



Standard for Powered Exterior Side Door System Design for New Passenger Cars

Abstract: This standard contains the minimum requirements for powered exterior side door systems and door system function on new rail passenger cars.

Keywords: doors, door systems, emergency evacuation

Summary: This standard identifies the minimum design requirements for powered exterior side door systems on new intercity and commuter rail passenger cars operating on the general railroad system of transportation. These doors provide entrance and exit for normal passenger boarding and detraining, as well as an emergency egress/access path. This standard sets out requirements and references regarding the design of this type of passenger door systems intended for use in specifications for the procurement of new passenger cars.

Scope and purpose: This standard shall be used in specifications for the procurement of new passenger cars. The requirements outlined herein are for newly manufactured door systems and should not be applied to door systems in use that may have variations in performance due to wear, etc. Passenger compartment doors (end frame and vestibule doors), manually operated doors, galley doors, room access, locker doors, equipment access doors, toilet doors, interior cab access door, luggage compartment doors and equipment hatches are not covered by this standard.

This Standard represents a common viewpoint of those parties concerned with its provisions, namely, transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, practices or guidelines contained herein is voluntary. 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. APTA recognizes that for certain applications, the standards or practices, as implemented by individual transit agencies, may be either more or less restrictive than those given in this document.

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1. Structure of standard

The design and operation of a powered door involves a complex system. Interfaces occur at individual doors, on a car basis and on a train basis. This standard is segregated to address design requirements that occur at these different levels:

- **Section 2** addresses design requirements for individual side door openings.
- **Section 3** addresses system design requirements for an individual car.
- **Section 4** addresses system design requirements for a coupled train.
- **Section 5** addresses overall system safety requirements.

2. Passenger exterior side door design requirements

This section provides design requirements for powered doors at an individual side doorway.

2.1 Door control station

A door control station may be provided in a car with powered doors to control the normal operation of the exterior side doors, or other doors on that car or other cars in the train via the line control signals.

A crew key or other secure device shall be required to enable a door control station in order to prevent unauthorized use. The key shall be captive while the station is energized. Removal of the key or device shall prohibit input of open and close commands at the station.

Door status indicators may be incorporated into the door control station to display the open or closed status of the doors at that doorway or on the car, and/or the status of the door-closed summary circuit. If indicators are provided on the door control station, a test feature shall be incorporated to provide a method of identifying failed indicators.

2.2 Door operators

A mechanical latching device shall be incorporated into the design of the powered door operator to ensure that the doors will not open in the absence of an open command or upon loss of power.

2.3 Closed and latched

At the end of the close cycle, a door shall be fully closed and mechanically latched to prevent an uncommanded door opening.

Detection shall be provided for each side door panel to indicate when the door is closed and latched. The detection shall be part of the door summary circuit.

2.4 Door manual opening and closing force

When power is removed from the door motor and the door latch is released, door panel friction, including seals and hangers, shall allow the doors to be opened or closed manually with as low a force as practicable.

2.5 Obstruction detection

The door system design shall incorporate a method to detect an obstruction in the path of a closing door. The force exerted on an obstacle required to trigger the detection of an obstruction shall not exceed the following when the door is powered to close:

- **Peak force (F_p):** 68 lbf
- **Effective force (F_e):** 45 lbf

Appendix A defines these values and a test procedure that shall be used to measure them in a required test.

When an obstruction is detected, the door system shall react in a manner that will allow the obstruction to be released. A method for detecting an obstruction and preventing the closure of a powered door shall be included as part of the design of the door controls. The doors shall not close and latch to permit a closed-door indication if an obstruction is detected.

2.5.1 Sensitivity

The sensitivity of the obstruction detection system shall be demonstrated as defined by the following test procedure when a door is commanded to close:

- The system shall detect a rigid flat bar, ¼ in. wide and 2 in. high, placed between and perpendicular to the door panels or between and perpendicular to the panel and doorframe (for a single panel door opening). This sensitivity shall be required along the length of the panel except the uppermost 3 in. and the lowermost 1 in. of the door leading edges.
- The system shall detect a rigid rod, ⅜ in. in diameter, placed between and perpendicular to the door panels or between and perpendicular to the panel and the doorframe (for a single panel door opening) at all locations along the length of the door leading edges, except the uppermost 3 in. and lowermost 1 in. of the seal.
- The test specimens for the above requirements shall be of sufficient length to span the door seals.

2.5.2 Pushback

Provisions may be provided to allow a door panel to be manually pushed back to permit an obstruction to be removed.

