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STANDARD

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PRESS Mechanical Working Group
Working Group

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 system, 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 doors, luggage compartment doors and equipment hatches are not covered by this standard. The requirements in this standard supersede all mechanical and non-structural requirements in APTA-PR-CS-S-012-02 that are applicable to powered exterior side doors.

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Participants

The American Public Transportation Association greatly appreciates the contributions of the members of the **Door Sub-Working Group of the PRESS Mechanical Working Group**, which provided the primary effort in the drafting of this document.

At the time this standard was revised, the sub-working group included the following members:

Chris Madden, AMTRAK, *Sub-Working Group Lead*

Mohamed Alimirah, *Metra*
Frank Banko, *WSP USA*
David Bennett, *Capital Metro. Trans. Authority*
Richard Bruss, *Retired*
Greg Buzby, *SEPTA*
Dennis Cabigting, *STV Inc.*
Kevin Carmody, *STV Inc.*
Joshua Coran, *Talgo Inc.*
Robert Festa, *MTA Long Island Rail Road*
Steve Finegan, *SNC-Lavalin Rail & Transit Inc.*
Sebastien Geraud, *ALSTOM Transport*
Jeffrey Gordon, *Federal Railroad Administration*
Eric Harden, *Knorr Brake Corp.*
James Herzog, *LTK Engineering Services*
Lew Hoens, *MTA Metro-North Railroad*
Reid Hunt, *Knorr Brake Corp.*
Paul Jamieson, *SNC-Lavalin Rail & Transit Inc.*
Robert Jones, *Stadler Rail Group*
Larry Kelterborn, *LDK Advisory, Inc.*
Joseph Kenas, *Bombardier Transportation*
Tammy Krause, *SNC-Lavalin Rail & Transit Inc.*
Peter Lapre, *Federal Railroad Administration*
Michael Liddle, *Knorr Brake Corp.*
Francesco Maldari, *MTA Long Island Rail Road*
Gerard McIntyre, *Knorr Brake Corp.*
Karl Mullinix, *Knorr Brake Corp.*
Joe Patterson, *Amsted Rail*
Gerhard Schmidt, *Siemens Mobility, Inc.*
Frederic Setan, *ALSTOM Transport*
Melissa Shurland, *Federal Railroad Administration*
Rick Spencer, *Knorr Brake Corp.*
Jeff Thompson, *SEPTA*
Anthony Tofani, *LTK Engineering Services*
Rudy Vazquez, *AMTRAK*
Tim Wineke, *Knorr Brake Corp.*

At the time this standard was updated, the **PRESS Mechanical Working Group** included the following members:

David Warner, SEPTA, *Chair*
Rudy Vazquez, AMTRAK, *Vice Chair*
Paul Jamieson, SNC-Lavalin Rail & Transit Inc., *Secretary*

Mohamed Alimirah, *Metra*
Carl Atencio, *Denver Transit Operators*
Frank Banko, *WSP USA*
Michael Barnes, *Jacobs*
Paul Bender, *Wabtec Corp.*
David Bennett, *Capital Metro. Trans. Authority*
Johnathan Bernat, *Knorr Brake Corp.*
Allen Bieber, *ACB RailTech Services, Inc.*
Brad Black, *Virginkar & Associates, Inc.*
Stephen Bonina, *WSP USA*
Glenn Brandimarte, *ORX Rail*
Tony Brown, *MTA of Harris County*
Richard Bruss, *Retired*
Michael Burshtin, *AMTRAK*
Dennis Cabigting, *STV Inc.*
Paul Callaghan, *Transport Canada*
Gordon Campbell, *Crosslinx Transit Solutions*
Kevin Carmody, *STV Inc.*
Steve Cavanaugh, *Metrolinx (GO Transit)*
Steve Chrismer, *ENSCO, Inc.*
Dion Church, *SNC Lavalin Rail & Transit Inc.*
John Condrasky, *Wabtec Corp.*

