APTA STANDARDS DEVELOPMENT PROGRAM

STANDARD

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PRESS Construction & Structural Working Group

Fixed Workstation Tables in Passenger Rail Cars

Abstract: This *Rail Standard* defines crashworthiness requirements for fixed workstation tables installed in passenger rail coach cars that are part of the general railroad system of transportation.

Keywords: crashworthiness, fixed workstation tables, passenger rail, safety

Summary: In passenger rail coach seating configurations with fixed workstation tables, there is a risk of serious thoracic and abdominal injury when passengers impact a table during a rail accident. Tables designed to absorb energy and limit contact forces can significantly reduce the risk of injury. Additionally, tables positioned between facing rows of seats can serve to compartmentalize occupants during a collision, which can limit secondary impact velocity and prevent tertiary impacts with other objects or passengers.

Scope and purpose: This standard, which improves passenger collision safety, applies to new railcar procurements and is intended to provide guidance for the design and testing of fixed workstation tables used in passenger rail cars. This standard applies to fixed workstation tables that are positioned at revenue seats in any type of passenger car but does not apply to fold-down seatback tables nor to tables in sleeping car rooms. Portions of this standard are intended to provide details on how to demonstrate compliance with the requirements of 49 CFR Part 238.233, Interior Fittings and Surfaces. The purpose of this standard is to define requirements for workstation tables that result in reduced injuries and fatalities due to table impacts during passenger rail accidents.

This *Standard* represents a common viewpoint of those parties concerned with its provisions, namely, ~~rail~~ operating/planning agencies, manufacturers, consultants, engineers, and general interest groups. In some cases, federal and/or state regulations govern portions of a transit system's operations. In those cases, the government regulations take precedence over this standard. .

Participants

The American Public Transportation Association greatly appreciates the contributions of the **PRESS Construction & Structural Working Group and its Workstation Table Sub-Working Group**, which provided the primary effort in the drafting of this *Rail Standard*.

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Fixed Workstation Tables in Passenger Rail Cars

1. Overview

In passenger rail seating configurations with fixed workstation tables, there is a risk of serious thoracic and abdominal injury when passengers impact a table during a rail accident [1, 2]. Tables designed to absorb energy and limit contact forces can significantly reduce the risk of injury. Additionally, tables positioned between facing rows of passenger seats can serve to compartmentalize occupants during a collision, which can limit secondary impact velocity and prevent tertiary impacts with other objects or passengers.

This standard defines crashworthiness requirements for fixed workstation tables installed in passenger rail cars that are part of the general railroad system of transportation. This standard applies to fixed workstation tables that are positioned at revenue seats in any type of passenger car but does not apply to fold-down seatback tables nor tables in sleeping car rooms. This safety standard applies to the procurement of workstation tables for new passenger rail cars and describes the tests and table performance requirements necessary to demonstrate compliance with this standard. This standard becomes effective on the date of authorization stated on the title page.

The requirements listed here are derived in part from industry and federal requirements. These requirements are contained in the Code of Federal Regulations, Title 49, Part 238, Section 233; and the United Kingdom Railway Group Standard GM/RT2100 Issue 4. Maximum allowable injury criteria values are derived from the Code of Federal Regulations, Title 49, Part 571, Section 208; GM/RT2100 Issue 4; and research results sponsored by the Federal Railroad Administration Office of Research and Development [3, 4].

2. Table attachment requirements

2.1 Attachment strength

A workstation table is considered to be an interior fitting and is subject to the attachment strength requirements in the Code of Federal Regulations, Title 49, Part 238, Section 233 Article (c). This section is intended to provide additional guidance in satisfying these CFR requirements.

The Code of Federal Regulations, Title 49, Part 238, Section 233 Article (c) specifies the following:

> Other interior fittings within a passenger car shall be attached to the carbody with sufficient strength to withstand the following individually applied accelerations acting on the mass of the fitting:
>
> - Longitudinal: 8g;
> - Vertical: 4g; and
> - Lateral: 4g.

The equivalent loads in Article (c) may be applied quasi-statically or dynamically. If the load is applied dynamically, then the acceleration time history shall have a duration of 250 ms and a peak of 4g in the lateral and vertical direction, and 8g in the longitudinal direction, with the peaks occurring at 125 ms; an example of the 8g crash pulse is shown in **Figure 3**.

2.2 Mounting hardware

The hardware used to attach the table to the carbody shall conform to the Code of Federal Regulations, Title 49, Part 238, Section 233 Article (d), as appropriate: To the extent possible, all interior fittings in a passenger car, except seats, shall be recessed or flush-mounted.