The force required to push back a door panel shall not exceed 45 lbf.

2.6 Interior status indicators

Each door opening shall be equipped with a means of identifying if a door is not closed and latched. This may be by an indicator at the affected door or in the vestibule.

A car-level diagnostic monitor may be used in addition to or in lieu of the interior indicator.

2.7 Closing warning

Audible and visual warnings shall be initiated at each doorway to warn the passengers that the door has been commanded to close.

2.8 Mechanical lock and latch

2.8.1 Door isolation lock

A lock (cutout/lockout) mechanism shall be installed at each door panel to secure a door in the closed and locked position, to provide a door-closed indication to the summary circuit, and to remove power from the door motor or door motor controls.

The door isolation lock shall be key operated or require a key to access and shall not be readily accessible to unauthorized personnel.

The device shall be capable of being overridden by the door emergency release mechanism.

2.8.2 Mechanical door latch

A mechanical device shall be incorporated into the design of the door mechanism to prevent the door from opening until an open command is received or the door emergency release is actuated. The mechanical latch shall be engaged at the end of the door closing cycle and shall activate the door latched sensor. The latch shall prevent doors from opening should the connection between the drive mechanism and the door supports become compromised.

2.9 Emergency release

A manual interior and exterior emergency release mechanism shall be provided at each exterior side door. The emergency release mechanism, when activated, shall unlatch the door, disengage or unlock the door isolation lock (if engaged), remove power from the door operator or controls and move the door toward the open position such that there is a minimum 1.5 in. gap at the leading edge of the door.

2.9.1 Design considerations

An emergency release actuation device shall be provided immediately adjacent to the door opening on the interior and exterior of the doorway. Each actuator shall be readily accessible to a person located inside or outside the door opening.

The actuation device shall be covered by a clearly labeled, frangible or hinged panel, to reduce nuisance operations.

The emergency release actuation device shall be readily accessible, without the use of tools or other implement, as per 49 CFR Part 238, (Rail) Passenger Equipment Safety Standards.

The emergency release mechanism shall be capable of unlocking and releasing the door so that the door can be manually opened without power.

The force necessary to actuate the interior emergency release mechanism shall not exceed 20 lbf. The force necessary to actuate the exterior emergency release mechanism shall not exceed 30 lbf using a lever type mechanism or 50 lbf using a “T” handle type mechanism.

The emergency release mechanism shall not require the availability of electric or pneumatic power. Neither shall the emergency release mechanism require the presence of any interlock signals (e.g. “low speed” or “zero speed” signals) for actuation. When actuated, the emergency release mechanism shall override any locks, and it shall be possible to manually open the released door with a force not to exceed 35 lbf.

The emergency release mechanism shall require manual reset.

2.10 Markings

2.10.1 Door identification

At or near each door location, there shall be a unique door identifier clearly displayed inside the car.

2.10.2 Emergency egress markings

The emergency release actuation device shall be clearly marked to show its purpose and method of operation as per APTA SS-PS-002-98, Rev 2, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment; 49 CFR Part 239, Passenger Train Emergency Preparedness; and 49 CFR Part 238, (Rail) Passenger Equipment Safety Standards.

3. Car-level door design

3.1 Door control stations

One or more door control stations may be provided in a car with powered doors to control the normal operation of the exterior side doors, other doors on that car or other cars in the train via trainline control signals.

A crew key or other secure device shall be required to enable a door control station in order to prevent unauthorized use. The key shall be captive while the station is activated. Removal of the key or device shall prohibit input of open and close commands at the station.

Door status indicators may be incorporated into the door control station to display the open or closed status of the doors at that doorway or on the car, and/or the status of the door closed summary circuit. If indicators are provided on the door control station, a test feature shall be incorporated to provide a method of identifying failed indicators.

3.2 Crew door

Provisions may be provided to allow a local door to remain open or to be opened, when commanded by a crew member, when the door is adjacent to an enabled door control station and train speed is below 20 mph.

The door shall automatically close and latch when train speed is above 20 mph or the door control station is deactivated while the train is in motion. The door shall remain closed and latched when train speed drops below 20 mph, until the door control station is enabled and a new open command is initiated.

3.3 No motion/zero speed system

A system shall be provided to detect when the car is in motion. Motion detection may be local or trainlined.

When motion is detected, opening of all doors on the car (except crew doors) shall be prevented.

