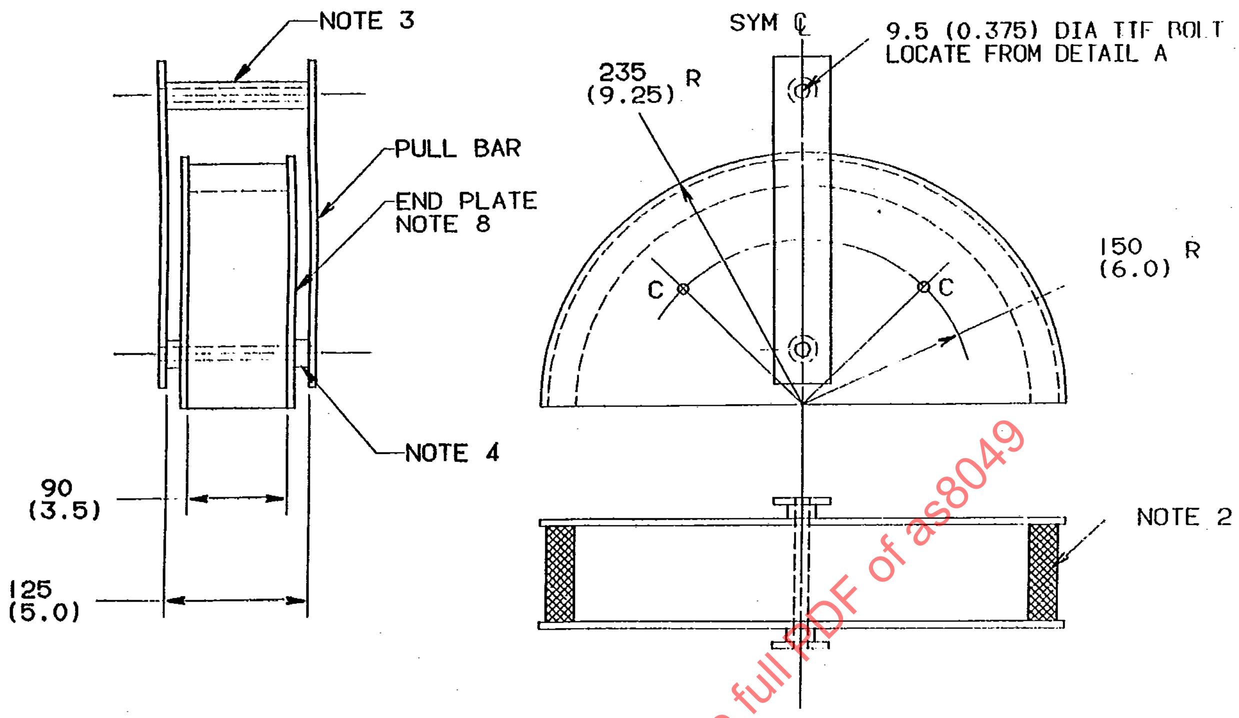
FIGURE 4 - Optional Body Block for Static Testing

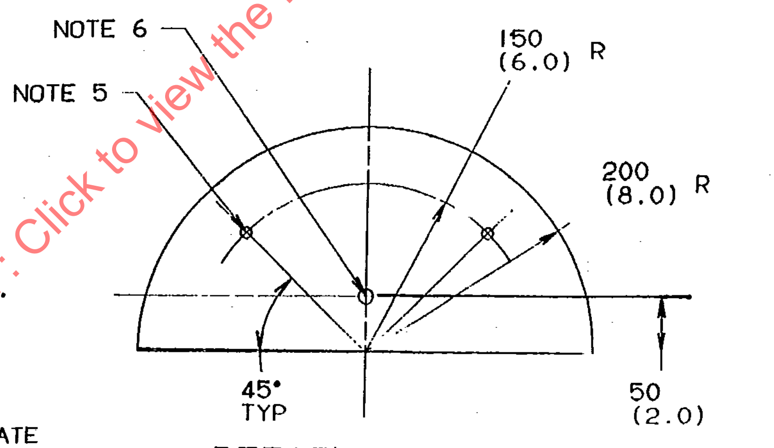


NOTES:

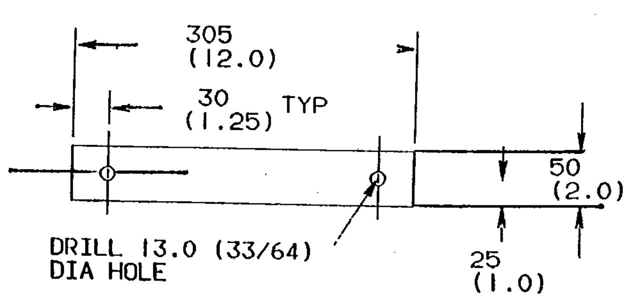
1. DIMENSIONS ARE IN MILLIMETRES, DIMENSIONS IN PARENTHESES ARE IN INCHES.
2. THIS SURFACE COVERED WITH NYLON OVER 25 (1.0) THICK SLOW REBOUND FOAM PAD.
3. 25 (1.0) O.D. STEEL SPACER OVER 19.0 (0.750) DIA BOLT.
4. REMOVE CENTER SECTION FORWARD OF THIS LINE AS REQUIRED FOR TESTS OF RESTRAINT SYSTEM WITH NEGATIVE-G STRAP.
5. DRILL 10.0 (25/64) DIA. HOLE AND COUNTERBORE AS REQUIRED FOR ATTACHMENT BOLTS AT LOCATIONS LABELED "B".
6. BLOCK MATERIAL: LAMINATED HARDWOOD.
7. PULL PLATE MATERIAL: 9.5 (0.375) STEEL.

