6. APTA PR-CS-S-011-99 Standard for Cab Crew Seating Design and Performance

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Abstract: This standard contains requirements and recommendations for the procurement, design, strength and testing of Crew Cab Seating for use in commuter rail.

Key words: cab car rail seats

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Standard for Cab Crew Seating Design and Performance

1. Overview

This standard covers crew cab seating primarily for pedestal, leg or cantilever mounting styles. This standard is intended to replace AAR Standard S-504 "Locomotive Cab Seats" for use of seats in passenger rail applications. This standard, however, provides suitable guidelines for styles not specifically covered by this standard.

1.1 Scope

This Standard applies to the seats provided for crew members in control cabs of passenger railroad revenue service locomotives

1.2 Purpose

The purpose of this standard is to define minimum design and performance criteria and recommended practices resulting in a minimum level of safety and comfort for passenger train operators.

This standard defines the testing provisions necessary to comply with requirements of *49 CFR 238*.[1] It also defines durability, drawing, maintenance, submittal and testing requirements and addresses issues raised in "*Locomotive Crashworthiness and Cab Working Conditions – Reports to Congress, September 1996."*

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superceded by an approved revision, the revision shall apply.

AAR S-504, Locomotive Cab Seats

Federal Railroad Administration, Locomotive Crashworthiness and Cab Working Conditions-Report to Congress September 1996

SAE AS8049, Performance Standards for Seats in Civil Rotocraft and Transport Airplanes

SAE ARP750, Passenger Seat Design Commercial Transport Aircraft

SAE J 899, Operator's Seat Dimensions for Off Road Self-propelled Work Machines

SAE J 826, Devices for Use in Defining and Measuring Vehicle Seating Accommodation

[1] For references in Italics, see Section 2.

SAE J 1454, Dynamic Durability testing of Seat Cushions for Off-Road Work Machines

49 CFR Part 238, Federal Railroad Administration Passenger Equipment Safety Standards

Mil-Std 1472E, Human Engineering Design Criteria for Military Systems, Equipment and Facilities

3. Definitions abbreviations, and acronyms

For the purpose of this standard, the following terms and definitions apply:

3.1 Definitions

3.1.1 seat manufacture: The agency or company responsible for the design, speculation compliance and warranty of the seat and it's design.

3.1.2 shall: Practices directed by shall are requires or standard practices.

3.1.3 should or may: Practices directed by should or may are recommended practices.

3.2 Abbreviations

SRP Seat Reference Point:	Given by SAE AS8049. Based on 50^{th} percentile male.
H-Point:	Hip Point and measure according to SAE J 826

4. General design requirements

4.1 Procurement specifications

This standard is intended to be supplemented by procurement specifications prepared by the Purchaser and directed to the Seat Manufacturer. These procurement specifications shall, as a minimum, include:

- Expected environmental operating conditions and standards against which measurable results should be measured for conditions such as temperature ranges, humidity, salt atmosphere, ultra-violet radiation, static electricity, and vibration.
- Drawing of the cab or other intended location of the cab seat showing controls to be manipulated by the occupant.
- Drawings or specifications giving visibility requirements for the occupant.
- Normally used cleaning agents.
- Narrative as to the duties normally performed by the occupant of the seat, including time periods during which these duties are to be performed.
- Format for parts, service and maintenance manual.

The procurement specifications may, at the option of the Purchaser, modify the requirements of this

standard where special conditions make such modifications reasonable and do not unduly or unreasonably alter the intent of this standard with respect to the crashworthiness design of the seat and the safety and comfort of the occupant.

APTA recommends that representatives of the ultimate users or occupants of the seat be consulted when either preparing procurement specifications given in this section or conducting the field test allowed under 4.2 of this standard.

4.2 Ergonomic and comfort analysis

For each application of the seat design, the seat manufacturer shall provide an analysis demonstrating that the seat and its application provides optimal ergonomics and comfort for the occupant. As a minimum, the analysis shall demonstrate the following:

a) That the seat adjustments shall be capable of accommodating the range of crew members specified such that all tasks normally performed by the crew members can be accomplished with optimal comfort and safety;

b) That the seat design provides adequate visibility for the range of occupants specified; and

c) That the seat design provides optimal occupant long-term comfort over the time period specified by the purchaser.

