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RECOMMENDED PRACTICE
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Rail Transit Vehicle Inspection and Maintenance Working Group

Propulsion Controls Periodic Inspection and Maintenance

Abstract: This *Recommended Practice* gives the minimum requirements for the periodic inspection and maintenance of propulsion controls used on rail transit vehicles.

Keywords: propulsion controls, inverter, chopper, switch resistance,

Summary: Rail transit vehicle propulsion controls in use today vary considerably in design. The components used, however, can be maintained using similar techniques, irrespective of the design variations. Propulsion controls fall into three general groups: switched resistance (e.g., DC cam), DC-DC chopper and DC-AC inverter.

Scope and purpose: This *Recommended Practice* provides guidance for the establishment of an inspection and maintenance program for propulsion controls. The term "propulsion controls" includes the power conversion equipment that transforms the line power of the contact conductor to the power used by the traction motors, and also includes the master controller. This *Recommended Practice* should be used in conjunction with the rail transit system's instructions and original equipment manufacturer (OEM) recommendations to perform periodic inspection and maintenance of rail transit vehicles. This document provides a framework to develop periodic inspection, maintenance and testing procedures that will result in safe, reliable and economical operation of propulsion controls.

This *Recommended Practice* 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. NATSA (North American Transit Services Association) and its parent organization 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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The American Public Transportation Association greatly appreciates the contributions of **APTA Rail Transit Vehicle Inspection & Maintenance Working Group** who provided the primary effort in the drafting of this *Recommended Practice*.

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Introduction

This introduction is not a part of APTA RT-VIM-RP-018-03 Rev 1, "*Recommended Practice for Propulsion Controls Periodic Inspection and Maintenance.*

This *Recommended Practice* 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 rail transit systems, may be either more or less restrictive than those given in this document.

This *Recommended Practice* describes the basic inspection and maintenance requirements of propulsion controls found on rail transit vehicles. APTA recommends the use of this recommended practice by:

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

Propulsion Controls Periodic Inspection and Maintenance

1. Frequency of conduct

Periodic inspection and maintenance tasks on the propulsion controls should be performed on a regular schedule as determined by the rail transit system (RTS). The frequency of any task contained within periodic maintenance and inspection should comply with all applicable federal, state and local regulations. Further, in the conduct of an operating authority's periodic inspection and maintenance programs, frequencies for individual tasks should be established based on a number of additional factors, including but not limited to the following:

- original equipment manufacturer (OEM)–recommended intervals
- industry experience
- operating environment/conditions
- historical data
- performance requirements
- failure analysis
- rail transit system's testing and experience
- reliability-centered maintenance programs

2. Requirements and specific tasks

WARNING: To avoid possible injury while using compressed air for dislodging dirt and debris, wear appropriate eye and respiratory protection. Keep air pressure at the nozzle below 30 psi.

WARNING: To avoid possible injury while using cleaning agents, consult and comply with precautions in the material safety data sheet for the product being used before it is used. Use products that have been proven safe and authorized for the application by the RTS.

WARNING: Before working on the propulsion system, make sure that the appropriate system circuit breakers or knife switches are open and properly locked, tagged and/or grounded in accordance with the RTS's procedures.

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

WARNING: To avoid possible injury, follow OEM and RTS procedures and any warning labels for discharging capacitors, which may store energy even after outside sources of power have been de-energized.

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WARNING: Cars must be secured by wheel chocks, parking (hand) brakes, etc., per agency procedures before working on a car.

CAUTION: Megger testing requires that precautions be taken to protect electronic components.

2.1 Materials

The following materials are required:

- approved lubricants
- additional materials as referenced in the OEM's maintenance manuals

2.2 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 required for the procedures in this document:

- multimeter
- insulation tester (megger)
- go/no-go gauges

These tools require periodic calibration as specified by the RTS practices.

2.3 Safety/personal protective equipment

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

RTS established safety practices, rules and procedures shall be followed at all times in the performance of these inspections and maintenance.

2.4 Training requirements

The 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.*

Personnel involved in these inspection and maintenance activities should be familiar with all OEM and RTS safety regulations applying to equipment operating at line voltage, including any storage devices that store energy even when off-line. Inspection personnel should be familiar with the wiring, harnessing and connection practices used on the equipment. They should know how to identify blown fuses and tripped safety devices; they should recognize serviceable and defective conditions in all the devices they inspect. They should be trained in the application and reading of gauges used in these inspections. They should be able to access diagnostic codes and be able to access diagnostic information using a PC where that is necessary. Periodic retraining and retesting should be undertaken to ensure that personnel know what they are inspecting and how to determine its fitness for service

2.5 Inspection and maintenance

In all the following procedures, the OEM's maintenance manuals should be referred to for such items as torque values, voltage settings, pass/fail criteria, condemning limits, clearance measurements and specific procedure methodology. Devices should be cleaned for proper inspection. These procedures cover only the

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visible inspection, adjustments and functional testing of propulsion control equipment. Methodologies for the resolution of deficiencies noted while performing these procedures should be tailored by the RTS in conjunction with the OEM's recommendations. Documentation of the inspection and maintenance process as to interval, deficiencies and resolution of those deficiencies found should be done in a comprehensive manner so as to create a useful database that will enhance the reliability and accountability of the process.