FIGURE 5A - Lower Torso Block





DETAIL A -CORE



DETAIL B -PULL BAR (NOTE 8)

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) DIA. HOLE AT LOCATIONS LABELED "C" THRU END PLATE AND CORE.
4. 13.0 (0.50) LONG X 25 (1.0) O.D. STEEL SPACER (2 PLACES) OVER A 13.0 (0.50) DIA BOLT.
3. 127 (5.0) LONG X 25 (1.0) O.D. STEEL SPACER OVER A 12.5 (0.50) 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 5B - Upper Torso Block

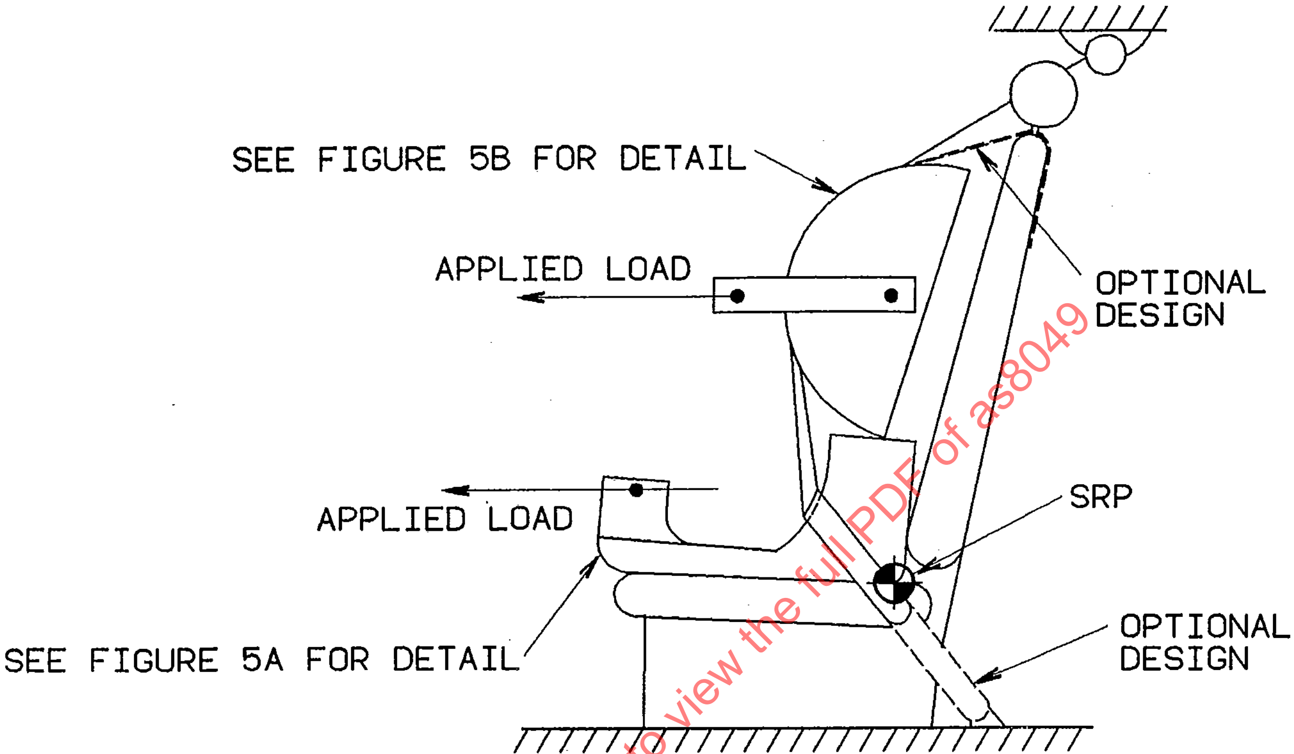


FIGURE 5C - Optional Combined Pelvic and Upper Torso Static Test

5.1.4 For forward or side loads, the body block shall be placed either on the actual bottom cushion or on a nonrigid foam block representative of the bottom cushion. For the side load, the back cushion or a nonrigid 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 3, or by a rigid block with the same back dimensions. The back cushion or an equivalent nonrigid 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.

5.1.6 Static resultant load application points are summarized in Table 2.

TABLE 2 - STATIC RESULTANT LOAD APPLICATION POINTS

Load	Forward-Facing Seat	Sideward-Facing Seat	Rearward-Facing Seat
Down	Evenly over seat bottom	Evenly over seat bottom	Evenly over seat bottom
Side	270 mm (10.5 in) up from SRP 215 mm (8.5 in) forward of SRP	270 mm (10.5 in) up from SRP	270 mm (10.5 in) up from SRP 215 mm (8.5 in) forward of SRP
Up	215 mm (8.5 in) forward of SRP	215 mm (8.5 in) forward of SRP	215 mm (8.5 in) forward of SRP
Forward	270 mm (10.5 in) up from SRP	270 mm (10.5 in) up from SRP and 215 mm (8.5 in) forward of SRP	270 mm (10.5 in) up from SRP
Rearward	270 mm (10.5 in) up from SRP	270 mm (10.5 in) up from SRP and 215 mm (8.5 in) forward of SRP	270 mm (10.5 in) up from 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 occupant and the seat.

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

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 at the c.g. of the mass.

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 which are equivalent in location to those in the aircraft. The static loads shall then be applied as specified in this section.

5.1.11 When a seat is to be installed or adjusts to face in more than one direction, tests shall be made to substantiate the seat strength for all intended positions.

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 static loads applied to a seat which uses upper torso restraint shall be 40% through the upper torso restraint and 60% through the pelvic restraint.

5.1.14 When a seat incorporates pelvic and 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 2.

5.1.15 After each test load is removed, measurements of permanent deformation, if any, shall be recorded.

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 without detrimental permanent deformation.