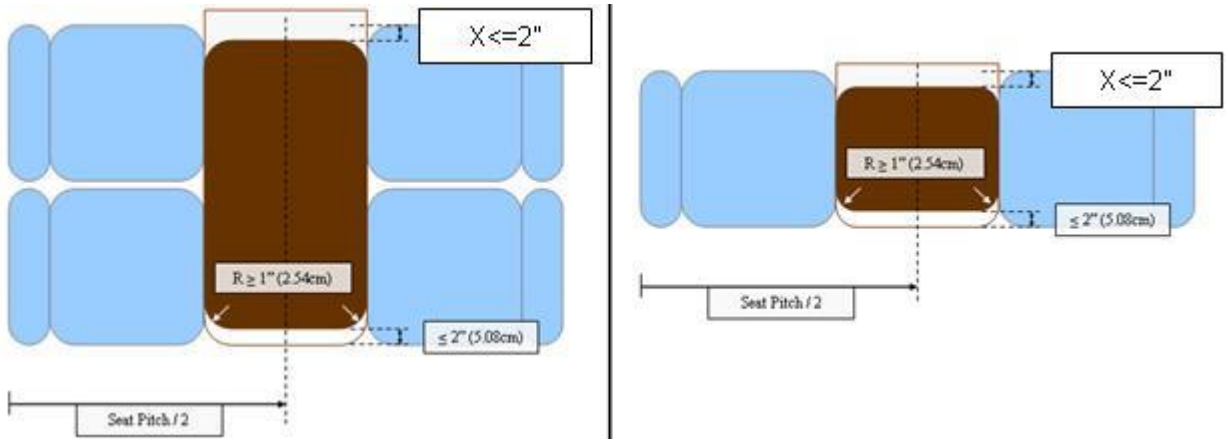
3. Table geometry requirements

The table design geometry shall minimize points of entrapment and concentrated loading points (associated with sharp radii) during a rail vehicle accident. The table shall compartmentalize occupants between the occupied seat and the table in the event of an accident.

The inboard corners of the table edge shall be rounded to a minimum radius of 1 in. (2.54 cm). The edges of the table's top and bottom shall be rounded to a minimum radius of $^{3}/_{16}$ in. (0.5 cm) around the entire perimeter. Laterally, the table shall begin at the wall or no more than 2 in. (5.08 cm) inboard of the outboard edge of the window seat base and extend to the inboard edge of the aisle seat base, or no more than 2 in. (5.08 cm) from the inboard edge of the aisle seat. See **Figure 1** for a schematic of the geometry measurements. While **Figure 1** depicts tables at one- and two-passenger seats, the same geometry requirements apply to tables located at three-passenger seats, or tables installed between a single seat and a double seat, or between a double and a triple seat. In the latter two cases, the table must extend to within 2 in. of the wider seat, per the schematic below. A tapered tabletop is permissible if it meets all the testing requirements in this standard.

If Option B is used in Section 5.2 to demonstrate compliance with the crashworthiness requirements, then the edge of the tabletop must be at least 2.0 in. thick. This additional requirement is intended to minimize concentrated abdominal loads in the event of a collision. This table thickness requirement is applied to Option B only because neither the dynamic sled test with standard 50th percentile anthropomorphic test device (ATD), nor the quasi-static loading test, is capable of assessing abdominal injury associated with overly concentrated loads.

FIGURE 1
Geometry Measurements, Top View



4. Operational testing

The objective of the operational testing is to demonstrate that the operational loads do not cause damage to the table that would prevent it from functioning as intended in a collision.

The table and its support structure shall be designed and tested to meet the individually applied quasi-static load requirements given below with no permanent yielding of structural materials, or loss of function, or change in appearance of the table or support structure. A small amount of yielding due to relieving of trapped manufacturing stresses (welding, forming, etc.) shall be permissible; however, there shall be no visible indication of permanent deformation.

The table shall be mounted on a rigid test fixture or simulated car structure using the same fasteners or attachment mechanism used in service — bolts, screws, seat track, tapping plate, etc. The tabletop shall not experience permanent deformation under the following individually applied load conditions:

a. Minimum 225 lbf (1000 N) load applied on a 5 × 5 in. area (±0.25 in.) in a vertical downward direction at a location on the top of the table that represents the worst-case loading condition, generally at a point farthest away from the table support structure. The load shall be applied for a minimum of 5 s.
b. Minimum 337 lbf (1500 N) load applied on an 8 in.(±0.25 in.) length across the full thickness of the tabletop in a longitudinal direction at a location on the table edge that represents the worst-case condition, generally at a point farthest away from the table support structure. The load shall be applied for a minimum of 5 s.

5. Crashworthiness testing

The objectives of crashworthiness testing are to demonstrate the following:

- The table effectively absorbs kinetic energy, while limiting the contact force between the occupants and the table.
- The table remains attached to the test sled or fixture.
- The table effectively compartmentalizes the occupants.
- The table effectively limits human injury of the head, chest, neck, abdomen and femurs.
- Table deformation does not expose occupants to sharp edges or spaces capable of entrapping an occupant during a rail accident.
- Table components that exceed the material yield strength shall display post-yield plasticity.

Two options are provided below to demonstrate that a particular table design complies with these crashworthiness objectives. The test(s) shall be conducted in accordance with the requirements given in Section 5.1 for Option A or Section 5.2 for Option B.

If a structurally identical table installed in a similar physical arrangement (see Section 6 for maximum variances allowed) has been tested in accordance with the requirements of this standard, then at the discretion of the purchaser and in lieu of added testing, the manufacturer may provide test data in accordance with Section 6 of this document to demonstrate that the table is in compliance with all the requirements of this standard.

5.1 Option A: Dynamic sled test with Hybrid IIIRS or THOR ATD

A dynamic sled test shall be conducted in accordance with the conditions given in Section 5.1.1. The required test measurements and documentation are given in Section 5.1.2. The workstation table shall comply with all the performance requirements listed in Section 5.1.3.