As an option for the purchaser, a field test may be substituted for the Ergonomic and Comfort Analysis. Details of the field test shall be agreed to between the seat manufacturer and the purchaser.

4.3 Operator sizes

Cab crew seats shall be designed to accommodate operator sizes from the 5^{th} percentile female (average 108 lb, 5’2”) through the 95^{th} percentile male (198 lb, 6’2”) as defined by Mil -STD-1472E. Surrogates of these occupants include the Hybrid III dummies. The Hybrid III 5^{th} percentile female dummy and the 95^{th}-percentile male dummy are both scaled versions of the Hybrid III 50^{th}-percentile male dummy specified under *49 CFR Part 572 Subpart E*. The size and weight of both the Hybrid III 5^{th}-percentile female, and the 95^{th}-percentile male dummies are based on anthropometric studies by the Human Biomechanics and Simulation Standards Committee Task Force of the Society of Automotive Engineers (SAE). These dummies represent the lower and upper extremes of the USA adult population, respectively.

4.4 Seat features

All crew cab seating shall have, as a minimum, the following features:

- Fully upholstered back rest and bottom cushion
- Reclining back rest
- Folding armrests

- Vertical adjustment
- Rotation
- Fore/aft adjustment
- Adjustable lumbar support
- Vibration dampening

In addition, the following features are optional, but recommended:

- Bottom cushion rake adjustment
- Vertical adjustment to armrests
- Fore/aft adjustment to bottom cushion with respect to back cushion

4.5 Environmental protection

The seat assembly shall be protected from corrosion, and shall be designed to the environmental conditions expected in railroad service or as specified in the Procurement Specifications. Factors such as temperature ranges, humidity, vibration, ultra-violet radiation and salt atmosphere, shall be considered in the seat design.

4.6 Static electricity

The seat design should incorporate a means to minimize the build up of static electricity.

4.7 Inspection for maintainability

The seat shall be designed to readily permit the inspection of all adjustment devices and the seat structure to mitigate the effects of normal use, normal cleaning, wear, abuse and corrosion.

4.8 Life of seat structure

The seat shall be designed for a 10 year life and shall be such that the strength of the seat structure and attachment to the car shall not be compromised by environmental factors, in service use (wear) and dissimilar metals over the specified life of the seat. All members of the primary seat structure shall be protected to minimize deterioration from environmental factors. Structural members shall 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.

4.9 Seat controls

All seat controls such as adjustment handles, levers, knobs, and buttons shall be designed for optimum ergonomic locations for accessibility and operation from the seated position. Seat controls

shall be protected against inadvertent or unsafe activation and shall be designed to be not easily removed. Activation of any seat controls shall not result in any unsafe, rapid or unexpected movement which could contribute to operator injury.

If possible, all seat controls should be located on both sides of the seat. All seat controls shall be operable from the seated position.

4.10 Plaque for operating instructions

As part of the seat installation, a plaque shall be provided that instructs the crew member as to how to safely operate the seat and its controls. The plaque shall provide any necessary cautions or warnings concerning its unsafe use. Graphics rather than verbiage should be used to the maximum extent possible. The location of the plaque shall be determined jointly by the purchaser, builder, and seat manufacturer, however, the plaque shall be located in a place visible to the potential occupant and/or operator of the seat. The plaque shall be permanently attached to its mounting and shall be resistant to casual attempts to remove it. The legend and graphics on the plaque shall remain legible after having been exposed to the normal railroad environment, including normal wear, cleaning agents and ultraviolet radiation.

5. Design features

5.1 Materials and workmanship

The seat shall be made of materials suitable for use in the railroad environment. All materials shall be new and of first class quality. The seat shall be free of protrusions, sharp edges or corners that could cause injury or catch or damage the occupant’s clothing with the seat adjusted to any position. The seat shall be free of rattles or loose joints which could create noise or vibration during normal operation. All parts of the seat shall be interchangeable with parts of like seats. No unusual adjustments or procedures such as grinding or bending of materials shall be required to replace parts that are designed to be replaced.

5.2 Dimensions

Cab crew seats should be designed according to the dimensions shown on Table 1 and Figure 1.