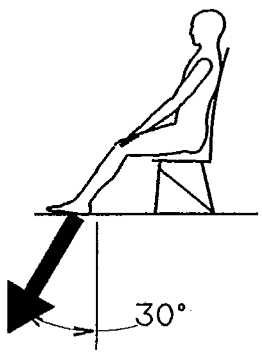
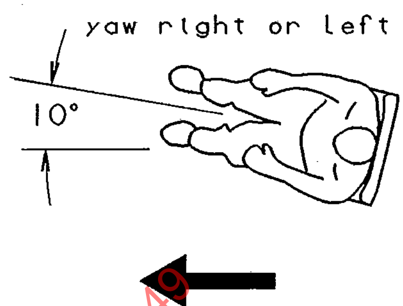
5.2.2 The structure is capable of supporting, without failure for at least 3 seconds, the ultimate static loads specified herein when applied separately.

If it can be shown that failure of an armrest on a seat assembly does not reduce the degree of safety afforded the occupant, such failure will not be cause for rejection.

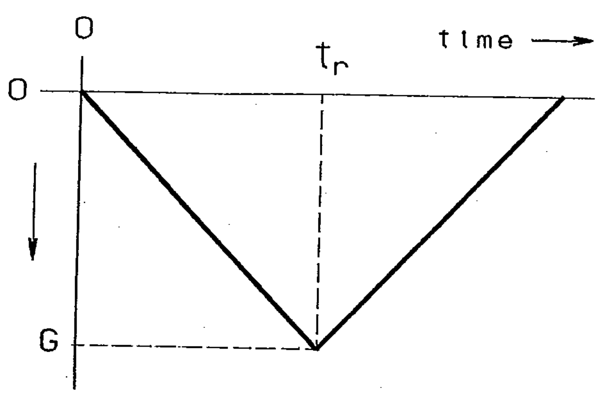
5.2.3 After application and release of ultimate loads, as described in 5.2.2, the seat permanent deformation limitations of 3.5 and its subparagraphs are met.

5.3 Dynamic Qualification Tests: This section specifies the dynamic tests to satisfy the requirements of this AS.

5.3.1 Dynamic Impact Test Parameters: A minimum of two dynamic impact tests shall be performed. 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 and 7).

	TEST 1	TEST 2
Illustration shows a forward-facing seat Inertial load shown by arrow		
Min V_i 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
Degrees pitch	0	10

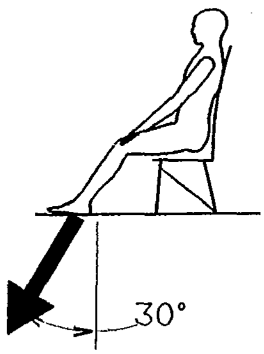
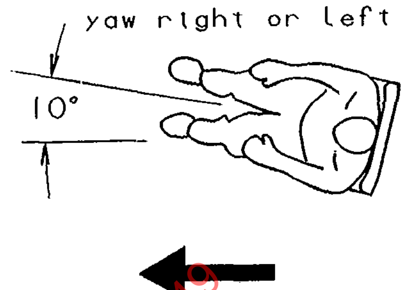
Test Pulse Simulating Aircraft Floor Deceleration-Time History:



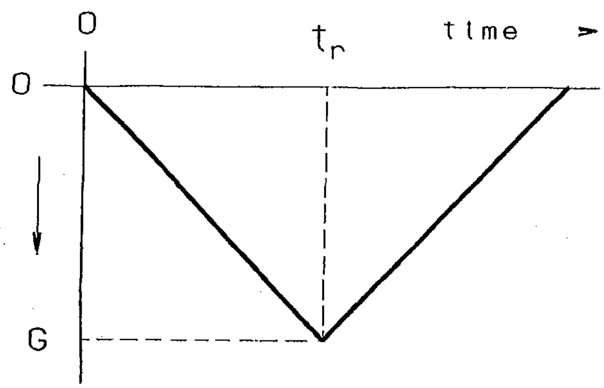
t_r = rise time

V_i = Impact Velocity

FIGURE 6 - Type A Seat/Restraint System Dynamic Tests

	TEST 1	TEST 2
Illustration shows a forward-facing seat Inertial load shown by arrow		
Min V_i 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	10
Degrees pitch	10	10

Test Pulse Simulating Aircraft Floor Deceleration-Time History:



t_r = rise time

V_i = Impact Velocity

FIGURE 7 - Type B Seat/Restraint System Dynamic Tests

5.3.1.1 Test 1 (Figures 6 and 7), 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 as a result of the 30 deg pitch angle. 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.

5.3.1.2 Test 2 (Figures 6 and 7), 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 as a result of the 10 deg yaw orientation. 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 will yield data on ATD head displacement, velocity, and acceleration time histories and the seat leg loads imposed on the seat tracks or attachment fittings.

5.3.1.3 For seats placed in repetitive rows, an additional test condition, using two 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, seat occupancy, and the effect of hard structures within the path of head excursions in the -10 to +10 deg 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.

5.3.1.4 Test 2 for Type A seats and Tests 1 and 2 for Type B seats require simulating aircraft floor deformation by deforming the test fixture, as prescribed in Figures 6 and 7, prior to applying the dynamic impact 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 are severely deformed by the forces associated with a crash.

5.3.2 <u>Occupant Simulation</u>: An anthropomorphic test dummy (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. An equivalent ATD shall provide the same response to the test conditions of the AS as the specified ATD. The ATDs shall be calibrated and periodically inspected for proper function. Modification of these ATDs is necessary, as outlined in 5.3.2.1, to record the compressive load between the pelvis and the lumbar column of the ATD.