3.3.1 Car no motion bypass

If car-level motion detection is provided, a local bypass switch may be provided to permit local car doors to be opened with a no-motion system failure. The bypass switch shall be located in an area inaccessible to unauthorized personnel and shall have provisions for sealing in the normal position.

3.4 Exterior indicators

Each vehicle shall be fitted with a minimum of two exterior indicators, one on each side of the vehicle, to visually display that a door is open on that vehicle.

4. Train-level door design

4.1 Door control

Door control stations may be provided in the cab of a passenger locomotive or control cab car. If provided, the functions, indicators and signage nomenclature shall be equivalent to the door control stations in the cars.

If the door control station is not provided elsewhere, the door control station shall be provided in the locomotive or control cab car.

4.2 Door summary circuit

A trainline door summary circuit shall be provided to give an indication in the controlling cab of the train that all exterior side doors are closed and latched, and/or locked out with a door isolation lock.

The door summary circuit shall include a traction inhibit feature that prevents the train from losing traction power when the train is stopped and until all doors are closed and latched and removes traction power from the train should any door open while the train is in motion, except as noted in Section 3.2 Crew door.

4.2.1 Door summary circuit bypass

Operating cabs shall be equipped with a door summary circuit bypass switch that, when activated, overrides the door summary circuit.

The summary circuit bypass switch shall have provisions for sealing in the normal position and shall provide an indication, visible to the engineer while seated in the normal operating position, when the train is operating in door summary bypass. The switch may be used to override the door summary circuit in the event a defective door fails to close and latch and the summary circuit cannot be completed when that defective door is secured using the door isolation lock mechanism, or due to a mainline failure of the summary circuit. The door summary bypass switch shall have an effect only from the cab controlling the train.

When operating in bypass, the override of the summary circuit shall not compromise any other door safety features.

4.3 No-motion

No-motion protection shall be provided either on a local car-level basis or on a train-level basis.

When train motion is detected, opening of all doors in the train, with the exception of the crew door(s), shall be prevented.

4.3.1 No-motion bypass

A bypass switch may be provided to permit doors to open with a no-motion detection system failure. The bypass switch, if provided, shall have provisions for sealing in the normal position and shall have an indicator to indicate when the train is being operated in bypass.

If provided on a train-level basis, the bypass switch shall have an effect only from the cab controlling the train.

4.4 End-of-train detection

Provisions shall be included to denote the end of the train so that all side passenger doors are protected by the door summary circuit.

If end-of-train switches are used, then the switches shall be secured in a manner to prevent access by unauthorized personnel.

4.5 Interoperability between fleets

To the extent practical, door systems shall operate in a consistent manner throughout a passenger railroad rolling stock.

4.6 Nomenclature

To the extent practical, the design of the doors system shall incorporate consistent label nomenclature and indicator coloring among control cab cars, coaches and locomotives.

4.7 Trainline interface

Discrete, dedicated trainlines shall be used for door-open and door-close commands, door-unlatch (if used), door-closed summary circuit, and no motion, if trainlined. Selected door commands may be transmitted by network.

5. System safety

The door system shall be designed in a fail-safe manner such that no single point of failure shall cause an unsafe condition. In the event of any door system failure, the door system shall default to a safe condition.

A valid door-open command, a valid enable signal (if used) and a valid no motion signal shall be required to allow a door to open when a door-open signal is generated from a de-energized door control station.

5.1 Fault tolerance

No single-point failure in the door system, internal to the car or train, shall cause:

1. any door to unlatch or open;
2. a door-open command to be transmitted or responded to when the train is in motion;
3. a door-closed indication to be transmitted when any door is unlatched or open; or
4. a door-closed indication to be transmitted when an unlatched or opening command is stored anywhere in the system.

A hazard analysis shall be performed to validate system safety.

5.2 Design validation

Proof of design shall be conducted to demonstrate that the door system complies with the performance and functional requirements specified in this document. A comprehensive series of measurements shall be taken and recorded for all parameters essential to show compliance with this document. These tests shall demonstrate that the specified characteristics and functions are achieved within the specified performance values.

5.3 Labeling consistency

Signage for the side door emergency release actuation device shall comply with the requirements of APTA PR -PS-S-002-98, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment, and 49 CFR Parts 238 and 239.

Door signage and indicator functions/colors shall be consistent throughout the train to the extent practical.

Appendix A: Door closing force measurement

Door closing force

The commanded closing of a power-operated door is a dynamic process, and when the leading edge of a moving door hits an obstacle, the result is a time-dependent dynamic reaction force. The resulting time domain load history profile is influenced by several factors, including but not limited to mass of the door, door acceleration and door dimensions. The following sections define a process for measuring the mean effective door closing force (F_e) and peak force (F_p), as referenced in Section 2.5.