Joshua Coran, *Talgo Inc.*
Michael Craft, *AMTRAK*
Brian Creely, *Siemens Mobility, Inc.*
Ryan Crowley, *SNC-Lavalin Rail & Transit Inc.*
Richard Curtis, *Curtis Engrg. Consulting Svc, Inc.*
Steven Dedmon, *Standard Steel, LLC*
Joe Di Liello, *VIA Rail Canada, Inc.*
David Diaz, *LTK Engineering Services*
Matthew Dick, *ENSCO, Inc.*
Adam Eby, *AMTRAK*
Phillippe Etchessahar, *ALSTOM Transport*
Gary Fairbanks, *Federal Railroad Administration*
Robert Festa, *MTA Long Island Rail Road*
Steve Finegan, *SNC-Lavalin Rail & Transit Inc.*
Gavin Fraser, *Jacobs*
Francesco Fumarola, *ALSTOM Transport*
Edward Gacsi, *New Jersey Transit Corp.*
Sebastien Geraud, *ALSTOM Transport*
Jeffrey Gordon, *Federal Railroad Administration*
Guillaume Ham-Livet, *ALSTOM Transport*
Nick Harris, *LTK Engineering Services*
Eric Harden, *Knorr Brake Corp.*
Jasen Haskins, *SNC-Lavalin Rail & Transit Inc.*
Elizabeth Hensley, *Wabtec Corp.*
James Herzog, *LTK Engineering Services*
Kenneth Hesser, *LTK Engineering Services*
Lew Hoens, *MTA Metro-North Railroad*
Christopher Holliday, *STV Inc.*
Gregory Holt, *Penn Machine Co.*
George Hud, *LTK Engineering Services*
Reid Hunt, *Knorr Brake Corp.*
John Janiszewski, *LTK Engineering Services*
Lucas Johnson, *TriMet*
MaryClara Jones*, Trans. Tech. Center, Inc.*
Robert Jones, *Stadler Rail Group*
Larry Kelterborn, *LDK Advisory, Inc.*
Joseph Kenas, *Bombardier Transportation*
Peter Klauser, *Vehicle Dynamics*
Heinz-Peter Kotz, *Siemens Mobility, Inc.*
Scott Kramer, *McConway & Torley LLC*
Tammy Krause, *SNC-Lavalin Rail & Transit Inc.*
Pallavi Lal, *LTK Engineering Services*
Peter Lapre, *Federal Railroad Administration*
Nicolas Lessard, *Bombardier Transportation*
Michael Liddle, *Knorr Brake Corp.*
Cameron Lonsdale, *Standard Steel, LLC*
Danial Luskin, *AMTRAK*
Chris Madden, *AMTRAK*
Francesco Maldari, *MTA Long Island Rail Road*
Brian Marquis, *Volpe Natl. Trans. Systs. Center*
Eloy Martinez, *LTK Engineering Services*
Francis Mascarenhas, *Metra*
Raynald Masse, *Reseau de Transport Metropolitain*
Robert May, *LTK Engineering Services*
Ronald Mayville, *Simpson Gumpertz & Heger, Inc.*
Richard Mazur, *Wabtec Corp.*
Patrick McCunney, *SNC-Lavalin Rail & Transit Inc.*
Gerard McIntyre, *Knorr Brake Corp.*
Bryan McLaughlin, *New York Air Brake LLC*
William Minnick, *Omni Strategy, LLC*
Karl Mullinix, *Knorr Brake Corp.*
Joshua Munoz, *LTK Engineering Services*
Luke Morscheck, *LTK Engineering Services*
Karl Mullinix, *Knorr Brake Corp.*
Paul O'Brien, *Utah Transit Authority*
Chase Patterson, *Voith Turbo, Inc.*
Joe Patterson, *Amsted Rail*
John Pearson, *LTK Engineering Services*
Martin Petzoldt, *Railroad Friction Products Corp.*
Ian Pirie, *STV Inc.*
Brian Pitcavage, *LTK Engineering Services*
Peter Reumueller, *Siemens AG Industry Sector*
Danial Rice, *Wabtec Corp.*
Steven Roman, *LTK Engineering Services*
Carol Rose, *STV Inc.*
Thomas Rusin, *Rusin Consulting Corp.*
Mehrdad Samani, *Jacobs*
Gerhard Schmidt, *Siemens Mobility, Inc.*
Martin Schroeder, *Jacobs*
Richard Seaton, *TDG Transit Design Grp. Intl. Inc.*
Frederic Setan, *ALSTOM Transport*
Patrick Sheeran, *LTK Engineering Services*
Melissa Shurland, *Federal Railroad Administration*
David Skillman, *Amtrak*
Rick Spencer, *Knorr Brake Corp.*
Rex Springston, *AECOM*
Mark Stewart, *SNC-Lavalin Rail & Transit Inc.*
Jonathan Sunde, *Strato, Inc.*
Lukasz Szymsiak, *VIA Rail Canada, Inc.*
Ali Tajaddini, *Federal Railroad Administration*
Jason Taylor, *Amsted Rail*
Jeff Thompson, *SEPTA*
Matthew Todt, *Amsted Rail*
Anthony Ursone, *UTC/Rail & Airsources, Inc.*
Frank Ursone, *UTC/Rail & Airsources, Inc.*
Michael Von Lange, *UTC/Rail & Airsources, Inc.*
Michael Wetherell, *McKissack & McKissack*
Brian Whitten, *SNC-Lavalin Rail & Transit Inc.*
Todd Williams, *Penn Machine Co.*
Kristian Williams, *Amtrak*
Nicholas Wilson, *Transportation Tech. Center, Inc.*
Tim Wineke, *Knorr Brake Corp.*
Reggie Wingate, *Knorr Brake Corp.*
Aleksey Yelesin, *AMTRAK*