5.1.1 Dynamic sled test conditions

A workstation table shall be mounted on a simulated car structure or rigid test fixture using the same fasteners or attachment mechanism used in service — bolts, screws, track, tapping plate, etc. If the table is fastened directly to a rigid test fixture, then tri-axial load cells shall be placed at the table mounting locations between the table and the test fixture to measure reaction loads applicable to structural car design for the purpose of confirming the adequacy of the carbody structure to accommodate these loads without failure. The application of load cells must not, however, affect performance of the fastening device.

A passenger seat shall be mounted to the test sled at the nominal location relative to the table for the intended rail service. A facing seat is not required to be mounted on the opposite side of the table; however, a means of evaluating potential intrusion of the workstation table toward a facing seat must be provided. Instrumented anthropomorphic test devices (ATDs), representative of 50th-percentile adult males, shall be positioned to face the direction of travel, such that all seats are simultaneously occupied by ATDs. At least one ATD shall be a Hybrid IIIRS [5], or Test device for Human Occupant Restraint (THOR) [6], that is capable of measuring compression and rates of compression of the abdomen and chest, and for calculating the injury criteria listed in Section 5.1.2 below.

If only one Hybrid IIIRS or THOR ATD is available, then that ATD shall be placed in the seat position nearest the wall. A standard HIII 50th-percentile male ATD, in accordance with 49 CFR 572, Subpart E, may be used in the other seat position(s). An ATD shall be positioned at the table in each available seat, facing the direction of travel.

The adjustment, positioning and care of all ATDs used in the testing processes shall be in accordance with the standards and requirements needed to comply with SAE standard AS8049, “Performance Standards for Single-Occupant, Side-Facing Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft.”

Each ATD shall be clothed in a form-fitting cotton stretch garment with short sleeves and mid-thigh-length bottoms. The ATDs shall also be fitted with shoes. Each ATD shall be centered in the seat, in as nearly symmetrical a position as possible and in a uniform manner so as to obtain reproducible test results. The following ATD components shall be positioned as follows:

- Back shall be placed against the seat back without clearance.
- Knees shall be separated by 4 in.
- Hands shall be placed on the thighs, palms down, as shown in **Figure 2**.
- Feet shall be placed flat on the floor so that the centerlines of the lower legs are approximately parallel.
- Lower legs shall be placed as close to vertical as possible.

The ATDs may be tethered to the sled; however, tethering shall not restrict ATDs such that evaluation of compartmentalization is impeded.

If a test fixture is used instead of a carbody section, then the fixture shall act as a rigid mounting point for the table and seats. See **Figure 2** for a schematic of the sled configuration. The test sled shall be subjected to an 8g, 250 ms crash pulse, as shown in **Figure 3**. The measured crash pulse shall comply with the requirements

established in SAE AS8049 Revision A, Appendix A, to determine that the actual pulse is within accepted tolerance parameters.

FIGURE 2
Schematic of Sled Configuration

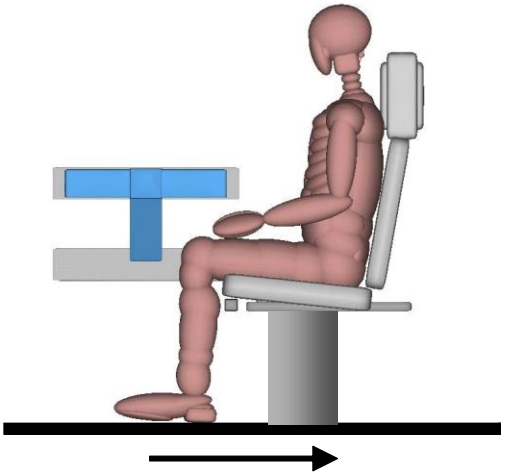
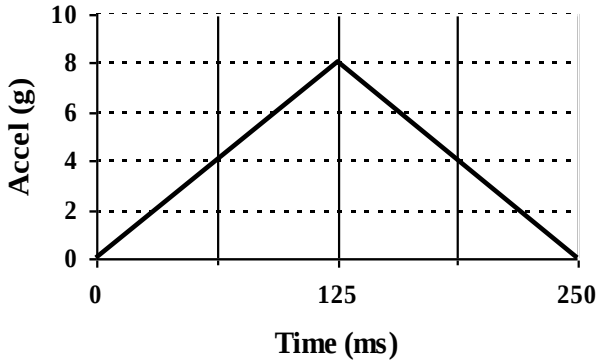


FIGURE 3
Longitudinal Crash Pulse



5.1.2 Dynamic sled test measurement and documentation requirements

The following data shall be obtained for each ATD during the test in accordance with SAE J211/1:

- triaxial head acceleration-time history
- triaxial chest acceleration-time history
- axial left and right femur force-time history
- upper neck extension/flexion bending moment, M_y time history
- upper neck axial force, F_z time history
- upper neck shear force, F_x time history
- chest compression-time history
- abdominal compression-time history
- longitudinal acceleration-time history of the test sled
- triaxial load cell force-time history, if load cells are used to measure reaction loads

The following measurements, which are needed for information related to potential configuration modification allowances provided in Section 6, shall be taken before the test (pre-test):

- Longitudinal distance (in a horizontal plane) between the front edge of the tabletop and the seat back on the side of the ATDs (depicted as measurement "A" in **Figure 4**).
- Vertical distance between top of tabletop and the highest point on the seat bottom cushion (depicted as measurement "B" in **Figure 4**). If a facing seat is not used, then the measurement may be taken on the launch seat, before the ATD is placed in the seat.

