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APTA Rail Transit Standards Vehicle Inspection and Maintenance Working Group

Door System Periodic Inspection and Maintenance for Rail Transit Vehicles

Abstract: This *Recommended Practice* provides guidance for performing periodic inspection and maintenance to door systems applied to rail transit vehicles. It provides a set of useful practices that can be selected and applied during the maintenance process.

Keywords: periodic inspection and maintenance, rail transit vehicle car door systems

Summary: This *Recommended Practice* describes the basic inspection and maintenance requirements of automated and manual door systems found on rail transit vehicles. APTA recommends the use of this recommended practice by:

- Individuals or organizations that inspect and maintain door systems on rail transit vehicles;
- Individuals or organizations that contract with others for the maintenance of door systems on rail transit vehicles; and
- Individuals or organizations that influence how door systems are maintained on rail transit vehicles.

Scope and purpose: This *Recommended Practice* is intended for use by rail transit systems (RTS) as a guide for developing systematic, comprehensive, equipment-specific door system inspection procedures. This *Recommended Practice* provides the framework for developing minimum inspection, maintenance, testing and alignment procedures to achieve safe and reliable operation of door systems installed in rail transit equipment. Each rail transit system should define the safety-critical elements of all door systems in its fleet.

These subsystems and components should include but are not limited to the door locking devices, warning devices, obstruction sensing, sensitive edges, door panel pushback, zero speed detection, panel position sensing and those subsystems and components of a manual end door system. RTS standards should specifically address the maintenance and testing of each safety-critical element.

Participants

The American Public Transportation Association greatly appreciates the contributions of **Gordon Campbell and Richard Berk,** who provided the primary effort in revising this *Recommended Practice*.

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Introduction

This introduction is not a part of APTA RT-VIM-RP-005-02 Rev 1, "*Recommended Practice for Door System Periodic Inspection and Maintenance for Rail Transit Vehicles*"

This Recommended Practice for Door System Periodic Inspection and Maintenance for rail transit vehicles 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 purely voluntary. In some cases, federal and/or state regulations govern portions of a rail transit system's operations. In those cases, the government regulations take precedence over these recommended practices. APTA recognizes that for certain applications, the standards or practices, as implemented by individual RTS, may be either more or less restrictive than those given in this document**.**

This Recommend Practice is intended to assist RTS personnel in performing basic maintenance and inspection procedures on rail transit door systems. Since each rail transit rail cars may be different, the procedures and steps described in this document will not necessarily be applied to, nor required for, every RTS maintenance and inspection procedure.

Door System Periodic Inspection and Maintenance

1. Overview of door system equipment

For the purposes of this recommended practice, rail transit vehicle door systems pertain to rail transit vehicle doors intended to permit the safe and efficient egress and access into and out of a rail transit vehicle; rail transit vehicle end doors intended to permit passenger movement between vehicles; and cab operator compartment doors intended for operator access. This recommended practice provides general guidance for performing periodic inspection and maintenance to automated and manual door systems applied to rail transit vehicles.

Rail transit vehicle door systems surveyed have a common function but vary considerably in form. This common function is achieved by different configurations of mechanical and electrical components supplied by different manufacturers. Due to differences in design, equipment and configuration, the recommended practices that follow offer general guidance for developing system-specific working maintenance documents. This overview provides a survey of door system equipment and configurations. It is intended to help the reader understand the text references to unfamiliar components and operating characteristics.

Sliding door actuators fall into two basic types, linear and rotary. Electric linear operators use a motor-driven lead screw. Electric rotary operators translate rotary motion to linear motion through mechanical links and transmit force to the door panel through levers. Air rotary operators use a cylinder driven rack and pinion. Pneumatic cylinders drive linear air operated actuators.

Swing plug, bi-folding and blinker electric operator actuators are all rotary. With air-operated, linear piston units, output is translated to rotary motion through a crank.

Door actuators can be configured to operate individual door leaves, or in the coordinated design, one operator operates both leaves in an entryway.

Sliding doors can be pocket type or exterior exposed type.