Gregory Yovich, *NICTD* Steven Zuiderveen, *Federal Railroad Administration*

Staff Advisers
Narayana Sundaram, *American Public Transportation Association*
Nathan Leventon, *American Public Transportation Association*

Introduction

This introduction is not part of APTA PR-M-S-018-10, Rev. 1.1, "Powered Exterior Side Door System Design for New Passenger Cars."

This standard applies to all:

1. Railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
2. Railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic, or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Powered Exterior Side Door System Design for New Passenger Cars

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 organized 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, 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 activate a door control station in order to prevent unauthorized use. Removal of the key or device shall deactivate the station.

If the door system is provided with a passenger open door function, the door control station shall be equipped with the device that enables the passenger open door function. The device shall only enable the use of the passenger open door function on the respective side of the car or train when the train is at a standstill and shall not open the doors. The train crew shall have the ability to override and cancel the enable function from an activated door control 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, then a test feature shall be incorporated to provide a method of identifying failed indicators.

2.2 Closed and latched

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

2.3 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.

2.4 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.

2.4.1 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 3 in. high, held 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 in the uppermost 3 in. measured from the top of door opening and in the lowermost 1 in. of the door leading edge measured from the top of the door opening threshold.
- The system shall detect a rigid rod, ⅜ in. in diameter, held 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 in the uppermost 3 in. measured from the top of door opening and lowermost 1 in. of the door leading edge measured from the top of the door opening threshold.
- The test specimens for the above requirements shall be of sufficient length to span the door seals.

2.4.2 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.

2.5 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.

2.6 Closing warning

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

2.7 Mechanical lock and latch

2.7.1 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.

2.7.2 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 or upon loss of power.

2.8 Emergency release

Visual instructions for emergency operations of each exterior side door shall be provided. A manual interior and exterior emergency release mechanism shall be provided at each exterior side door. A clearly labeled emergency release mechanism, when activated, shall unlatch the door, disengage, or unlock the local door isolation lock (if engaged), remove power from the door operator or controls, and allow the door to be moved to the open position. Provision shall be made to allow the door to be moved to the open position after activation of the emergency release mechanism. Examples of such provisions are: a gap that provides a minimum 1.5 in. clearance, a handle, a recess grab, or other means acceptable to the operating railroad. Feedback shall be provided to indicate that the mechanism has been actuated. Examples of such feedback are: movement of the door, orientation of the pull handle, an indicator light, an audible alarm at the door or other means acceptable to the operating railroad.

2.8.1 Design requirements

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 unlatching, unlocking, and releasing the door so that the door can be manually opened without power.

The emergency release mechanism shall not require the availability of electric or pneumatic power to activate. The emergency release actuation device shall be readily accessible, without the use of tools or another implement. 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. When actuated, the emergency release mechanism shall override any local door isolation 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. No interlock signal (e.g. "low speed" or "zero speed" signals) or mechanism shall prevent the actuation of the emergency release mechanism, except as noted in Section 2.8.1.1.