The following measurement shall be taken after testing (post-test):

- Longitudinal distance (in a horizontal plane) between the front edge of the tabletop and the seat back on the side opposite the ATDs (depicted as measurement "C" in **Figure 4**). If a facing seat is not used, then measurement "C" shall be calculated using the theoretical position of the facing seat.

The following injury criteria shall be computed for each ATD (per the definitions described at the end of this document):

- head injury criterion (HIC15)
- 3 ms chest g's
- axial femur load
- upper neck axial tension/compression loads
- neck injury criterion (Nij)
- chest compression
- chest viscous criterion (VC)
- abdominal compression
- abdominal viscous criterion (VC)

Unless otherwise indicated, instrumentation for data acquisition, data channel frequency class and moment calculations are the same as those given for the 49 CFR Part 572, Subpart E, Hybrid III Anthropomorphic Test Device.

The test shall be captured using high-speed video cameras providing an overhead view (plan view) and a side view (elevation view). Lighting shall be sufficient for high-quality analysis of the recording. Pre- and post-test still digital photographs of the test configuration shall be taken. At a minimum, photographs of the test sled should be taken from all four sides, as well as close-up photographs of the seats and tables to document any damage.

5.1.3 Dynamic sled test performance requirements

For a successful test, the following requirements must be met:

1. The table and any table components must remain attached to the test fixture or simulated rail car structure, with the exception of superficial, nonstructural components of negligible weight.
2. The table shall not penetrate the survival space reserved for occupants in the facing seat, where applicable, so as not to entrap the facing passengers or prevent egress. The survival space, as depicted by measurement "C" in **Figure 4** and **Figure 5**, shall not be less than 15 in., as measured post-test (theoretical location if facing seat is not used in actual test) using predominant seat pitch for seats surrounding tables.
3. The ATDs shall be compartmentalized, as defined in the definitions at the end of this document.
4. All injury measurements computed in Section 5.1.2 must meet the following criteria, which are defined at the end of this standard:
    - Head injury criterion, HIC15, shall be less than 700*.
    - Neck injury criterion, Nij, shall be less than 1.0*.
    - Neck axial tension, F_z, shall be less than 938 lbf (4170 N)*.
    - Neck axial compression, F_z, shall be less than 899 lbf (4000 N)*.
    - Chest deceleration shall be less than 60g over a 3 ms clip*.
    - Chest compression shall be less than 2.5 in. (63 mm)*.
    - Chest viscous criterion shall be less than 1.0 m/s+.
    - Abdominal compression shall be less than 2.6 in. (67 mm)+
    - Abdominal viscous criterion shall be less than 1.98 m/s+.
    - Axial femur load shall be less than 2250 lbf (10,000 N)*.

NOTE: Items marked with * were originally derived from 49 CFR 571.208. Items marked with + were originally derived from GM/RT2100, Issue 4.

FIGURE 4
Schematic Depicting Pre- and Post-Test Measurements

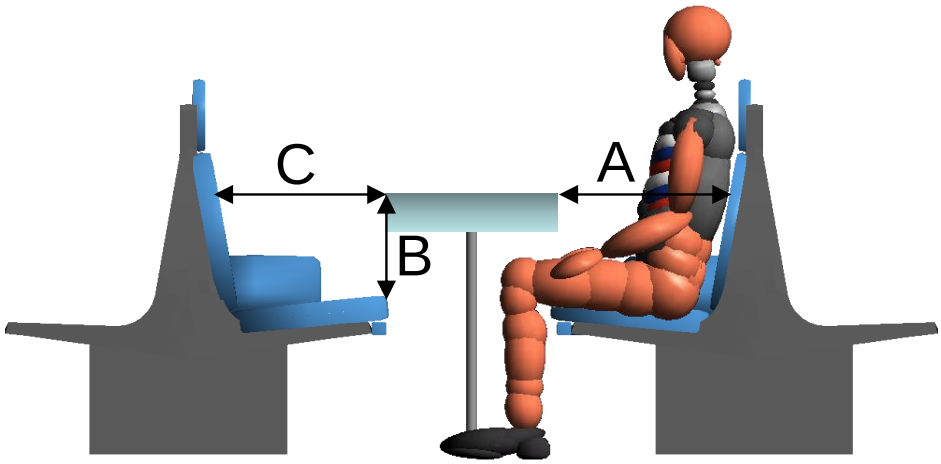
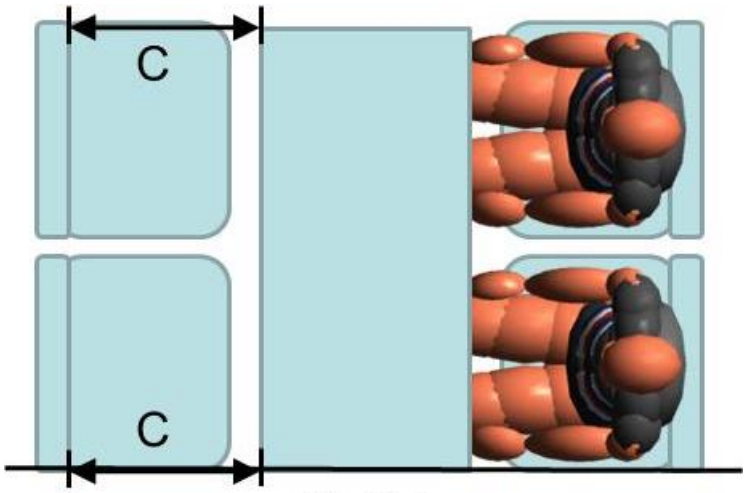


FIGURE 5
Schematic Depicting Measurement Locations



5.2 Option B: Dynamic sled test with standard HIII ATD coupled with quasi-static testing

Option B may not be used to demonstrate compliance for tables with an edge thickness less than 2.0 in. (50 mm). Thinner tables must conform to the requirements in Option A. Option B may not be used to demonstrate compliance for adjustable tables. Adjustable tables must conform to the requirements in Option A.