End doors can be either hinged swing type or sliding pocket type doors. Sliding doors can be automatic or manual operation.

There are various arrangements for detecting and/or extricating obstructions, providing safety for passengers:

- A large, soft, floppy, leading door edge that permits extraction of an obstruction.
- Panel pushback to permit extraction of an obstructed item with panel position sensing for safety interlock.
- Mated (tongue and groove) semi-rigid door edges to enhance panel position sensing capability and the recycle trigger point when there is an obstruction.
- Monitoring door-closing force or current for obstruction sensing with recycle to release.
- Monitoring door closing time for obstruction sensing with recycle to release.
- Sensitive door edges that detect when deformed by an obstruction and can be configured to remove power, apply brakes or recycle the doors to release the obstruction.
- Additional use of newer technologies, including infrared, microwave, laser, etc.

There are common approaches to door locking:

- Mechanism inherent locking (over-center) with drive motor unlocking.
- Separate lock mechanism (solenoid lock) independent of the drive mechanism.
- A combination use of inherent primary locking and solenoid secondary locking.
- Other types of manual locks

There are two different approaches to door control technology:

- Relay logic.

  NOTE: Vital relays may be applied to control safety-critical door functions.

- Microprocessors or programmable logic controllers for non-safety-critical functions that use redundancy and/or speed cycle checking for safety functions.

Nine different light rail transit vehicle exterior power operated door system configurations have been identified as follows:

- Outward bi-folding, overhead, air operated
- Outward bi-folding, overhead, electric operated
- Inward bi-folding, overhead, electric operated
- Sliding plug, overhead, electric operated
- Sliding pocket, overhead, electric operated
- Sliding pocket, overhead, air operated
- Blinker, overhead, air operated
- Outside swing plug, overhead air operated
- Outside swing plug, overhead electric operated

Four different heavy rail transit vehicle exterior power operated door system configurations have been identified as follows:

- Sliding pocket, overhead, electric operated
- Sliding pocket, overhead, air operated
- Sliding pocket, pocket, electric operated
- Sliding pocket, floor, electric operated

Access equipment integrated with door systems include retracting steps, manually and power operated bridge plates and power operated lifts.

2. Frequency of conduct

Periodic inspection and maintenance tasks on the doors system should be performed on a regular schedule as determined by RTS. The frequency of any periodic maintenance and inspection task should comply with all applicable federal, state and local regulations. Further, in the conduct of RTS periodic inspection and maintenance program, frequencies for individual tasks may be established based on a number of additional factors, including but not limited to:

- OEM-recommended intervals;
- industry experience;
- operating environment/conditions;
- historical data;
- reliability-centered maintenance program development;
- failure analysis;

- rail transit system's testing and experience; and
- regulatory requirements.

3. Requirements and specific tasks

Prior to attempting or commencing any inspection or repair of a rail transit vehicle door system, it is recommended that the applicable OEM recommendations and RTS procedures are followed.

WARNING: To avoid possible injury while using compressed air for dislodging dirt and debris, wear appropriate eye, face and respiratory protection meeting minimum ANSI or other applicable national industry standards, or as directed by the RTS. Keep air pressure at the blowgun nozzle below 30 psi.

WARNING: Use only those cleaning products and lubricants proven safe and authorized for use by the rail transit system. Consult OEM and MSDS references for suitability for each application to prevent personal injury and damage to the equipment.

WARNING: To avoid possible injury if door equipment operates unexpectedly, ensure that power to the door operator and control power is shut off and remains off until personnel are safely clear of moving parts. In addition, for air-operated equipment, ensure that door actuator air pressure is exhausted before placing hands, tools or cleaning material in or near the operator.

WARNING: To avoid possible injury while moving doors manually for inspection purposes, keep hands and tools away from levers, linkages, and pinch points.

WARNING: To avoid possible injury from air venting unexpectedly or unanticipated operation of air-powered door equipment, ensure that the air supply to the door motor is cut off and that pressure in the cylinders is bled off.