5.3.2.1 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 dummy pelvis just below the lumbar column. This modification is shown in Figure 8. The illustration shows a commercially available femur load cell, with end plates removed, that has been adapted to measure the compression load between the pelvis and the lumbar column of the ATD.

A femur load cell is selected because of its availability in most test facilities and its ability to measure the compression forces without errors due to sensitivity to shear forces and bending or twisting moments which are also generated during the test. To maintain the correct seated height of the ATD the load cell must be fixed in a rigid cup which is inserted into a hole bored in the top surface of the ATD pelvis. The interior diameter of the cup provides clearance around the outside diameter of the load cell, so that loads are transmitted only through the ends of the cell. If necessary, ballast shall be added to the pelvis to maintain the weight of the original (unmodified) assembly.

Alternative approaches to measuring the axial force transmitted to the lumbar spinal column by the pelvis are acceptable if the method:

a. Accurately measures the axial force and is insensitive to moments and forces other than that being measured

b. Maintains the intended alignment of the spinal column and the pelvis, the correct seated height, and the correct weight distribution of the dummy

c. Does not alter the other performance characteristics of the dummy

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

5.3.2.3 Submarining indicators such as electronic transducers, may be added on the dummy pelvis. These are located on the anterior surface of the ilium of the dummy 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.

5.3.2.4 ATDs shall be maintained at a temperature range between 18.9 to 25.6°C (66 to 78°F) and at a relative humidity from 10 to 70% for a minimum of 4 hours prior to and during testing.

5.3.2.5 Each dummy should be clothed in form-fitting cotton stretch garments with short sleeves, mid-calf length pants, and size 45 (11E) shoes weighing about 11 N (2.5 lb).

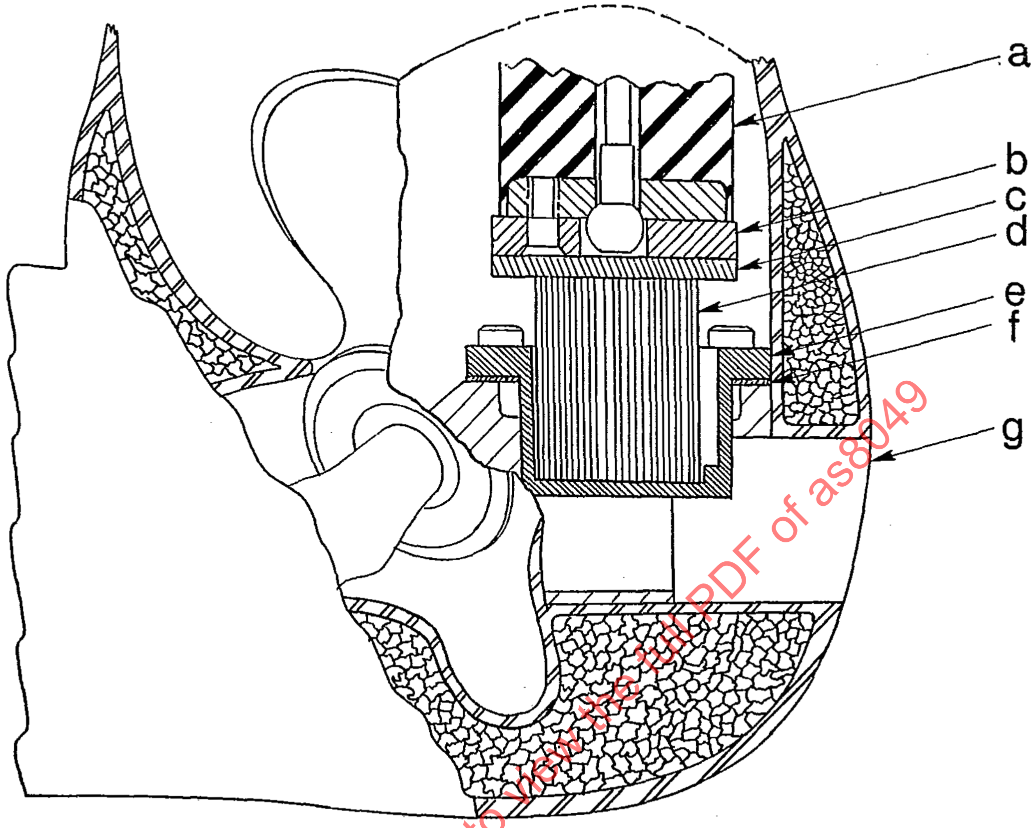


FIGURE 8 - Installation of Pelvic-Lumbar Spine Load Cell in Part 572B Anthropomorphic Dummy. This illustration shows an acceptable adaptation of a femur load cell (d) at the base of the dummy lumbar spine (a). The load cell is in line with the centerline of the lumbar spine, and set below the top surface of the pelvis casting to maintain the seated height of the dummy. A rigid adapter cup (e) is fabricated to hold the load cell and a hole is bored in the dummy pelvis to accept the cup. Clearance must be provided between the walls of the adapter cup and the load cell for the wires leading from the cell. The bottom of the load cell is bolted to the adapter cup. Adapter plates having similar hole patterns in their periphery are fabricated for the lower surface of the lumbar spine (b) and the upper surface of the load cell (c). These plates are fastened to the lumbar spine and load cell with screws through holes matching threaded holes in those components, and are then joined together by bolts through the peripheral holes. The flange on the adapter cup has a bolt hole pattern which matches that on the pelvis. The cup is fastened to the pelvis using screws to the threaded holes in the pelvis. Spacers (f) may be placed under the flange of the cup to obtain the specified dummy seating height. Additional weight should be placed in the cavity below the adapter cup to compensate for any weight lost because of this modification. The instrument cavity plug (g) is cut to provide clearance for the adapter cup and added weight.