5.3 Cushions and upholstery

Cushions shall be contoured to provide optimal occupant retention and comfort during normal operation. Cushioning material shall be durable and shall be capable of passing the cushion life test described herein. Seat cushion covering should not cause sliding of the occupant and should not be easily torn or cracked. The upholstery material should permit good ventilation.

5.4 Recline

Seat back should recline according to the dimensions specified. Recline control should provide for infinite adjustment through the range specified. Recline mechanism design shall be such that activation of the recline control does not allow a sudden change in back rest position.

5.5 Armrests

Crew cab seats should be equipped with two folding armrests. Armrests should be horizontal when in the down position. Armrests shall fold up from the horizontal position such that occupant ingress and egress from the seat is completely unimpeded in any seat adjustment configuration. Top of armrests should be padded.

5.6 Vertical adjustment

Crew cabs seats shall be capable of a minimum of 3 inches [76 millimeters] of vertical adjustment. Ideally, the vertical adjustment should allow for an infinite number of vertical locations between the extremes of adjustment and should not require that the occupant reduce or remove his or her weight from the seat to raise the seat. Vertical adjustment mechanisms which do not meet this requirement shall be approved by the purchaser.

5.7 Rotation

The seat should have a minimum of 180^0 of rotation (swivel) from forward to rear facing position. Rotation should be such that at the 90^0 position, the seat faces the centerline of the car. The rotation mechanism shall have positive locks in the forward (0^0) and the rearward (180^0) positions. The design of the rotation mechanism should require minimal effort for proper operation. For example, the rotation mechanism should be supported with ball or roller bearings to minimize the need for adjustment.

5.8 Lumbar support

The seat back cushion shall have an adjustable lumbar support to provide adequate occupant support and should accommodate the range of occupants specified. The lumbar support mechanism shall be adjustable both in curvature and vertical location. Vertical adjustment shall have two positions approximately 2 inches [51 millimeters] apart.

Table 1 - Seat Dimensions

	Dimensions in Inches [Millimeters] (or as noted)				
Description	Fig 1 Item	Max	Nom	Min	Notes (SRP to be determined according to SAE J 826)
Back Cushion Height	A	25 [635]	21 [533]	18 [457]	
Back Cushion Width	B	22 [559]	20 [508]	18 [457]	
Bottom Cushion Length	C	18 [457]	17 [432]	16 [406]	Can be adjustable to degrees
Bottom Cushion Width	D	22 [559]	20 [508]	18 [457]	
Bottom Cushion Angle	E	12 degrees	10 degrees	7 degrees	Can be adjustable to 0^0
Back Cushion Angle	F	12 degrees	15 degrees	0 degrees	Adjustable from Min to Max
Armrest Height	G	8.5 [216]	8 [203]	7 [178]	Can be adjustable
Armrest Length	H	12 [203]	10 [254]	8 [305]	
Armrest Lateral Spacing	J	22 [559]	20 [508]	18 [457]	
Lumbar Support	K	11 [279]	10 [254]	9 [229]	Adjustable from Min to Max
Armrest Width	L	5 [127]	3 [76]	2 [51]	
Lumbar Curvature	R	12 [305]	10 [254]	6 [152]	Adjustable from Min to Max
Seat Height	M	19 [483]	17.5 [445]	16 [406]	Adjustable from Min to Max