2.8.1.1 Speed Interlock (Plug Doors and Tier II/III Only)

For plug-type doors on all equipment and all door types on Tier II and Tier III equipment, a speed interlock preventing actuation of emergency release mechanism when the vehicle is moving is permitted, providing the interlock is designed to prevent unintended blocking of the emergency door release in an emergency situation when the vehicle is at standstill. Operating the emergency release actuation device with the interlock active shall not result in actuation of the emergency release mechanism and the emergency release actuation device shall automatically return to or remain in the de-actuated position. The interlock shall be an active system where the default state is the non-interlocked position and shall return to the non-interlocked state in cases of power loss. The interlock shall prevent emergency release mechanism actuation only under the following conditions:

1. Speed signals are received from two independent sources that both indicate car motion, neither of which shall be the no-motion circuit (if axle rotation is used for both sources, reference must be from separate axles); and
2. Control signals are present with consistent logic—e.g., short circuit, open circuit, or contradicting control signals shall not allow false lockout.

Additionally, control signal oversight with a microprocessor-based on-board electronic condition monitoring controls shall be provided.

The electronic condition monitoring controls shall be capable of:

1. Self-health monitoring and display circuit faults; and
2. Disabling the interlock upon loss of power or any contradiction of control signals.

2.9 Markings

2.9.1 Door identification

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

2.9.2 Emergency egress markings

The emergency release actuation device shall be clearly marked to show its purpose and method of operation as per APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for 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. If provided, the functions, indicators and signage nomenclature shall be equivalent to the door control stations in section 2.1.

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 activated 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 activated 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, then 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 section 2.1.

If the door control station is not provided elsewhere, then 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 taking 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 that 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 other trainline 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 system failure. If provided, the bypass switch, shall:

- be located in each cab
- be inaccessible to unauthorized personnel
- have provisions for sealing in the normal position
- have an effect only from the cab controlling the train
- have an indicator to indicate when the train is being operated in bypass.

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 Trainline interface

Discrete, dedicated trainlines shall be used for door-open and door-close commands, door-enable (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 an activated door control station.

5.1 Fault tolerance

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

- any door to unlatch or open;
- a door-open command to be transmitted or responded to when the train is in motion;
- a door-closed indication to be transmitted when any door is unlatched or open;
- a door-closed indication to be transmitted when an unlatched or opening command is stored anywhere in the system; or
- a speed interlock (as per Section 2.8.1.1), if provided, to prevent an emergency release mechanism from operating.

A hazard analysis shall be performed to validate system safety.

5.2 Design validation

Proof of design tests 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 all 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-006-23, “Emergency Egress/Access Signage and Low-Location Exit Path Markings for 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.

Related APTA standards

APTA PR-CS-S-012-02, "Door Systems for New and Rebuilt Passenger Cars"
APTA PR-E-RP-017-99, "27-Point Control and Communications Trainlines Locomotives and Locomotive Hauled Equipment"
APTA PR-IM-RP-003-98, "Door System Periodic Inspection and Maintenance"
APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment"

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.

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 Cabooses
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-1472F%20Human%20Engineering.pdf

IEEE 1475, Standard for the Functioning of and Interfaces Propulsion, Friction Brake, and Train Borne Master Control on Rail Rapid Transit Vehicles, "Definitions, 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 locked 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 a door isolation lock.

enable: A design feature that authorizes 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 that 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

CFR	Code of Federal Regulations
ETF	Engineering Task Force
IEEE	Institute of Electrical and Electronic Engineers
lbf	pound-force
N	Newtons
NATSA	North American Transportation Services Association
PRESS	Passenger Rail Equipment Safety Standards
RSAC	Railroad Safety Advisory Committee