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, and provides the floor deformation if needed for the test; it provides anchorage points if necessary for the restraint system; it provides floor or footrest for the dummy; and it positions instrument panels, bulkheads, or a second row of seats, if required.

5.3.3.1 Floor Deformation Fixtures: For the typical seat with four seat legs 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 deg relative to the longitudinal (x) axis. The roll beam shall be capable of ±10 deg roll about the centerline of floor tracks or fittings. A means shall be provided to fasten the beams in the deformed positions.

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 necessary (see 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.

5.3.3.3 Aircraft Floor Track or Attachment Fitting Simulation: An example of the minimum required representation of a floor track is shown in Figure 9A, detail A, for one type of seat track. The track or other attachment fittings must be representative of those used in the aircraft. Alternatively, 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 an aircraft, or to a more critical track or attachment fitting than that used on an aircraft, to demonstrate that the loads measured in the dynamic impact test will not fail the track or attachment fitting used on an 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 rear seat leg attachment point is near the pitch beam axis of rotation. The seat positioning pins or locks shall be fastened in the same manner as would be used in the aircraft, including the adjustment of antirattle mechanisms, if provided. The remainder of the test preparations shall then be completed (dummy installation and positioning, instrumentation installation, adjustment and calibration, camera checks, etc.).

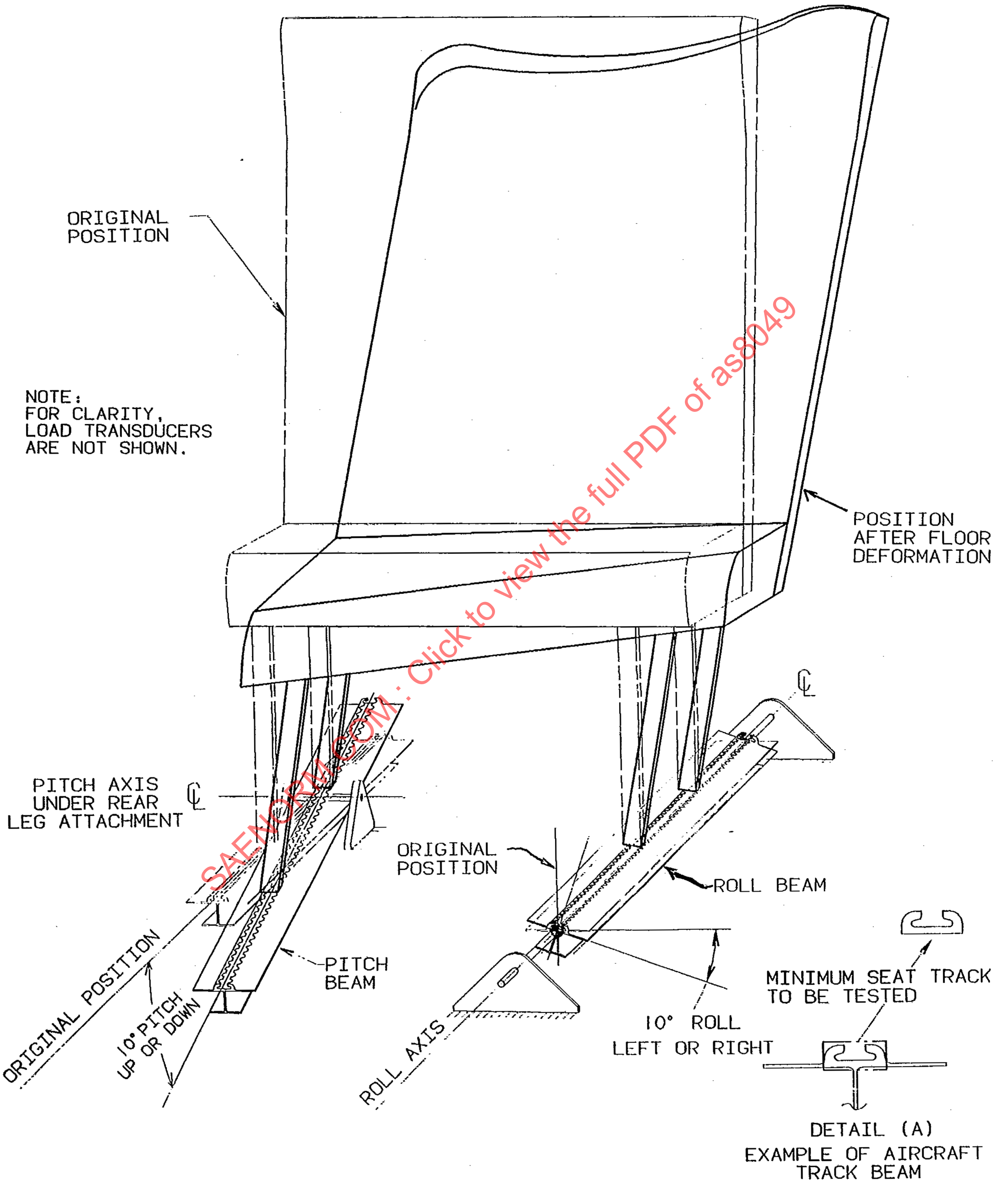


FIGURE 9A - Schematic Floor Deformation Fixture; Seat Legs Attached at Floor Level

