Fixed Workstation Tables in Passenger Rail Cars

Abstract: This Safety 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: fixed workstation tables, passenger rail, safety, crashworthiness

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 coach 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 is intended to provide guidance for the design and testing of fixed workstation tables used in passenger rail coach cars as it applies to passenger collision safety. 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 table standard applies to fixed workstation tables positioned at revenue seats in coach and cab cars, including electrical multiple units (EMUs) and diesel multiple units (DMUs), and in all classes of coach seating, i.e. business class, first class, economy, coach, etc. This standard does not apply to fold-down seatback tables or other non-fixed tables, or to tables in sleeping cars, dining cars, lounge cars or food service cars.
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1. Overview

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 [1]. Tables designed to absorb energy and limit contact forces can significantly reduce the risk of injury. Additionally, tables positioned between facing rows of coach 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 coach and cab cars that are part of the general railroad system of transportation. This table standard applies to fixed workstation tables positioned at revenue seats in coach and cab cars, and in all classes of coach seating, i.e. business class, first class, economy, and coach, etc. This standard does not apply to fold-down seatback tables or other non-fixed tables, or to tables in sleeping cars, dining cars, lounge cars or food service cars. 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; American Public Transportation Association (APTA) SS-C&S-016, revision 2; and the United Kingdom Railway Group Standard GM/RT2100 Issue 4. Maximum 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.

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:

1. Longitudinal: 8g;
2. Vertical: 4g; and
3. 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 4 or 8G, as appropriate, 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 \( \frac{3}{16} \) inch (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 the figure below 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 later two cases, the table must extend to within 2” of the wider seat, per the schematic below. A tapered table top is permissible if it meets all of the testing requirements in this standard.

4. Operational testing

The objective of the operational testing is to verify 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, 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, i.e., 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 sec.

b. Minimum 337 lbf (1500 N) load applied on an 8 in.(±0.25 in.) length across the full thickness of the table 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 sec.

5. Dynamic sled testing

The objectives of sled testing are to verify the following:

- The table effectively absorbs kinetic energy, while minimizing the contact force between the occupants and the table.
- The table remains attached to the test sled.
- The table effectively compartmentalizes the occupants.
- The table effectively minimizes human injury.

The following test is required to verify that a particular table design meets these objectives. The test shall be conducted in accordance with the conditions given in Section 5.1. The required test measurements and documentation are given in Section 5.2. The workstation table shall meet all the performance requirements listed in Section 5.3.

If a structurally identical table has been tested in accordance with the requirements of this standard, then at the discretion of the purchaser, the manufacturer may provide test data in accordance with Section 6 of this document to satisfy that the table is in compliance with all the requirements of this standard, for approval of the subject table by the purchaser.

5.1 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, i.e., bolts, screws, track, tapping plate, etc. If the table is fastened directly to a rigid test fixture, then triaxial 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, but is optional. 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 an ATD for each test. The ATDs shall be test devices for Human Occupant Restraint (THORs)[2], or Hybrid III RRs [3], that are capable of measuring compression of the abdomen and chest, and corresponding rates of compression, and for calculating the injury criteria listed in Section 5.3 below.
If advanced ATDs with abdominal instrumentation are not available, then Hybrid III 50th-percentile male ATDs, in accordance with 49 CFR Part 572, Subpart E, may be used in the sled test. In this case, a validated computer model, developed using a commercial computer code such as MADYMO [4], shall be used to demonstrate that the table can meet the abdominal injury criteria specified in Section 5.3 under the same simulated test conditions. Model validation requirements are described below in Section 5.3.1.

If only one THOR or HIIIRS ATD is available, then that ATD shall be placed in the seat position nearest the wall. A standard HIII 50th-percentile male ATD 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. Computer modeling will not be required to demonstrate compliance with abdominal injury criteria for the standard ATDs, provided that the required abdominal injury criteria are measured and met for at least one THOR or HIIIRS ATD.