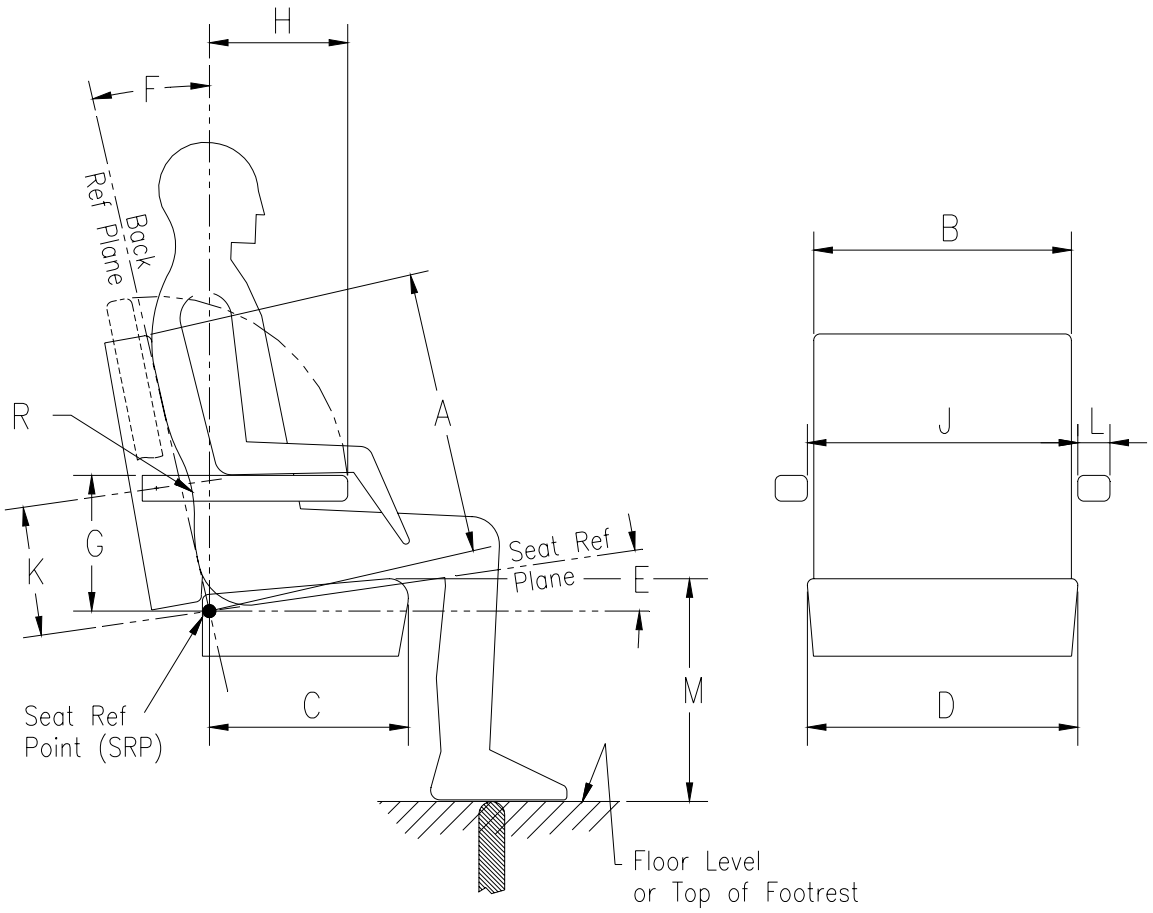

Figure 1 - Seat Dimensions

6. Seat strength requirements

6.1 General

The seat design shall be tested to demonstrate that it meets or exceeds the static and dynamic load conditions as given in paragraphs 6.2 and 6.3. Unit tested shall be representative of actual production seats. Testing shall be done with the seat adjusted to the configuration(s) which produce the maximum stresses on the seat structure or mechanisms.

Both Static and Dynamic Attachment Testing shall be performed with a test set-up duplicating as closely as possible the attachment of the seat assembly to the car structure. A waiver may be granted from this requirement for those applications where the seat assembly is being retrofitted to existing equipment. In this case, the seat may be attached to a rigid base as agreed to by the purchaser and seat manufacturer.

The seat shall be subject to the Service Life Cycle Testing given in Section 9.2 of this standard prior to static load testing and seat attachment testing.

6.2 Static load tests

The seat shall be subjected to each of the static loads listed below and as shown in Figure 2. In each case, there shall be no yielding or fracture of any structural material during the testing. All

loads shall be applied and held for a minimum time of 3 seconds. A maximum of 1/8 inch (3 millimeters) permanent set is allowed for each load case. All adjustment mechanisms shall remain operable subsequent to testing. Measurements for permanent set shall be made after testing relative to a point located at the seat mounting.

6.2.1 Bottom cushion static load test

450 pounds (2003 newtons) vertical downward on bottom cushion applied uniformly over a 12 inch x 12 inch [305 millimeter x 305 millimeter] area located at the front center of the bottom cushion.

6.2.2 Back rest static load tests

A horizontal force applied to the upper back cross member of the seat back structure that produces a moment of 3300 inch pounds (373 newton meters) about the SRP. The test shall be performed to produce both a clockwise and a counter-clockwise moment. The horizontal force shall be applied at the vertical centerline of the seat back.