WARNING: To avoid possible injury, notify all concerned that equipment is about to be energized before restoring power. If vehicles are coupled and controls are trainlined, ensure that it is safe for equipment in coupled cars to become operational before energizing any high-voltage or battery circuits.

3.1 Materials

Approved lubricants are normally required for door system inspection and maintenance. Reference OEM maintenance manuals for additional materials.

3.2 Tools

In addition to special tools, gauges or fixtures that may be recommended by the OEM or developed by the RTS, the following equipment is called for by the procedures contained in this *Recommended Practice*:

- multimeter*;
- portable electrical and electronic test devices*;
- stopwatch;
- vacuum cleaner;
- go/no-go gauges*; and
- force measuring gauges.*
- flashlight and inspection mirror.

NOTE: Tools marked with an asterisk (*) require periodic calibration as specified by the rail transit system's practices.

3.3 Safety/personal protective equipment

Appropriate personal protective equipment, meeting minimum ANSI standards, as required by the RTS, shall be worn at all times in the performance of these inspection and maintenance tasks.

3.4 Training requirements

RTS and/or their maintenance contractors should develop and execute training programs that provide employees with the knowledge and the skills necessary to safely and effectively perform the tasks outlined in this *Recommended Practice*. To correctly judge the safety and serviceability of vehicle door systems, maintenance workers and their supervisors must thoroughly understand the equipment they are charged with maintaining. Contemporary door systems employ complicated mechanical components that are controlled by sophisticated electrical controls. Maintenance workers assigned as inspectors should be skilled and experienced employees. In addition to the fundamental technical skills required of these employees, maintenance workers who inspect and maintain vehicle door systems should have received detailed formal training in the theory of operation, alignment and testing of the door systems they will maintain.

3.5 Inspection and maintenance, de-energized condition

Skilled and trained maintenance workers experienced with door system equipment and operation should perform these inspections following the OEM and RTS procedures. For consistency, maintenance workers should work from standard check sheets, which guide the work. Each step of the inspection should be acknowledged as complete as the task is completed. Checking off each inspection element provides accountability for completeness and for the correctness of work performed. The practice also provides maintenance workers and their supervisors with a record of inspection progress for continuity if the work is passed to other maintenance workers or shifts. Deficiencies discovered during the inspection should be recorded on the inspection check sheets and signed by the inspector completing the inspection.

When repairs or adjustments are completed, the repair technician must sign off that repairs have been made on the inspection form. If deficiencies are not signed off as corrected on the inspection forms, the disposition of the each incomplete item should be noted on the inspection sheet (i.e., re-inspected and found serviceable or converted to work order number). The supervisor or a RTS designee must complete final review and sign off that the inspection has been completed. It is important to develop a system that tracks deferrable repairs until those repairs are signed off as completed.

3.5.1 Review of history

Microprocessor fault data logs and vehicle maintenance history files should be available and reviewed before work begins. Diagnostic information may pinpoint components that are repeatedly failing, perhaps intermittently. Troublesome components can be identified and receive more detailed inspection and function checks.

3.5.2 Cleaning

Remove debris and loose hardware from equipment operator enclosures, tracks and guides. If loose hardware is from the door operator, note the location of missing hardware for close inspection and replacement. Follow approved procedures for cleaning accumulations of dust and grit from exposed lubricated surfaces of equipment operators. Avoid forcing dirt into door operator electrical or mechanical components while cleaning. Vacuuming is preferable to blowing out the operator enclosure.

3.5.3 Electrical components

3.5.3.1 DC Motors

Inspect commutators for burning, discoloration or surface roughness. Replace the motor if there is evidence of excessive arcing. Check brush length, condition of carbon ways, caps and springs. Replace unserviceable components where necessary.

> **NOTE:** Refer to APTA RT-VIM-RP-010-02, *"Electric Motor Periodic Inspection and Maintenance,"* for additional guidance in developing motor inspection procedures.

3.5.3.2 AC Motors

Inspect bearings for leakage. Verify tightness of hardware. Inspect motor leads for tightness of connections and any signs of overheating, chafing or broken insulation. If chafing is found reposition and/or protect the lead. If broken insulation replace motor. If one or two leads show overheating, check starter resistance or inverter drive for cause of phase unbalance. Repair motor or inverter as required.