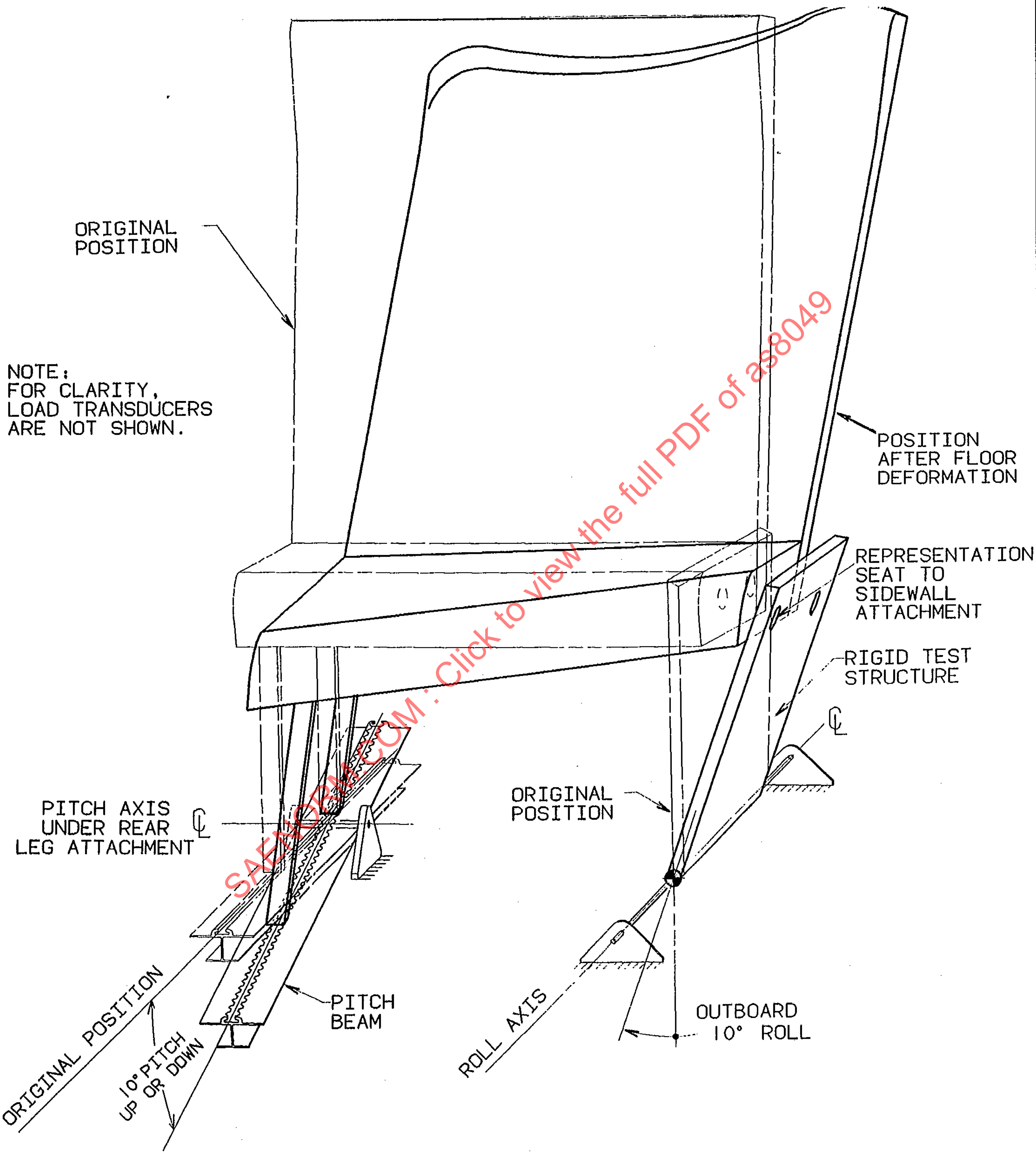


FIGURE 9B - Schematic Test Fixture; Side Wall Mounted Seat

5.3.3.4 (Continued):

The floor deformation shall be accomplished as the final action before the test. The roll beam shall be rotated 10 deg and locked in place, and then the pitch beam shall be rotated 10 deg and locked in place. Each direction of rotation shall be selected to produce the most critical loading condition on the seat and floor track or fitting.

5.3.3.5 Alternative Mounting Configurations: The preceding discussion described the fixture and floor deformation procedure that would be used for a typical seat that uses four seat legs and 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 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 mount solely to a bulkhead will not be subjected to deformation prior to the test. The test fixture shall provide either a rigid bulkhead or hold an actual bulkhead panel. If a test fixture with a rigid bulkhead is used, the seat/restraint system shall attach to fittings installed in a test panel equivalent to those in the actual installation.

c. Seats that are attached to both the floor and a bulkhead shall 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 shall 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 shall 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.

d. Seats that are mounted between sidewalls or to the sidewall and floor of an aircraft shall be tested in a manner that simulates aircraft fuselage cross-section deformation during a severe crash. Brackets shall be provided to attach the seat to the test fixture at the same level above the fixture floor representing the installation above the aircraft floor.

5.3.3.5 (Continued):

A sidewall bracket shall be located on the roll beam. Then, as the beams are rotated to produce the most critical loading condition (sidewall rotates outward), the combined angular and translational deformation will simulate the deformation which could take place in a crash (see Figure 9B for a schematic representation).

e. If a seat is cantilevered from one sidewall without connection to other structure, it is not subject to floor deformation. A determination shall be made whether sidewall deformations could be expected which 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.

f. Multiple occupant seat assemblies may have more than two pairs of legs in some installations. If these assemblies are of fairly constant cross section and are comparable with respect to floor deformation tolerance, the outer leg assemblies shall be subjected to floor deformation as described in 5.3.3.4. The inner leg pairs shall be maintained in their normal, undeformed position for the dynamic tests.

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 and +10 deg. 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.

5.3.3.7 Other Fixture Applications: Test fixtures shall provide a flat foot rest for dummies used in tests of passenger seats and crewmember seats that are not provided with special foot rests or foot operated aircraft controls. The surface of the foot rest shall be covered with carpet (or other appropriate material) and be at a position representative of the undeformed floor in the aircraft installation. 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 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 dummy's pelvis, that the upper torso restraint straps remain on the dummy's shoulder during impact and documenting 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 to the floor.