6.2.3 Armrest vertical load tests

250 pounds (1000 newtons) vertically downward on each armrest and located 10 inches (254 millimeters) from the pivot point of the armrest. For armrests less than 10-in. long, the load should be applied at the furthest point on the armrest from the pivot.

6.2.4 Armrest horizontal load tests

250 pounds (1000 newtons) horizontally on each armrest and located 10 inches (254 millimeters) from the pivot point of the armrest. Test shall be repeated on both the inner and outer surfaces of the armrest. For armrests less than 10-in. long, the load should be applied at the furthest point on the armrest from the pivot.

6.2.5 Anti-rotation tests

A moment equal to 1600 inch-pounds. (181 newton-meters) in the horizontal plane shall be applied to the seat and shall be oriented to load the rotation lock mechanism. Test shall be performed in both the clockwise and counterclockwise directions on each rotation lock position.

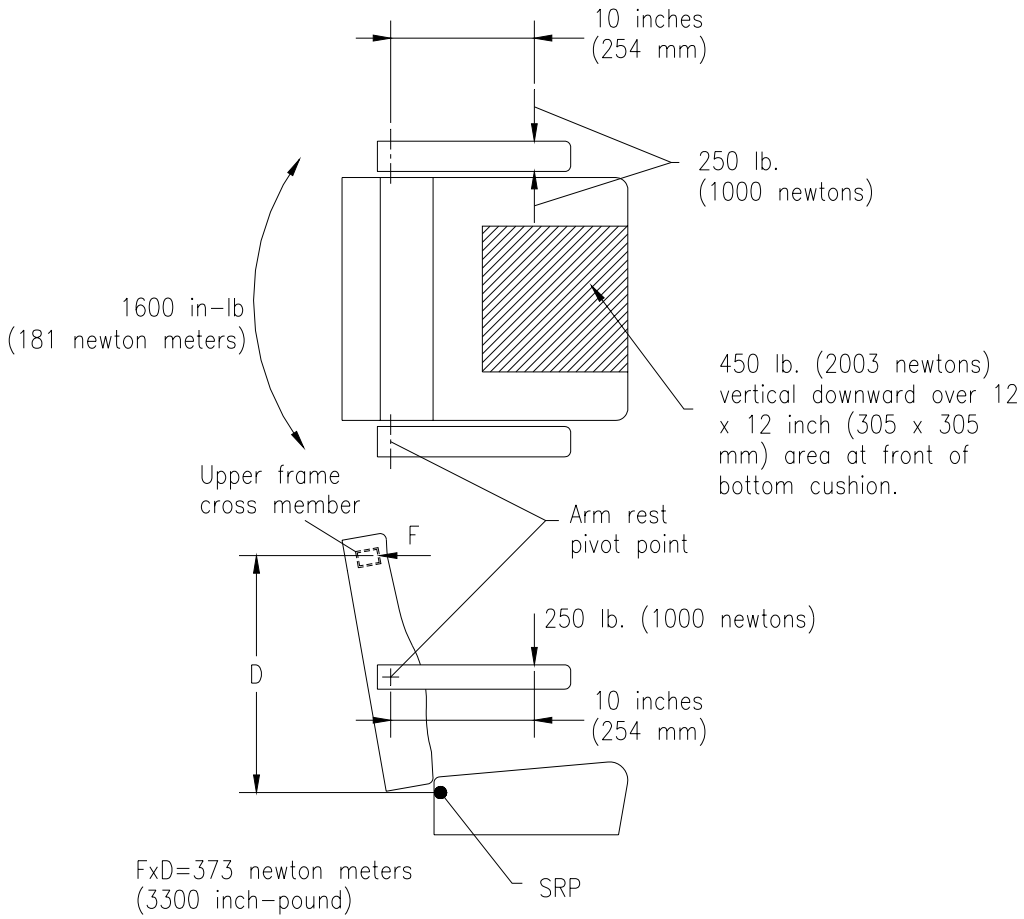

Figure 2 - Static Load Tests

6.3 Dynamic seat attachment test

The seat and its attachment to the car shall have an ultimate strength capable of withstanding the loads due to the following individually applied accelerations acting on the mass of the seat and the occupant equal in stature to the 95th percentile male:

Longitudinal: +/-8g

Lateral: +/-4g

Vertical: +/-4g

The acceleration pulse shall be triangular in shape with a peak acceleration as given above and shall have a 0.25 second time base. Acceleration pulses shall be as shown in Figures 3 and 4.