If Option B is selected to demonstrate table crashworthiness, then the following two tests shall be conducted:

- a dynamic sled test with standard HIII 50th percentile male ATDs; and
- a quasi-static destructive loading test.

The purpose of the dynamic sled test is to demonstrate that:

- the table remains attached to the test sled;
- the table effectively compartmentalizes the occupants; and
- the table effectively limits human injury for the head, chest, neck and femurs.

The purpose of the quasi-static test is to demonstrate that:

- the table effectively absorbs kinetic energy, while limiting the contact force between the occupants and the table. The performance requirements for this test were chosen to limit human injury to the abdomen.

5.2.1 Dynamic sled test

The test conditions, measurement and documentation requirements, and performance requirements for the Option B dynamic sled test are described in this section.

5.2.1.1 Dynamic sled test conditions

The dynamic sled test for Option B shall be conducted according to the test conditions in Section 5.1.1, except that the ATDs shall all be standard HIII 50th percentile male ATDs, in accordance with 49CFR572, Subpart E.

5.2.1.2 Dynamic sled test measurements and documentation requirements

The measurement and documentation requirements for Option B shall follow the instructions provided for Option A in Section 5.1.2, with the exception of abdominal compression time history and injury criteria for abdominal compression and the abdominal viscous criterion.

5.2.1.3 Dynamic sled test performance requirements

The performance requirements for Option B shall follow the instructions provided for Option A in Section 5.1.3, with the exception of injury criteria requirements for abdominal compression and the abdominal viscous criterion.

5.2.2 Quasi-static test

The test conditions, measurement and documentation requirements, and performance requirements for the Option B quasi-static test are described in this section.

5.2.2.1 Quasi-static test conditions

The quasi-static loading test is subject to the following conditions. A workstation table shall be mounted on a rigid test fixture or simulated car structure using the same fasteners or attachment mechanism used in service — bolts, screws, track, tapping plate, etc. The workstation table shall be destructively tested under quasi-static loading conditions.

The quasi-static test shall be conducted with the loads applied to the table simultaneously via rigid body blocks (depicted in **Figure 6**), one at each seat position, to which hydraulic cylinders shall be attached (see **Figure 7** for a schematic of the test setup). The body blocks shall be aligned laterally at the center of each seat

position for the intended service. The body blocks shall be centered vertically on the table edge. The displacement rate of the cylinders shall be approximately 2 in./min. The motion of each hydraulic cylinder shall be stopped independently when the individually applied load at a single seat position exceeds 2250 lbf, or when the maximum table crush has been achieved, whichever comes first.

FIGURE 6
Body Block (dimensions are in inches)

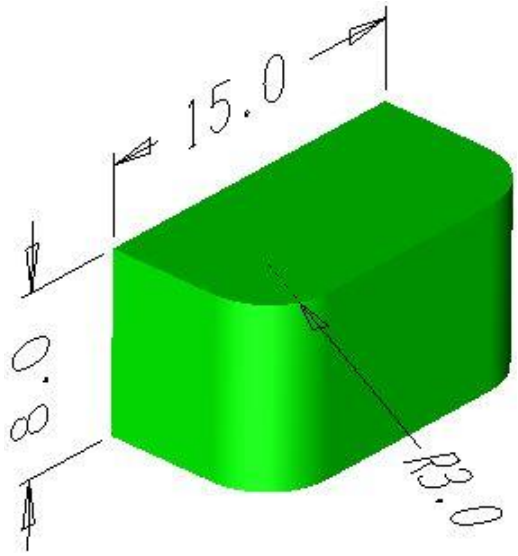
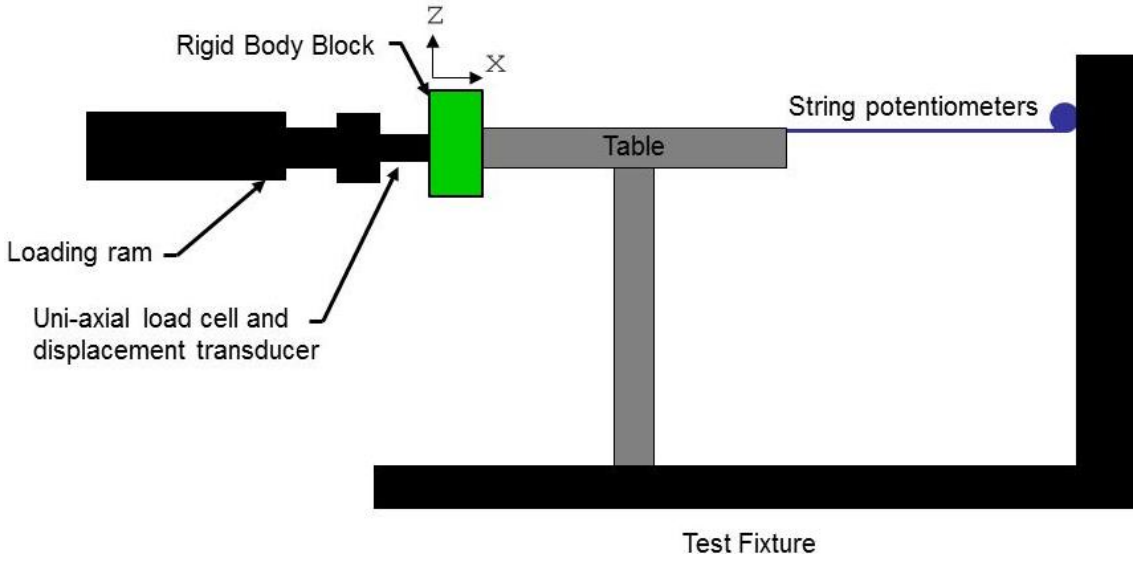