5.3.4.1 Electronic Instrumentation: Electronic instrumentation shall be accomplished in accordance with SAE J211. 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, based on a constant output/input ratio versus frequency response plot which begins at 0.1 Hz (+1/2 to -1/2 dB) and extends to the high frequency limit (+1/2 to -1 dB). Frequency response characteristics beyond this high frequency limit are also specified. When digitizing data, the sample rate should be at least five times the -3 dB cutoff frequency of the presample analog filters. Since most facilities set all presample analog filters for Channel Class 1000, and since the -3 dB cutoff frequency for channel class 1000 is 1650 Hz, the minimum digital sampling rate would be about 8000 samples per second. For the dynamic tests discussed in this AS, the dynamic data channels shall comply with the following channel class characteristics:

a. Sled or drop tower vehicle acceleration shall be measured in accordance with the requirements of Channel Class 60, unless the acceleration is also integrated to obtain velocity or displacement, in which case it shall be measured in accordance with Channel Class 180 requirements.

5.3.4.1 (Continued):

b. Belt-restraint system loads shall be measured in accordance with the requirements of Channel Class 60.

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 60.

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

g. 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.

a. High speed cameras that provide data used to calculate displacement or velocity shall operate at a nominal speed of 1000 frames per second. Photo instrumentation methods shall not be used for measurement of acceleration. The locations of the cameras and of 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. Rectilinearity of the image shall be documented. If the image is not rectilinear, appropriate correction factors shall be used in the data analysis process.

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. A rigorous, verified analytical procedure shall be used for data analysis.

5.3.4.2 (Continued):

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 dummy's pelvis can be observed by documentation cameras placed to obtain a "best view" of the anticipated event. These cameras shall 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 pre-test installation and the post-test response of the ATDs and the test items. At least four pictures shall be obtained from different positions around the test items in pre-test and post-test conditions. Where an upper torso restraint system is installed, post-test pictures shall be obtained before moving the dummy. For additional post-test 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 post-test 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 post-test 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 <u>Selection of Test Articles</u>: Many seat designs compose 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 highly stressed configuration shall be selected for the dynamic tests so that the other configurations could be accepted by comparison with that configuration.

5.3.5.1 In all cases, the test item shall be representative of the final production item in all structural elements, and shall include the seat, seat cushions, restraints, armrests and armcaps; functioning position adjustment mechanism and correctly adjusted breakover (if present); food trays or any other service or accoutrement that is part of the seat design; and any other items of mass that are carried or positioned by the seat structure such as weights simulating luggage carried by luggage restraint bars [90 N (20 lb) per passenger place], fire extinguishers, survival equipment, etc. If these items of mass are placed in a position that could limit the function of an energy absorbing feature in the test item, they should be of representative shape and stiffness as well as weight.

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 elements, especially joints or fasteners, that 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.

5.3.6 Selection of Test Conditions: The tests shall achieve the most 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.

5.3.6.2 If multiple row testing is used to gather data to assess head and femur 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-deg yaw in Test 2, the seat back breakover, 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.

5.3.6.3 If nonsymmetrical upper torso restraints (such as single diagonal shoulder belts) are used in a system, they shall be installed on the test fixture in a position representative of that in the aircraft and which would most likely allow the ATD to move out of the restraint. For example, in a forward-facing crew seat equipped with a single diagonal shoulder belt, the seat should be yawed in Test 2 in a direction such that the belt passes over the trailing shoulder.

5.3.6.4 If a seat has vertical or horizontal adjustments, it shall be tested in the position used by a 50th-percentile male occupant in the aircraft installation.

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 the test, the pitch and roll floor beams may be returned to their neutral position 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 dummy representing the dummy head center of mass so that the necessary data can be obtained. These data can be used by the interior designer to ensure either that head impact with the interior will not take place or that, should any unavoidable head impacts occur, they can be evaluated using HIC.

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. Lead-wires shall be routed to avoid entanglement with the dummy or test item, and sufficient slack shall be provided to allow motion of the dummy or test item without breaking the lead-wires or disconnecting the transducer. Calibration procedures shall consider the effect of long transducer lead-wires. Head accelerometers and femur load cells shall be installed in the dummy in accordance with the dummy specification and the instructions of the transducer manufacturer. The load cell between the pelvis and the lumbar column shall be installed either in accordance with the approach shown in Figure 8 of this AS, or 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 and should not contact 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.

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. 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 item.

5.3.8 <u>Procedure to Set Up the Test</u>:

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

b. The ATD should be placed in the center of the seat, in as nearly a symmetrical position as possible.

c. The ATD's back should be against the seat back without clearance. This condition can be achieved if the ATD legs are lifted as it is lowered into the seat. Then, the ATD is pushed back into the seat back as it is lowered the last few inches into the seat pan. Once all lifting devices have been removed from the ATD, it should be rocked slightly to settle it in the seat.

d. The ATD's knees should be separated approximately 100 mm (4 in).

5.3.8.3 (Continued):

e. The ATD's hands should be placed on the top of its upper legs, just behind the knees. If tests on crew seats are conducted in a mockup that has aircraft controls, the ATD's hands should be lightly tied to the controls. If only the seat/restraint system is tested, the ATD's hands should be tied together with a slack cord that provides approximately 610 mm (24 in) of separation before the cord becomes tight. This will prevent excessive arm flail during the dummy rebound phase.

f. All seat adjustments and controls shall be set as indicated in 5.3.6.4. If a seat has special requirements dictating its position, adjustment, orientation, etc. for take-off or landing, the test seat shall represent those conditions.

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 a 45-deg footrest for flightcrew 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.