For the purposes of attachment design testing, the weight simulating the occupant shall not be restrained in any way other than that provided by features on the seat for example, the armrests inside loading and the seat back in afterward loading. The weight shall be equal in mass to a 95th percentile male and located in the seat such that the center of gravity of the seat and occupant is simulated.

The seat and simulated occupant shall be tested in both longitudinal directions, both lateral directions, and both vertical directions. As a result of the testing, yielding of the seat structure is permissible, however, the seat shall stay attached to the car and no part of the seat shall become detached or become a missile. Adjustment mechanisms shall maintain the seat in the position to which it was adjusted prior to testing.

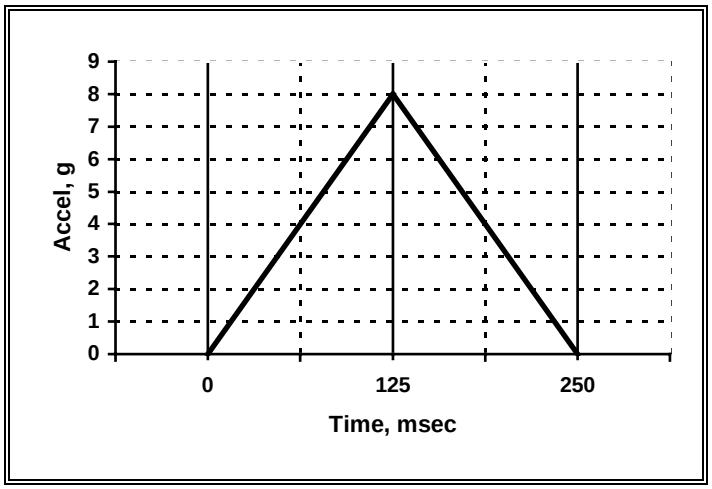

Figure 3 - Seat Attachment Test - Longitudinal Acceleration Pulse

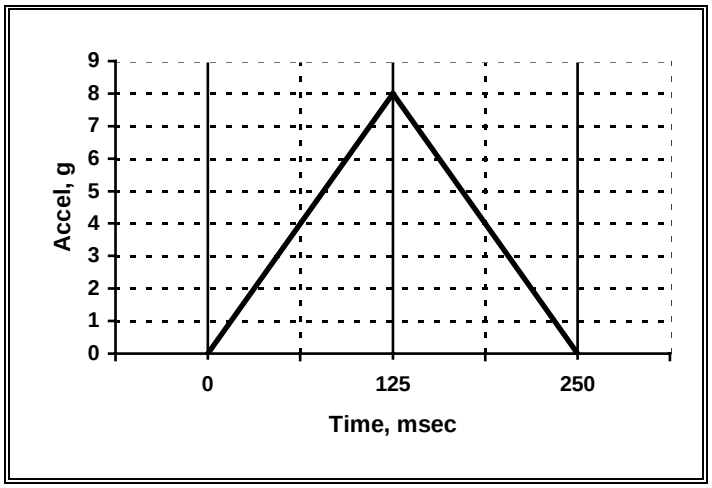

Figure 4 - Seat Attachment Test - Lateral and Vertical Acceleration Pulse

7. Smoke and flammability

All materials used in the seat construction shall meet the requirements of *49 CFR Part 238, Appendix B*[2]. Test reports from recognized independent laboratories shall be submitted to the purchaser. A matrix showing the total weight of all materials, where used, BTU content, test identity, test requirements, test results and nature and quantity of products of combustion shall be submitted to the purchaser.

[2] For references in Italics, see Section 2.

8. Maintainability

The seat shall be easy to maintain and clean and shall require no unscheduled adjustments or lubrication for the specified life of the seat. Design of seat shall be such that parts can be replaced with the use of standard hand tools. Components of like seats are interchangeable. Pockets where dirt and debris can collect should be minimized.

9. Durability

The seat and its adjustment mechanisms not referenced in Table 2 shall be demonstrated to provide a 10 year life through simulated life cycle testing agreed between seat manufacturer and purchaser. Testing shall simulate actual expected use as closely as possible by placing simulated loads in the seat where indicated.