FIGURE 7
Schematic of Test Setup



5.2.2.2 Quasi-static test measurements and documentation requirements

The force-time history and displacement-time history of each loading ram shall be measured. The longitudinal displacement of the tabletop shall be measured on the side opposite the load applications in line with the applied loads using string potentiometers (see **Figure 7**).

The table penetration into the passenger space on the opposite side of the table shall be calculated by subtracting the longitudinal deflection of the table (measured by string potentiometers) from the initial theoretical longitudinal distance between the table edge and the seat back.

The energy absorbed by table deformation at each table position shall be calculated as follows:

- Plot the table deflection vs. time, where deflection is equal to the displacement of the loading ram, from t_0 to t_f, where:
  - t_0 = time that ram contacts the table; and
  - t_f = time that force returns to zero.
- Cross-plot the force vs. deflection time history from t_0 to t_f.
- Integrate the force vs. deflection time history from t_0 to t_f to calculate the energy absorbed by plastic (permanent) table deformation at each seat position.

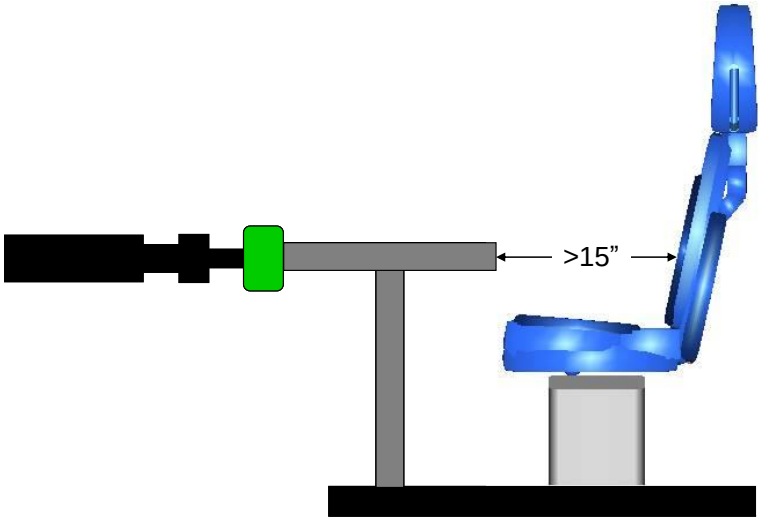
Still photographs of the table shall be taken pre- and post-test. The progress of the test shall also be recorded using a digital video camera at two locations (top and side views).

5.2.2.3 Quasi-static test performance requirements

For a successful test, the following requirements must be met:

1. The table and any table components must remain attached to the test fixture or simulated rail car structure, with the exception of superficial, nonstructural components of negligible weight.
2. The table shall not penetrate the survival space reserved for occupants in the facing seat, where applicable, so as not to entrap the facing passengers or prevent egress. The survival space, as depicted by measurement "C" in **Figure 4** and **Figure 5**, shall not be less than 15 in., as measured post-test (theoretical location if facing seat is not used in actual test) using predominant seat pitch for seats surrounding tables.
3. The energy absorbed by plastic (permanent) deformation at each seat position, as calculated above, must be at least 6250 in.-lbf when the applied load reaches 2250 lbf, or when the maximum table crush has been achieved, whichever comes first.

FIGURE 8
Schematic Depicting Minimum Space Requirement



6. Test implementation plan, procedures and report

All testing performed by the table manufacturer shall be documented with a test plan, test procedures and test report. The test implementation plan and test procedures should be submitted and approved by the purchaser prior to actual testing. Tests should be scheduled to allow the purchaser to witness the testing. The purchaser may elect to accept existing test reports and procedures, provided that the table to be purchased is demonstrated to be structurally identical to that tested and that the test reports and procedures meet the requirements listed below.

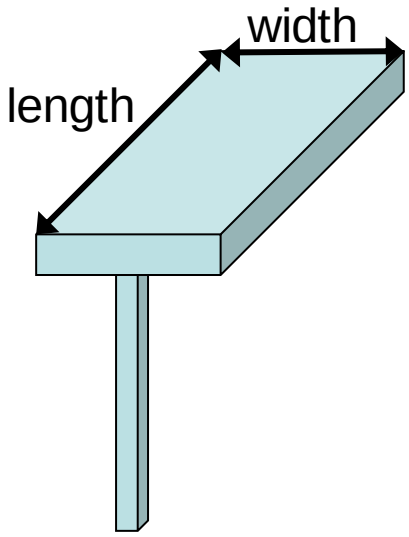
If a structurally identical table design had been tested in a specific configuration and met all the requirements of this standard, then it does not need to be retested for a different installation configuration if all the parameter modifications are within the defined acceptable tolerance range below:

1. Longitudinal distance (in a horizontal plane) between the front edge of the tabletop and the seat back (depicted as measurement “A” in **Figure 4**): +1/-3 in.
2. Vertical distance between top of tabletop and the highest point on seat bottom cushion (depicted as measurement “B” in **Figure 4**): ±1 in.