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 seated in the center of the occupant placement, 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 four inches.
- 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. If a computer model is used instead of an advanced ATD to evaluate abdominal injuries, then the measured acceleration time history from the test sled shall be used for the crash pulse in the model.
5.2 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/extension 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 shall be taken before the test (pre-test). These pre-test measurements are needed for information related to potential configuration modification allowances provided in Section 6:

- 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 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 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)
- 3ms chest Gs
- 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 cameras providing an overhead view and a side 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.

### 5.3 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.
2. The crush of the table shall not result in any exposed sharp edges with which an occupant would be at risk of coming into contact; nor spaces capable of entrapping an occupant during a rail accident.
3. Any table components that exceed the material yield strength shall display post-yield plasticity.
4. 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 shall not be less than 15 in., as measured post-test (theoretical location if facing seat is not used in actual test).
5. The ATDs shall be compartmentalized, as defined in the definitions at the end of this document.
6. All injury measurements computed in Section 5.2 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 60 G over a 3ms 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\(^+\); and
   - 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.
5.3.1 Performance requirements for validated computer model
If a computer model is used (as described above in Section 5.1) to demonstrate compliance with the requirements for abdominal compression and abdominal viscous criterion, then the computer modeling results will be considered to be valid if all of the following requirements are met:

1. The modeling results for all injury measurements specified in Section 5.3 for the head, neck, chest and femur are below the maximum threshold values and also within ±20 percent of the comparable injury criteria measurements from the sled test.
2. Measurement “C” (depicted in Figure 4 above) taken from the model shall be within ±20 percent of the physical measurement taken post-test. If a facing seat is not used, then measurement “C” shall be calculated using the theoretical position of the facing seat.
3. The peak permanent table crush estimated with the computer model is within ±20 percent of the peak permanent table crush measured in the sled test, for each seat position.

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 reports. 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, at his or her option, 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, it does not need to be retested for a different installation configuration if all of 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.; and
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, it does not need to be retested if geometry changes are within the defined acceptable tolerance range below:

1. Tabletop length: +1/-3 in.; and
2. Tabletop width: +3/-0in. (see schematic in Figure 5).

**FIGURE 5**
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 test 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.

<table>
<thead>
<tr>
<th>TABLE1</th>
<th>Submittals</th>
<th>Reference Standard Section</th>
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<tr>
<td></td>
<td>Operational Quasi-Static Test Report</td>
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<td></td>
<td>Dynamic Sled Test Report</td>
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<tr>
<td></td>
<td>Computer modeling results with validation documentation per Section 5.3.1, if applicable</td>
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</table>
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. **Reference documents/drawings**

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 572: Anthropomorphic Test Devices
- SAE J211-1, Surface Vehicle Recommended Practice
- 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

10.1 **Procurement specifications**

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


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, \(C(t) = \frac{D(t)}{D_{AB}}\)
- \(D(t)\) = instantaneous abdominal compression (mm)
- \(D_{AB}\) = depth of the uncompressed abdomen test device (mm)

**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 60Gs, 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:

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

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, i.e., 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.

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

\[
HIC = \left( t_2 - t_1 \right) \left[ \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t) dt \right]_{\text{max}}^{1.5}
\]

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 Gs
- 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 (Fz) load measured at the upper neck load cell, filtered at CFC1000.

**neck axial tension criterion:** Peak tensile axial (Fz) load measured at the upper neck load cell, filtered at CFC1000.
Nij (neck injury criterion): A value calculated according to the following formula:

\[ N_{ij} = \frac{F_z}{F_{int}} + \frac{M_y}{M_{int}} \]

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:** Refers to the impact between the rail car and an object, such as another rail car, during a collision.

**secondary impact:** Refers to the impact of passengers with interior structures during a collision.

**tertiary impact:** Refers to 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
- **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
- **MADYMO** Mathematical DYnamic MOdels
- **ms** milliseconds
- **m/s** meter per second
- **N** Newton
- **Nm** Newton-meter
- **SAE** SAE International, formerly the Society of Automotive Engineers
- **sec** second
- **THOR** Test device for Human Occupant Restraint
- **VC** viscous criterion