> **NOTE:** Refer to APTA RT-VIM-RP-010-02, *"Electric Motor Periodic Inspection and Maintenance,"* for additional guidance in developing motor inspection procedures.

3.5.3.3 Switches, relays, resistors and solenoids

Check the attaching hardware and physical condition of limit switches, relays, resistors and solenoids. When practical, operate switches and relays manually, checking for binding or inconsistent operation. When recommended, measure resistance and perform continuity checks across the contacts and coils of de-energized switches, relays, resistors and solenoids. When required, adjust limit switches and relays to specification.

3.5.3.4 Electronic devices

Inspect modules, boards, door open encoders and freestanding electronic devices for signs of unusual discoloration from heat. Replace devices where necessary.

3.5.3.5 Wiring and terminations, plugs and receptacles

Inspect wire for damaged or missing insulation and signs of overheating. Check that terminations are tight and have not overheated. Secure harnesses away from moving elements. Verify that wiring is dressed to minimize strain on the terminations. Check that plugs and receptacles are tight and not corroded. If plugs are disconnected, check for pushed-back elements that may cause intermittent contact even with the plugs fully connected. Replace or repair components as required.

3.5.3.6 Threshold and pocket heaters

Inspect for proper operation of heating elements and associated controls.

> **NOTE:** Threshold and pocket heater inspection may best be included in general car heat system checks. Refer to APTA RT-VIM- RP-004-01, *"Heating, Ventilation and Air Conditioning Periodic Inspection and Maintenance."*

3.5.4 Mechanical components

3.5.4.1 Gearboxes and chain speed reducers/belt drives

While manually operating the connected door panel or access device slowly, inspect reducers for excessive lost motion or looseness. If roughness or unusual resistance is detected, inspect the reducer more thoroughly.

Repair or replace as required. When applicable, check lubricant levels. Replenish lubricant according to specifications. Where power transmission belts are applied, check the belt tension against specifications. Inspect belts for fraying, thinning or cracking. Adjust tension or replace belts as required. Where chain is applied as a transmission element, inspect for looseness and abrasion. Adjust or replace components as required.

3.5.4.2 Lead screws (linear actuators)

While manually opening and closing the connected door panel slowly, inspect the lead screw, nut, locking pawls or detents and support bearings for excessive lost motion, looseness or metal shavings. If roughness or an unusual increase or decrease in resistance is detected, inspect the lead screw, nut and support bearings more thoroughly. Repair or replace as required. Re-lubricate according to specification. Ensure that locking devices fully engage and lock.

3.5.4.3 Levers, links, rod ends, locking pawls and rollers

While manually operating the connected door panel or access device slowly, inspect connecting levers, links, locking pawls and rod ends for excessive lost motion and looseness or binding. Check that adjustable link locking devices are in place and tight. Inspect rollers for binding, skidding or excessive looseness. Service specified lubrication points with approved lubricants. Check linkage adjustments against specifications. Adjust, repair or replace as required. Verify that locking devices fully engage and lock.

3.5.5 Pneumatic components

3.5.5.1 Differential door motors and cylinders

Inspect the attaching hardware for looseness. Tighten or replace as necessary. Lubricate the cylinders at specified intervals, following approved procedures. Repair air leaks.

3.5.5.2 Manually and solenoid-actuated valves

Inspect the attaching hardware for looseness. Tighten or replace as necessary. Ensure that manually operated valve stems rotate smoothly. Repair air leaks.

3.5.5.3 Air lines

Inspect tubing for kinks, air leaks and abrasion. Inspect and tighten tubing fittings. Verify that rigid tubing is clamped to prevent flexing and to limit vibration. Verify clamp tightness. Verify that flexible tubing is secured away from moving elements. Replace tubing and tighten or replace fittings as required. Re-secure air lines as required.

3.5.5.4 Strainers

Service strainers at specified intervals, following approved procedures.