It may be desirable to manufacture a table with slightly different tabletop geometry for different applications. If minor geometrical changes are made to an otherwise structurally identical table design that had been tested and met all the requirements of this standard, then it does not need to be retested if geometry changes are within the defined acceptable tolerance range below:

1. Tabletop length: +1/-3 in.
2. Tabletop width: +3/-0 in. (see schematic in **Figure 9**).

FIGURE 9
Schematic of Tabletop Geometry Definitions



6.1 Test implementation plan

The test implementation plan shall describe how the tests will be conducted, including a description of the test fixtures, instrumentation and data acquisition system. Prior to table testing, a test plan shall be submitted by the table manufacturer to the purchaser. The final test plan shall be reviewed and approved by the purchaser.

6.2 Test procedures

A set of test procedures for each test shall be prepared by the table manufacturer and submitted for approval to the purchaser. The test procedures shall as a minimum include the following:

- test objective
- complete description of test article
- pass/fail criteria
- list of test equipment
- schematic illustration(s) of test setup
- description of the attachment of the table to the text fixture/load cells
- time and location of tests
- sequential, step-by-step test procedure
- test data sheets (for recording data during testing)
- drawing of the assembled seats depicting all dimensions of the assembly, with references to the floor and adjacent facing seats and table

6.3 Test reports

Test reports shall as a minimum include the following:

- test requirements
- text or cover letter that provides a summary of the test results, the date and location of the test, and the signature of the person or people responsible for conducting the test and writing the report
- calibration data for all test measuring equipment
- pre- and post-test measurements (dimensions, etc.)

- calculated injury criteria, per test requirements
- graphical output of all data channels
- test videos
- pre- and post-test photos

7. Flammability and smoke emission

Materials used in table construction shall meet the requirements given in 49 CFR Part 238, Appendix B.

8. Engineering drawings

As part of its work and prior to the supply of tables, the table manufacturer shall submit engineering drawings for approval. The drawings shall, at a minimum, include the following:

- overall dimensions and tolerances of the table assembly
- weight and location of the center of gravity of the table assembly
- mounting requirements including hole sizes, recommended bolt sizes and torque requirements, and recommended grade of bolts to be used for mounting
- description of materials

9. Submittals for approval

Prior to acceptance of the table by the purchaser, the table manufacturer shall submit the documentation listed in **Table 1**.

TABLE1
Submittals

Submittal	Reference Standard Section
Operational Quasi-Static Test Report	4
Crashworthiness Testing Report	5
Test implementation plan	6.1
Test procedures	6.2
Test reports	6.3
Flammability and Smoke Emission Report(s)	7
Engineering drawings	8

As an option, submittals from previous table procurements may be submitted to satisfy this requirement as negotiated by the purchaser and table manufacturer, provided that any deviations from previously tested tables are within the acceptable tolerance range defined in Section 6.

10. Procurement specifications

This standard is intended to be supplemented by procurement specifications prepared by the purchaser and directed to the table manufacturer.

Related APTA Standards

- APTA-PR-CS-S-006-98 Rev 1, Standard for Attachment Strength of Interior Fittings for Passenger Rail Road Equipment
- APTA PR-I&M-RP-002-98: "Development Model for Rail Car Technical Documentation"

References

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

- 49 CFR Part 238, Section 103: Fire Safety
- 49 CFR Part 238, Section 233: Interior Fittings and Surfaces
- 49 CFR Part 571, Section 208: Federal Motor Vehicle Safety Standards
- 49 CFR Part 572: Anthropomorphic Test Devices
- SAE J211-1, Instrumentation for Impact Test - Part 1 - Electronic Instrumentation
- SAE AS8049, Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft
- GM/RT2100, Issue Four, Requirements for Rail Vehicle Structures, Railway Group Standard , United Kingdom, Rail Safety and Standards Board Ltd., December 2010

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Definitions

abdominal compression criterion: Peak *x*-axis deflection measured at each abdominal sensor, filtered at CFC600.

abdominal viscous criterion (VC): A value calculated according to the following formula, using the *x*-axis data from each abdominal sensor, filtered at CFC600:

$$\text{Abdominal VC} = V(t) \times C(t),$$

where
V(t) = instantaneous abdominal velocity (m/s)
C(t) = instantaneous abdominal compression ratio, C(t)=D(t)/DAB
D(t) = instantaneous abdominal compression (mm)
DAB = depth of the uncompressed abdomen test device (mm)

adjustable tables: Fixed tables that have moveable parts, such as a hinged or sliding portion of the tabletop, designed for improved ingress/egress.

axial femur load criterion: Peak axial femur load (F_z), filtered at CFC600.

chest compression criterion: Peak *x*-axis deflection measured at the sternum, filtered at CFC600.

chest deceleration criterion: The resultant chest deceleration, filtered at CFC1000, shall not exceed 60g, except for intervals whose cumulative duration is not more than 3 ms.