Terms and definitions

closing force ($F(t)$)

Time-dependent force function, measured at the closing edges of the door.

Pulse duration (T)

Time between t_1 and t_2 ,

$$T = t_2 - t_1$$

Where, t_1 is the threshold of sensitivity at a point in time where the closing force first exceeds 11.25 lbf and t_2 is the time after t_1 at which the closing force first becomes less than 11.25 lbf and remains less than 11.25 lbf.

Peak force (F_p)

Maximum value of the closing force measured within the pulse duration.

Effective force (F_e)

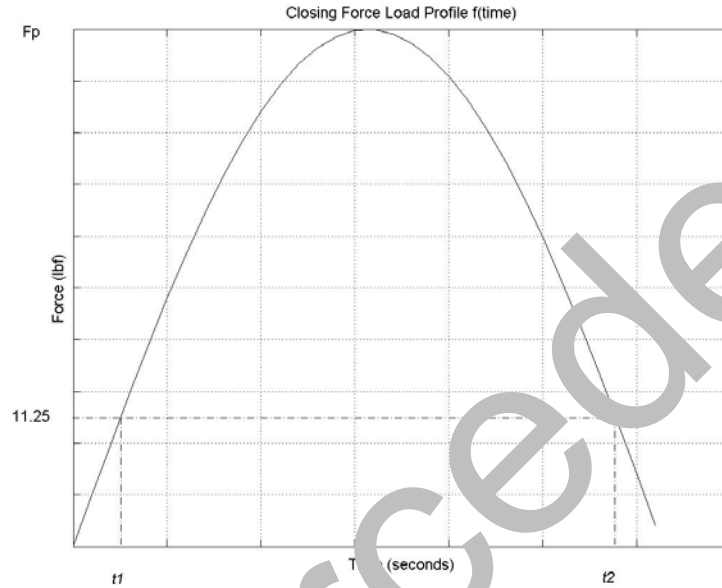
Average value of the closing force measured within the pulse duration.

$$F_e = \frac{1}{T} \int_{t_1}^{t_2} F(t) dt$$

Parameter relation

The parameters noted above are depicted in **Figure 1** below, where the time-based closing force curve represents an arbitrary shape that may not conform to actual profiles seen in practice. Actual profiles may vary depending on system design and operating specifications.

FIGURE 1
Example Closing Force Load Profile



Mean effective force (F_E)

The arithmetical mean value of the effective forces, measured at the same measuring point for several trials (*n*).

$$F_E = \frac{\sum_{i=1}^n (F_e)_i}{n}$$

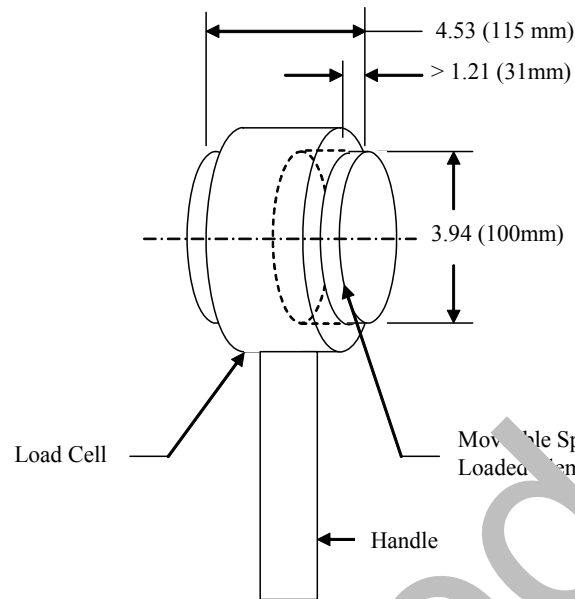
Force measuring device

The force measuring device shall utilize a load cell for capturing closing force data measured over time. See **Figure 2** for a depiction of an example measuring device.

The measuring device shall have the following characteristics:

- It shall consist of two housings with an outer dimension of 3.94 in. (100 mm) in diameter and 4.53 in. (115 mm) in width.
- As part of the device, a compression spring shall be fitted between the two housings to permit displacement of the load cell along its width in proportion to the magnitude of load applied. The stiffness of this spring shall be 57.1 ± 1.14 lbf/in. (10 ± 0.2 N/mm), with a deflection range sufficient to accommodate maximum peak forces greater than 68 lbf (300 N).