3.5.6 Door panel, suspension and guides

3.5.6.1 Door panel

Inspect door panel glazing and glazing rubber or retention frame. Inspect door panels for damage, straightness and uniformity. Inspect all rivets, screws or other fasteners. Replace any that are loose or damaged. Inspect the door pocket interior for debris and any other condition that may result in door panel damage. Inspect weather stripping and nose rubber for tears or loose attachment. Replace as necessary. Cut out or balance bi-fold or blinker doors, and then open and close the leaves manually, inspecting bi-fold panel hinges and bi-fold and blinker door pivots for binding or excessive looseness.

3.5.6.2 Panel suspension

While manually operating sliding pocket door panels, evaluate alignment and condition of the hangers, bearings, balls and guides. If required, adjust according to procedures. Open cantilevered plug doors, and then inspect support arms and pivots. Replace damaged components. Service lubrication points with specified lubricants. Align door panels per specification. Verify tightness of all fasteners. Re-torque loose hardware. Replace unserviceable fasteners with specified hardware. Re-torque to specification.

3.5.6.3 Door guides

Inspect door tracks and guides for wear. Inspect door tracks and guides for proper alignment. Adjust to specification. Check tightness of all attaching fasteners. Re-torque as required.

3.6 Inspection and maintenance, energized condition

The energized function check of a rail transit vehicle door system during inspections provides assurance that the equipment is safe to operate. Follow OEM and RTS procedures to ensure that each control function and passenger safety device is tested in a way that replicates how the feature should function in service. Use the documentation procedures outlined in Section 3.5 (above).

3.6.1 Door system controls

Door or access equipment operators function upon receiving a command control signal. Door equipment control signals can be initiated by a train crewmember or may be communicated to the rail transit vehicle by a wayside berthing signal. Control signals are normally trainlined so that all in-service doors respond alike in coupled cars. Summary interlock circuits ensure that all in-service doors are closed and locked before the car or train can be moved. Local passenger-actuated controls are enabled by a train crewmember. Passengers may then control activation of doors or power operated access devices locally at an entryway. Crew key controls operate adjacent door and access equipment. Local emergency controls unlock and de-energize (or balance) door operators, allowing the panels to be manually opened in case of emergency.

3.6.1.1 Local door system controls

Local controls are located at entryways. They control a single door operator or may control all door and access equipment for the local entryway. Controls may be inside, outside or both inside and outside the rail transit vehicle. Vehicle end doors intended to provide interior access from one vehicle to another may also be locally controlled. These can be manually activated by pushing button on either side of the door or automatically activated through the use of sensors.

Passenger-actuated controls

Following OEM recommendations and RTS procedures, functionally test interior and exterior passenger-actuated door, tread-step actuated door and access equipment operation request controls at each entryway. Repair as required. Check powered access equipment cycle speeds. As equipment is being operated, verify door and access equipment control points for speed or torque reduction and for end of cycle power cut off. Check warning device duration timing and verify the presence of hesitations or delay programmed into the cycle. Adjust or repair as required.

Crew actuated controls

Check crew key-actuated local controls for proper function. If not verified in the passenger actuated controls inspection above, check powered access equipment cycle speeds. As equipment is being operated, verify door and access equipment control points for speed or torque reduction and for end-of-cycle power cutoff. Check

warning device duration timing, and verify the presence of hesitations or delay programmed into the cycle. Adjust or repair as required.

Emergency door release controls

Check operation of all emergency door release mechanisms. Adjust and lubricate actuators as required according to specifications. Cut out each door operator. Ensure that with door operators cut out, controls function as designed. Close doors. Verify that emergency releases reset.

Warning devices

Check local indicating lamps and audible alarms or annunciators for proper operation. Repair or replace as required.

3.6.1.2 Master door system controls

Using OEM recommendations and RTS procedures, functionally test the door system operation using controls at an operating cab or control console. Confirm that equipment responds correctly. Troubleshoot, repair or replace defective control devices. Check indicating lamps and audible alarms for proper operation. Repair or replace as necessary.