chest viscous criterion (VC): A value calculated according to the following formula, using the *x*-axis data measured at the sternum, filtered at CFC600:

$$\text{Chest VC} = 1.3 \times V(t) \times C(t)$$

where
V(t) = instantaneous chest velocity (m/s)
C(t) = instantaneous chest compression ratio, C(t) = D(t) / 229
D(t) = instantaneous chest compression in mm.

coach seating: Revenue seats in rail passenger coach cars and cab cars, in all classes of service — business, first, coach, economy, etc.

compartmentalization: An interior design strategy that aims to contain occupants between rows of seats or between seats and tables during a collision, preventing occupants from traveling over seats or tables and impacting other passengers and hostile objects. During sled testing, ATD compartmentalization is evaluated up until the point of maximum forward progress of the ATD. The ATD must be confined between the workstation table (potentially deformed) and the initially occupied seat until the ATD begins to rebound and move away from the impacted table.

facing seats: Adjacent rows of passenger rail coach seats where one row of seats is facing forward and one row of seats is facing backward. These seating configurations are referred to as face-to-face seats, or open-bay seats when a workstation table is not present.

fixed tables: Tables that are permanently affixed to the rail car. Tray tables attached to seatbacks are not considered to be fixed tables and are not subject to the requirements of this standard.

HIC15 (head injury criterion): A value calculated according to the following formula, using the resultant head acceleration, filtered at CFC1000:

$$HIC = \left[(t_2 - t_1)\left[\frac{1}{t_2 - t_1}\int_{t_1}^{t_2} a(t)dt\right]^{2.5}\right]_{\max}$$

where
t_1, t_2 = any two points in time during the head impact, in seconds
a(t) = the resultant head acceleration during head impact, in g's
HIC15 indicates that t_1 and t_2 are not separated by more than 15 ms. HIC15 shall not exceed 700.

ingress/egress space: Space available for passengers to occupy or leave an occupant space. This has importance for both normal passenger seating and also for emergency exit considerations.

longitudinal: The direction in a horizontal plane parallel to the direction of travel.

lateral: The direction in a horizontal plane perpendicular to the direction of travel.

neck axial compression criterion: Peak compressive axial (F_z) load measured at the upper neck load cell, filtered at CFC1000.

neck axial tension criterion: Peak tensile axial (F_z) load measured at the upper neck load cell, filtered at CFC1000.

Nij (neck injury criterion): A value calculated according to the following formula:

$$N_{ij} = \frac{F_z}{F_{\text{int}}} + \frac{M_y}{M_{\text{int}}}$$

where
F_z = axial upper neck load-time history, filtered at CFC1000
F_{int} = critical intercept values used for normalization, 1530 lbf (6086 N) in tension, and 1385 lbf (6160 N) in compression;
M_y = flexion/extension neck bending moment-time history at the occipital condyle, filtered at CFC600;
M_{int} = critical intercept value used for normalization, 229 lbf-ft (310 Nm) in flexion, and 100 lbf-ft (135 Nm) in extension;
F_x = shear upper neck load-time history, which is used to compute the neck bending moment, M_y, about the occipital condyle, filtered at CFC1000.

primary impact: The impact between the rail car and an object, such as another rail car, during a collision.

secondary impact: The impact of passengers with interior structures during a collision.

tertiary impact: Another impact with the interior subsequent to a secondary impact during a collision. For example, a passenger may experience a secondary impact with a seat back and then a tertiary impact with another object in the car.

workstation table: A fixed interior table that is installed in a passenger rail coach car, consisting of a flat tabletop and its supporting structure that is often installed between facing seats.

Abbreviations and acronyms

APTA	American Public Transportation Association
ATD	anthropomorphic test device
cm	centimeter
CFR	Code of Federal Regulations
DMU	diesel multiple unit
EMU	electrical multiple unit
ft	foot
G, or g	acceleration due to gravity
HIC	head injury criterion
in.	inch
lb-ft	pound-foot
lbf	pounds force
Nij	neck injury criterion
ms	milliseconds
m/s	meter per second
N	Newton
NATSA	North American Transit Services Association
Nm	Newton-meter
s	second
SAE	SAE International, formerly the Society of Automotive Engineers
THOR	Test device for Human Occupant Restraint
VC	viscous criterion

Summary of changes

Revision – 1. The original version of this workstation table safety standard specified the use of an advanced test dummy capable of evaluating abdominal injury to demonstrate the crashworthiness of workstation tables in Section 5. Due to the limited availability of these test dummies, this revision offers an alternative set of crashworthiness requirements. An equivalent level of safety will be provided by tables that comply with either crashworthiness option.

The first option is to conduct a dynamic 8g sled test using at least one advanced test dummy, as per the original version of the standard. The second option is to conduct a dynamic 8g sled test using standard HIII 50th percentile male test dummies, combined with a separate quasi-static destructive loading test. The quasi-static test is needed to assess the risk of abdominal injury, in lieu of testing with a test dummy that is instrumented to evaluate abdominal injury. If Option B is used, then the edge of the tabletop must be at least 2.0 in. This additional requirement is to address the hazard of concentrated abdominal loading caused by thin tables, which cannot be properly evaluated without the advanced test dummy.

It is presumed that once advanced test dummies become commercially available for testing in the United States, the first option will be the preferred choice, as only one test will be required instead of two.

Revision-1 also contains general editorial improvements and clarifications.

Document history

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