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Definitions, abbreviations, and acronyms moved to the rear of the document.
- Two new sections added: “Summary of document changes” and “Document history.”
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar, and general flow of text.
- Names of participants updated.
- Introduction updated to comply with standard for PRESS.
- Globally, the term “activate” replaced “enable.” Activate replaces enable in order to prevent confusion with a door enable trainline or feature that authorizes operation of a side door.
- Section 2.1: Removed the requirement for capturing the key or device when the DCS is activated and replaced with language that allows the designer & train owner to specify if they choose to ‘capture’ the key but specifies in plain terms that the DCS is activated with key/device in place and deactivated when removed. This section was also expanded to include details on authorizing and de-authorizing a passenger open door function (if desired and equipped). Previously, this document did not specifically call out if a passenger open door function was allowed or prohibited and how its authorized use would be safely controlled by a train crew.
- Former Section 2.2: Duplicated the requirements of Section 2.7.2 (formerly 2.8.2) while specifically requiring that the latch be part of the operator. This may not always be the case and consensus was to remove Section 2.2.
- Section 2.2 (formerly 2.3): In the 1st paragraph, unintentional replaced uncommanded. Uncommanded changed to unintentional as the door latch mechanism functions to prevent a door from opening unintentionally. Unintentional is used elsewhere in the standard to reference latch functionality as well.
- Section 2.4.1 (formerly 2.5.1): Sensitivity locations clarified. Input received from industry indicated that the areas for sensitivity measurement on sliding plug doors should be referenced from door opening versus leading edge. Sliding plug doors are designed with overlap or areas of the leading edge that extend beyond the clear opening of the door (for flush sealing purposes) on the top and bottom. Generally, on the very top of the door opening is where the drive mechanism is located as well. These areas are not exposed to passenger movement or other obstructions.
- Section 2.7.2 (formerly 2.8.2): Added “or upon loss of power” which previously only existed under former Section 2.2, which has been removed as it is redundant and specifies a particular location for the latch. It is a condition that the mechanical latch should protect against.
- Section 2.8 (formerly 2.9): Added “Visual instructions for emergency operations of each exterior side door shall be provided.”
- Section 2.8 (formerly 2.9): Added clearly labeled requirement for emergency release mechanism.
- Section 2.8 (formerly 2.9): Clarified that the activation of the emergency release mechanism is only to affect the local door. Changed wording to “allow the door to be moved to the open position” from “move the door toward the open position.” Added “Provision shall be made to allow the door to be moved to the open position after activation of the emergency release mechanism.” Added additional acceptable means of moving a door to an open position. Added feedback requirement. Testing and feedback from Industry revealed that consistently meeting the 1.5" gap requirement for sliding plug doors is not possible. Discussions from RSAC- ETF in 2017/2018 led to a specific set of requirements that could replace the 1.5" gap while providing an equivalent level of feedback and operability to a passenger using the emergency release. These requirements include clear instructions for emergency release at each door, feedback to the passenger that the release has been activated successfully and a provision that allows the door to be manually moved to the open position. Some

examples of these provisions are provided in the draft. Other provision types would be allowed if acceptable to the operating railroad and approved during the design review process.

- Section 2.8.1 (formerly 2.9.1): Changed title to "Design requirements" from "Design considerations." The emergency release actuation device shall be readily accessible, without the use of tools or another implement." Added requirements for plug-type doors and tier II and III equipment.
- Section 2.8.1.1: New Section added. Justification for speed interlock: Based upon prior incidents on high speed equipment where passengers have opened exterior side doors when the train was operating at speed, the international best practice requires a speed interlock to ensure that doors cannot be manually opened at speed. Requiring doors to be able to be opened while the train is in motion, especially at high speed, creates a significant hazard to passengers onboard, on the platform, or along the wayside due to the significant pressure wave associated with high speed operations. In addition, open plug doors could get damaged and possibly dislodged causing potential impact to other trainsets, people on platforms, and could create the potential for derailments. It is therefore not recommended that plug type doors be absolutely required to open manually when the train is in motion. The specific requirements for the design and the conditions for the operation of the speed interlock for emergency release mechanism have been provided in the draft language. Though single point failures and fault tolerance are addressed in the document for this optional feature, a specific SIL was not assigned to this feature. It was determined that this should be evaluated, assigned, and analyzed on a case-by-case basis as a part of the design and testing of a new vehicle and does not require specific assignment here. Included in this section are details which provide a very specific set of (serial logic) conditions that must be met to allow the interlock to activate while disallowing the interlocks blocking of the emergency release function under any other combination of signals, inputs, power states or mechanical handle positions. The fail-safe or default state shall always be the non-interlocked state.
- Sections 2.1, 3.1, and 4.1: Sections 3.1 and 4.1 were redundant as the same text is presented in section 2.1. Borrowed language from 4.1 to synchronize these 3 sections while removing duplicate text that would need to be changed in multiple sections for any future changes.
- Section 5.1: Added bullet "a speed interlock, if provided, to prevent an emergency release mechanism from operating." It was felt that it was imperative for the emergency release mechanism speed interlock to not fail in a state that prevents emergency release operation due to a single point failure and that it should be added to the existing list of critical features requiring a system safety hazard analysis.
- Former Sections 4.5 (Interoperability between fleets): 49 CFR Part 238.137 addresses operating with a mixed consist. The text served as a suggestion and not a requirement. There were discussions from Industry regarding removing section 4.5 altogether since it is more of a best practice and not a design requirement.
- Former Section 4.6 (Nomenclature): This section contained text that served as a suggestion and not a requirement. There were discussions from Industry regarding removing section 4.6 altogether since it is more of a best practice and not a design requirement.
- Definitions: In the definition of the term enable, "that authorizes" replaced "controlled automatically or manually by the train crew." Refined the definition to better clarify the purpose of the enable, or enable trainline, feature.
- Definitions: In the definition for door isolation lock, "locked" replaced "latched" to be consistent with the use of the two words in the standard. Latched refers to the normal retention of the door in the closed position by the mechanical door latch described in section 2.7.2 (formerly 2.8.2). Locked refers to the securing of the door in the closed position by the door isolation lock described in section 2.7.1 (formerly 2.8.1). This is also in line with the definitions for 'latch' and 'lock' provided in this standard.