FIGURE 2
Rendition of Example Closing Force (Load Cell) Measuring Device



Force measurement procedure

Conditions of measurement

- Temperature range: 50 °F to 86 °F.
- The vehicle shall be positioned on a horizontal level surface.
- The powered door system shall be operating in a normal condition.

Measurement method

Using a force measuring device (see previous section) held between closing edges of the door, time dependent measurements of the door closing force at the door middle height shall be taken. Measurement time shall be sufficient to contain the pulse duration (T).

Closing force data provided by the measuring device used for calculations of pulse duration (T), effective force (F_e), mean effective force (F_{E}) and peak force (F_p) shall be filtered using a low-pass filter with a corner frequency of 100 Hz.

To compute a mean effective force (F_E) as defined above and referenced in Section 2, at least three separate measurements ($n = 3$) shall be taken at the measuring point.

References

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

American Public Transportation Association standards (www.aptastandards.com/):

- APTA PR-PS-S-002-98, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment
- APTA PR-IM-RP-003-98, Recommended Practice for Door System Periodic Inspection and Maintenance
- APTA PR-E-RP-0017-99, 27 Point Control and Communications Trainlines Locomotives and Locomotive Hauled Equipment

Code of Federal Regulations (<http://www.gpoaccess.gov/cfr/>):

- 49 CFR, Part 37, Transportation Services for Individuals with Disabilities (ADA)
- 49 CFR, Part 38, Accessibility Specification for Transportation Vehicles
- 49 CFR Part 223, Safety Glazing Standards, Locomotive, Passenger Cars, and Cars
- 49 CFR, Part 238, (Rail) Passenger Equipment Safety Standards
- 49 CFR, Part 239, Passenger Train Emergency Preparedness.

Department of Defense, Design Criteria Standard, Human Engineering Design Criteria for Military Systems, Equipment and Facilities, MIL-STD-1472E, March 1998.

<http://www.deepsloweasy.com/HFE%20resources/MIL-STD-1472E%20Human%20Engineering.pdf>

IEEE 1475, Standard for the Functioning of and Interfaces Provision, Friction Brake, and Train Borne Master Control on Rail Rapid Transit Vehicles, "Terminology, Abbreviations and acronyms."

Definitions

bypass: A device designed to override a function.

cutout: A device designed to remove a feature or function from operation.

diagnostic monitor: A monitor that displays the fault status of the systems on a car or a car within the train consist.

door control station: A control panel, activated by a crew key, that provides a train crew the ability to control exterior power operated side doors either locally and/or via trainline.

door isolation lock: A cutout/lockout mechanism installed at each exterior side door panel (leaf) used to secure a door in the closed and latched position, to provide a door-closed indication to the summary circuit, and to remove power from the door motor or door motor controls.

door pocket: A compartment into which a door panel is retracted when in the open position.

door status indicator: A device visible to the train crew and/or passengers that provides an indication of the status (open or closed) of the door.

door summary bypass: A device designed to override the door summary circuit.

door summary circuit: A trainline door circuit that provides an indication in the controlling cab of the train that all exterior side doors are closed and latched, and/ or locked out with door isolation lock.

enable: A design feature controlled automatically or manually by the train crew operation of the door.

end-of-train feature: A feature used to determine the end of the train or the last passenger car in the train for the door summary circuit.

exterior side door(s): The door(s) on the side of the passenger car normally used for passenger access and egress.

fail-safe: A design feature that shall maintain or result in a safe condition in the event of malfunction or system failure.

inhibit: To prevent the operation of a feature or function.

interface: A point at which two or more systems, subsystems or structures meet to transfer energy and/or information.

latch: A mechanical device used to secure a door in the closed position in normal operation.

leading edge: The edge of a door leading a closing movement.

lock: A mechanical device used to secure a door in the closed position when the door is taken out of service.

no-motion system (zero speed): A system that detects motion of the train or vehicle.

power operation: Door capability that results in the door opening or closing by means of an electric or pneumatic mechanism or a combination thereof controlled from one or more locations.

pushback: A door function that allows the door panel to be moved a specified distance in the open direction by applying a force to the leading edge.

train crew: People authorized to carry out the duties of operating the train.

trainline door circuit: A circuit used to convey door signals over the length of the train.

Abbreviations and acronyms

ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
CFR	Code of Federal Regulations
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
lbf	pound-force
MIL-STD	Military standards
N	not