5.3.8.4 For tests where the ATD's head is expected to impact a fixture or another seat back, the head and face of the ATD shall be dusted with chalk dust to mark head contact areas.

5.3.8.5 The restraint system adjustment shall be made as follows. The restraint system shall not be tightened beyond the level that could reasonably be expected in use and the emergency locking device (inertia reel) shall not be locked prior to the impact. Automatic locking retractors shall be allowed to perform the webbing retraction and automatic locking function without assistance. Care shall be taken that emergency locking retractors which are sensitive to acceleration do not lock prior to the impact test because of pre-impact acceleration applied by the test facility. If comfort zone retractors are used, they shall be adjusted in accordance with instructions given to the user of the restraint system.

If manual adjustment of the restraint system is required, slack shall be removed but the restraint system shall not be adjusted so that it is unduly tight. Webbing preload in manually adjusted pelvic restraint systems shall not exceed 50 - 70 N (12 - 15 lb). Since this load is too small to be accurately measured by transducers selected to measure the high loads encountered in the impact test, it should be measured manually as the restraint is being adjusted. Special gauges to assist in making this measurement are commercially available. The webbing force applied to a manually adjusted upper torso restraint shall be just sufficient to remove slack. Preload in the restraint system shall be checked and adjusted if necessary just prior to the floor deformation phase of the test.

5.3.8.6 Floor deformations, if applicable, shall be applied with the load measuring instrumentation functioning so as to record the imposed loads at attachment points.

5.3.9 Data Analysis:

5.3.9.1 General: All data obtained in the dynamic tests should be reviewed for errors. Baseline drift, ringing, and other common electronic instrumentation problems should be detected and corrected before the tests. Loss of data during the test is readily observed in a plot of the data versus time and is typically indicated by sharp discontinuities in the data, often exceeding the amplitude limits of the data collection system. If these occur early in the test in essential data channels, the data should be rejected and the test repeated. If they occur late in the test, after the maximum data in each channel has been recorded, the validity of the data should be carefully evaluated, but the maximum values of the data may still be acceptable for the tests described in this AS. The HIC does not represent simply a maximum data value, but represents an integration of data over a varying time base. The head acceleration measurements used for that computation are not acceptable if errors or loss of data are apparent in the data at any time from the beginning of the test until the ATD and all test articles are at rest after the test.

5.3.9.2 Impact Pulse Shape: Data for evaluating the impact pulse shape are obtained from an accelerometer that measures the acceleration in the direction parallel to the inertial response shown in Figures 6 and 7 of this AS. The impact pulse intended for the tests discussed in this AS has a symmetrical (isosceles) triangular shape. Since this ideal pulse is considered a minimum test condition, it is possible to evaluate the actual test pulse by comparing it with the ideal triangular pulse. The ideal pulse can be drawn, to scale, in the data plot of the test sled or carriage acceleration versus time.

The test pulse is acceptable if the plotted data are equal to or greater than the ideal impact pulse. However, this can lead to using a test pulse significantly higher than the ideal pulse unless the test facility has precise control in generating the test pulse. To avoid that problem, an alternate graphic technique may be used to evaluate test impact pulse shapes which are not precise isosceles triangles. The graphic technique, illustrated in Appendix A, uses the following steps:

a. Extend the calibration baseline (zero G) through the plot of test sled or carriage acceleration versus time.

b. Locate the maximum acceleration (Gp) indicated on the plot.

c. Construct reference lines parallel to the baseline at levels of 0.1 Gp, 0.9 Gp, and 1.0 Gp.

5.3.9.2 (Continued):

d. Construct an onset line through the intersection points of the 0.1 Gp and 0.9 Gp reference lines with the increasing (onset) portion of the data plot. The data plot shall not return to zero G between the two points selected.

e. Locate the intersection points of the onset line with the baseline and with the 1.0 Gp reference line. The interval between these two points, measured along the time axis of the data plot, is considered the rise time (t_r) of the test impact pulse.

f. The rise time of the test impact pulse shall not exceed the value of (t_r) given in Figure 6 or 7 for each test.

g. The area under the data plot curve within the rise time of the test impact pulse shall represent at least one half of the impact velocity given in Figures 6 and 7 for each test. If the value of peak acceleration measured in the test exceeds the level given in Figure 6 or 7 by no more than 10%, the pelvis to lumbar spinal column force, femur loads and the upper torso restraint force measured in the test may be adjusted by multiplying the measured values by the ratio of the peak acceleration given in Figure 6 or 7 divided by the measured peak acceleration, if necessary.

h. The magnitude of Gp shall equal or exceed the minimum G given in Figure 6 or 7 for each test.

i. The area under the data plot curve from the intersection point of the onset line and the zero G basline and a later time not more than 2.3 times the appropriate rise time specified in Figure 6 or 7 shall equal or exceed the minimum impact velocity specified in Figure 6 or 7.

5.3.9.3 Head Injury Criterion (HIC): Data for determining the HIC need be collected during the tests discussed in this AS only if the ATD's head is exposed to impact in a particular aircraft installation. The HIC is calculated according to the following equation:

$$HIC = \left[(t_2 - t_1) \quad [(1/(t_2 - t_1)) \int_{t_1}^{t_2} a(t)dt]^{2.5} \right] MAX.$$

Where: t_1, t_2 = any two points in time during the head impact, in seconds

$a(t)$ = the resultant head acceleration during the head impact, in multiples of g's.

The HIC is a method for defining an acceptable limit; i.e., the maximum value of the HIC shall not exceed 1000. The HIC is calculated by computer based data analysis systems. The discussion that follows outlines the basic method for computing the HIC, but manual attempts to use this method with real data are likely to be tedious. The HIC is based on data obtained from three mutually perpendicular accelerometers