Revision 1.1:

- Sections 2.9.2 and 5.3: Changed reference for Emergency signs and markings to APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment"

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	Oct. 4, 2010	Feb. 11, 2011
First revision	July 19, 2019	Sept. 13, 2019	Nov. 4, 2019	Jan. 10, 2020	Jan. 17, 2020
Revision 1.1	July 19, 2019	Sept. 13, 2019	Nov. 4, 2019	Jan. 10, 2020	July 26, 2023

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 2.4.

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 and remains less than 11.25 lbf.

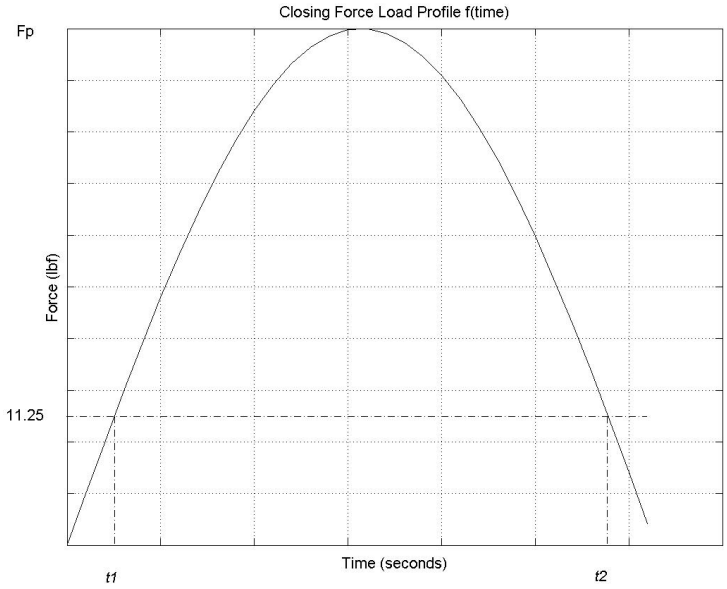
peak force (F_p): Maximum value of the closing force measured within the pulse duration.

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**, 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).

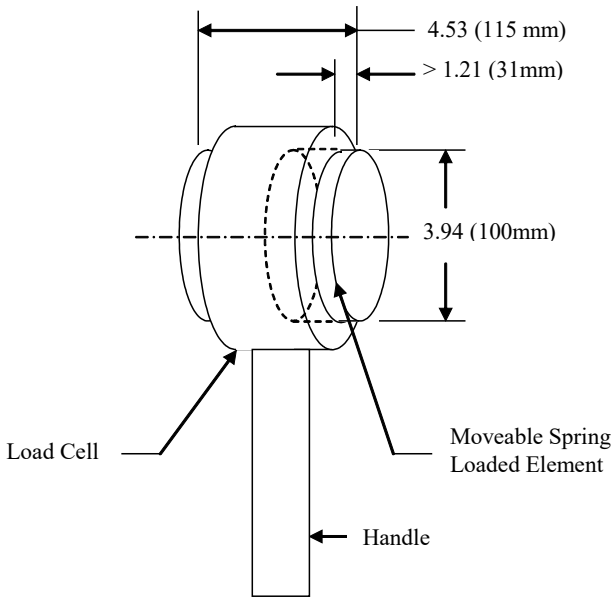
$$F_E = \frac{\sum_{i=1}^{n}(F_e)_i}{n}$$

force measuring device: The force measuring device shall use 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 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.