3.6.2 Passenger safety devices

3.6.2.1 Obstruction sensing

Using OEM recommendations and RTS procedures, functionally test obstruction sensing by allowing doors to close on the specified go/no-go gauge. Check that traction or power interlock circuits function as designed with the no-go gauge gapping the closed-door panels. Where photoelectric obstruction sensing is installed, clean the light source lens and the reflector. Ensure that when the light beam is obstructed, the doors function appropriately.

3.6.2.2 Sensitive edges

Using OEM recommendations and RTS procedures, functionally test sensitive edges by deflecting each door panel nose rubber as the doors close. Panels should recycle within specified timing. Adjust pressure wave switches, if so equipped, or replace components as required.

3.6.2.3 Pushback

Using OEM recommendations and RTS procedures, functionally test door panel pushback. With panels closed and locked, manually push the panel open. Check the pushback distance and confirm that the panel cannot move further. Gauge the force required to move each panel through the pushback zone. Adjust as required.

3.6.2.4 Traction power interlock/inhibit

Confirm that when any traction inhibit protected door is unlocked or opened, the propulsion and braking systems function as designed.

3.6.2.5 No motion (zero speed) detection

Using OEM recommendations and RTS procedures, functionally test that the speed detection circuits receive a speed signal and switch at the specified speed to inhibit door operation.

3.6.2.6 Panel position sensing

Using OEM recommendations and RTS procedures, functionally test that as each door panel opens a panel position sensing device interrupts the traction or power interlock circuit independent of switches or sensors that are installed on the door operator.

3.6.2.7 Sensor Technology

Using OEM recommendations and RTS procedures, functionally test infrared, microwave, laser or other new sensor technology for proper performance. Adjust or replace as required.

3.7 Correction of deficiencies

Any deficiencies uncovered during the inspections required in Section 3.5 through 3.6 should be corrected and documented in accordance with the RTS procedures and OEM recommendations.

Related APTA Standards

American Public Transportation Association *Recommended Practices*:

APTA RT-VIM-RP-004-01, *"Heating, Ventilation and Air Conditioning Periodic Inspection and Maintenance"* (Previously numbered as APTA RT-RP-VIM-004-01)

APTA RT-VIM-RP-010-02, *"Electrical Motor Periodic Inspection and Maintenance"* (Previously numbered as APTA RT-RP-VIM-010-02)

References

None

Definitions

access equipment: Any vehicle entryway accessory that may be deployed to aid the boarding of passengers, including steps that deploy when doors are operated.

blinker doors: Bi-parting doors that swing inwards and to the sides of the door opening

check sheets: Forms with provision for acknowledging completion of outlined inspection and maintenance tasks.

de-energized: Automatic door equipment that is disconnected from its power source and will not operate automatically.

door guide: Tracks or other restraints that constrain the motion of door panels.

door operator: The drive mechanism that operates door panels.

door panel: The moveable barrier element of a vehicle entryway.

energized: Automatic door equipment that is poised to operate when a command signal is received.

lost motion: Motion and force that is not transmitted to the door panel due to cumulative clearances in the door operator mechanical components.

operating agency: Purchaser, lessee or contractor that utilizes equipment for the carriage of people.

original equipment manufacturer: Enterprise that designs and builds equipment initially.

plug door: Rigid door panels that are rotated from outside the car shell when open, and into the entryway portal when closed.

pocket: Cavity formed by the car shell outer wall and inner liner that receives door panels when open.

Abbreviations and acronyms

ANSI American National Standards Institute
MSDS material safety data sheet
NATSA North American Transit Services Association
OEM original equipment manufacturer
RTS Rail Transit System
psi pounds per square inch

Summary of document changes

1. Document formatted to the new APTA recommended practice format.
2. Sections have been moved and renumbered.
3. Scope and summary moved to the front page.
4. Sections of definitions, abbreviations and acronyms moved to the rear of the document.
5. Three new sections added: "Summary of document changes," "Note on Alternate Practices" and "Document history."
6. 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.
7. Working Group membership updated.
8. Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document.
9. Document title changed by adding *'for Rail Transit Vehicles'* at the end of the title.

Document history

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