A cycle is defined as moving the seat component from one extreme position to the opposite extreme position and then returning to the original position.

After testing, the seat shall not exhibit failure of any component or result in wear which would compromise the structural integrity of the seat. Seat controls and adjustments shall not exhibit any substantial change in function or force required to activate.

Results of testing shall be documented by test reports as described below.

9.1 Cushion durability test

A cushion durability test shall be performed using *SAE J 1454*[3] as a guide. Tests shall be performed on both bottom and back cushion. Test shall consist of an automotive "jounce and squirm" test using a "jounce and squirm" machine similar to that shown in Figure 5. Each cushion shall be subjected to the following:

- 200,000 jounce cycles @ 100 cycles per minute
- 4,000 squirm cycles @ 4 cycles per minute
- 180 lb. load on bottom cushion
- 110 lb. on back cushion

Jounce and squirm cycles shall be applied simultaneously, although motions shall be independent. Thigh and torso forms shall be employed to transmit the motions to the cushions. Forms shall be located as would a seated passenger, using the procedure given in *SAE J 826*.

As a result of testing, cushions shall not show undue wear or signs of failure. Cushion upholstery shall show no tearing or ripping and shall remain attached to the cushion pans or structure. Upholstery stitching shall show no signs of unraveling or breakage. Cushion foam shall show no signs of tearing, shearing or loss of height.

[3] For references in Italics, see Section 2.

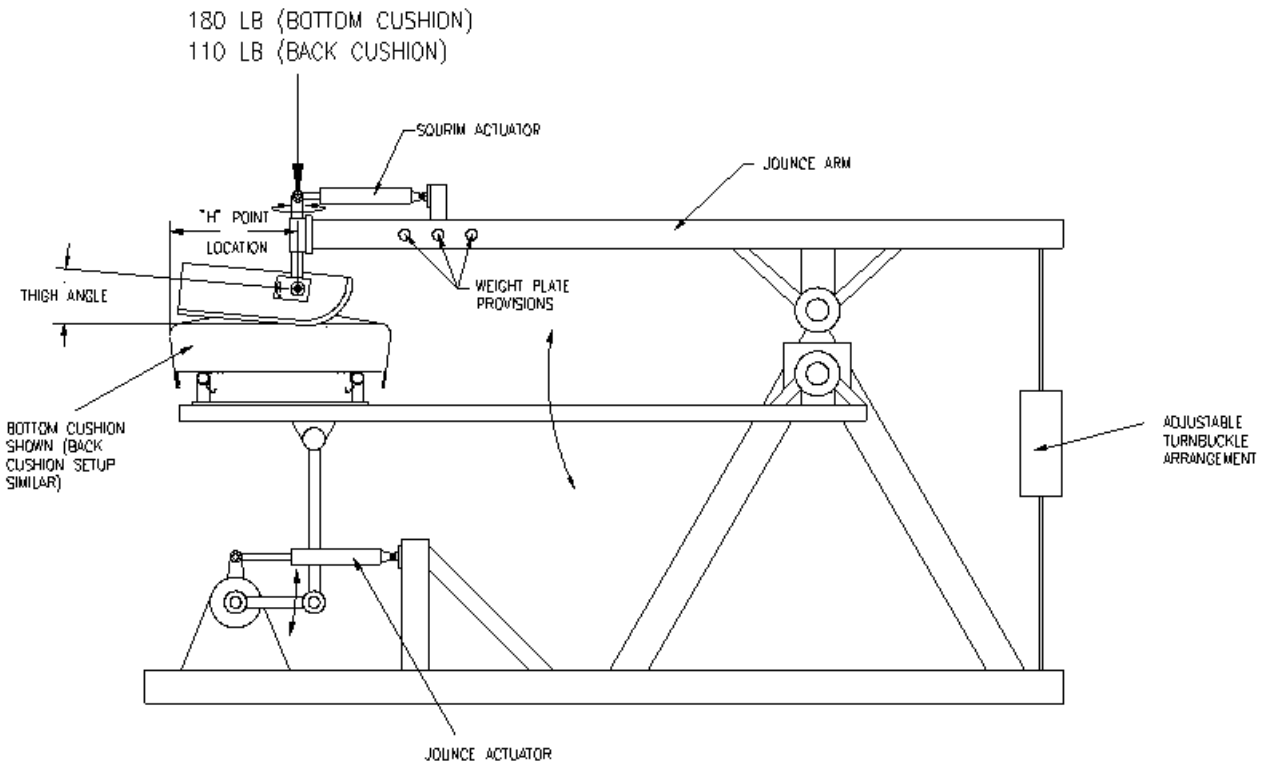

Figure 5 - "Jounce and Squirm" Machine

9.2 Service life cycle test

The durability of the seat and its adjustment mechanisms shall be demonstrated by testing as follows:

Table 2 - Life Cycle Test Requirements

Component	Test Cycles	Load Condition
Recline Mechanism	15,000	None
Armrest Folding	20,000	None
Vertical Adjustment	20,000	185 lb.
Fore / Aft Adjustment	20,000	185 lb.

Loads shall be placed in the seat to simulate the weight of the 50th percentile male.

10. Test procedures and reports

All seat testing performed by the seat manufacturer shall be documented with test procedures and test reports. This shall include the procedures and reports for Static Load Tests, Seat Attachment Tests, Cushion Durability Tests and Service Life Cycle Tests.

Test procedures shall be submitted and approved by purchaser prior to actual testing. Tests shall be scheduled to allow purchaser to, at his or her option, witness testing. The purchaser may elect to accept existing test reports and procedures provided the seat to be purchased is demonstrated to be identical to that tested and the test reports and procedures meet the requirements listed below.

10.1 Test procedures

Test procedures shall as a minimum include:

- Test objective
- Complete description of item to be tested
- Pass/fail criteria
- List of test equipment
- Descriptions and/or drawings of test setup
- Description of test personnel required
- Scheduled time and location of tests
- Sequential, step by step test procedure
- Test data sheets (for recording data during testing)

10.2 Test reports

Test reports shall as a minimum include:

- A copy of the test procedure meeting the requirements listed above.
- Text or cover letter which gives a summary of the test results, the date and location of the test, and includes the signature of the person or person(s) responsible for conducting the test and writing the report.
- Calibration data for all test measuring equipment
- Pre and post test measurements (dimensions, adjustment activation force, etc.)
- Filled-in Test Data Sheet
- Photos of test set-up and results

11. Parts, service and maintenance manuals

When not superseded by the requirements of the purchaser's own specifications, as part of its work the seat manufacturer shall provide a manual or manuals. The manual(s) shall:

Provide seat specifications and application data (such as weight, envelope dimensions, ranges of motion, mounting dimensions, mounting bolt sizes, grade and torque requirements, etc.)

- Provide installation and removal information
- Provide assembly and disassembly instructions and data
- Serve as an aid in training the crew members in the safe use of the seat
- Provide a list of replacement parts with part numbers and ordering information
- Provide exploded views of the seat assembly and its components
- Provide scheduled and unscheduled maintenance instructions and data, such as the periodic checking of fasteners (including torque values), lubrication instructions and cleaning instructions
- Format and size of manual(s) shall be as agreed to by purchaser and seat manufacturer.

12. Engineering drawing

As part of its work and prior to the supply of seats, the seat manufacturer shall submit an engineering drawing for approval. The drawing shall, as a minimum, include the following:

- Overall dimensions and tolerance of the seat assembly
- Depictions of the range of motions of all adjustments and tolerances in the range of motions
- Mounting requirements including hole sizes, recommended bolt sizes and torque requirements and recommended grade of bolts to be used for mounting
- Location and operation of all seat controls
- Forces required to operate the seat controls during normal use
- Description of materials including cushion and fabric as well as colors and model number.

13. Submittals for approval

The seat manufacturer shall submit the following for approval:

Table 3 - Submittal Requirements

Submittal	Reference Standard Section
Ergonomic and Comfort Analysis (or field test report)	4.2
Static Load Test Reports	6.2
Seat Attachment Test Report	6.3
Smoke and Flammability Test Reports	7.
Smoke and Flammability Test Matrix	7.
Cushion Durability Test Report	9.1
Service Life Cycle Test Report	9.2
Test Procedures	10.1
Parts, Service and Maintenance Manual(s)	11.
Engineering Drawing(s)	12.