Since there is a wide variation in system architecture of propulsion controls, no attempt is made to specify what components should be inspected. Different rail transit systems may configure this work to accommodate craft assignments, shift assignments, maintenance philosophy, etc.

The key to an effective inspection is a worker who knows what to inspect and who can accurately determine its condition. Check sheets are an effective way to accomplish this. The check sheet should be backed up by explanatory information. This information should be keyed to the check sheet for convenience, by using the same section numbering, for instance. The check sheet should list the inspections to be made, provide a place to identify the inspector and provide a place to record deficiencies. There should be a method of recording the disposition of items not corrected and a way to track those items until they are repaired. Provision should be made for identification of the person making the repairs.

Provision should be made for a supervisor or other designated employee to review and sign the completed inspection check sheets. Completed inspection check sheets should be filed in accordance with the RTS's document retention policy.

> **NOTE:** Computerized maintenance management information systems may not accommodate technician signatures. In the absence of a signature line, it is the responsibility of the RTS to ensure that inspection reports can be traced back to the individual performing the inspection for accountability.

2.5.1 Review of history

Microprocessor fault data logs (where used) and vehicle maintenance history files should be available and reviewed before starting inspection/maintenance. Diagnostic information can pinpoint components that are repeatedly failing, perhaps intermittently. Troublesome components can be identified and receive more detailed inspection and functional checks.

2.5.2 Cleaning

Cleaning should be completed before any inspection work begins. Cleaning processes vary with the type of propulsion controls in use and the effectiveness of filtering and sealing. Typical methods include the following:

- Air blow/vacuum. Essential for switched resistor equipment and may be used on solid-state equipment where required.
- Manual wipe down of electrical insulating surfaces.
- Clean heat sinks.
- Change or clean cooling air filters.

Whatever method is used, instructions for cleaning should be written and should describe in detail the components to be cleaned, as well as the methods, tools and cleaning agents to be used. Wherever possible, photographs and illustrations should be used to identify components to be cleaned.

2.5.3 Inspection, control voltage de-energized

Inspect the following and clean/repair/replace as required:

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a) Check master controller cam, switches and potentiometer. Ensure that mechanical handle interlocks function as intended and lubricate as required.
b) Check control group enclosures for damage and proper fitting of covers, cooling ducts and latches.
c) Check electronic card racks for proper seating of circuit cards.
d) Check bus, cable and wiring harnesses for proper routing and securement.
e) Check fuses, circuit breakers and other protective devices.

NOTE: The reasons for a blown fuse or tripped circuit breaker should be found and corrected.

f) Check capacitors for signs of leakage.
g) Check resistors for signs of overheating or loose connections.
h) Check air lines for leakage and damage.
i) Check electrical connectors for signs of looseness, overheating or corrosion.
j) Check electrical insulating surfaces on semiconductors and other insulators for dirt or signs of flashover.
k) Check switchgear for tip condition, arc chutes, shunts, blowout coils, operating coils/air cylinders, mechanical components such as cam followers, springs and shafts. Repair or replace as required. Apply lubricant as required. Wherever possible, objective, measurable criteria should be specified, along with the required gauges or measurement limits. Illustrations of new, acceptable-for-service and fully worn conditions should be used wherever possible.
l) Check manual wheel size compensation, and adjust as required (if so equipped).

2.5.4 Inspection, control voltage energized

Performance of this portion of the inspection is specific to the propulsion controls in use. The car should be set up with the propulsion system control voltage energized and *line voltage de-energized*.

a) Check that control voltage(s) are within specified limits. Adjust as required.
b) Check that air pressure is within specified limits. Adjust as required.
c) Trouble codes/diagnostic indicators should be recorded and cleared.
d) A sequence or self-test should be performed to the extent possible for the particular equipment.
e) Verify propulsion and braking commands from master controller and automatic train control (ATC)/automatic train operation (ATO) system where applicable.
f) Verify interlock signals, including door, braking and signal system.
g) After lockout devices have been removed, restore all circuit breakers, switches and cutouts to operating position.
h) Verify operation of the load weigh system.

2.6 Functional (road, track) test

At intervals specified by the RTSs maintenance procedures, the car should be instrumented and tested to verify motoring and braking rates. Equipment designs that annunciate or log abnormal rates or currents may not require this test.

a) Instrument the car or prepare its diagnostic system to record the motoring and braking performance values per OEM and RTS procedures.
b) Operate the car(s) in sufficient motoring and braking modes to ensure that motoring and braking rates are within RTS specifications.

2.7 Correction of deficiencies

Any deficiencies uncovered during the inspections required in Sections 2.5 and 2.6 should be corrected and documented in accordance with RTS procedures and OEM recommendations.

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Related APTA Standards

None at this time.

References

The following documents should be used in conjunction with this *Recommended Practice*:

- original equipment manufacturer's inspection, maintenance and testing manuals
- RTS procedures for testing and inspection of electrical equipment and related safety procedures

Definitions

DC-AC inverter: A propulsion system that uses a variable voltage/variable frequency inverter to supply power to alternating current (AC) traction motors and thereby to accelerate the car and provide dynamic braking, if so equipped.

DC-DC chopper: A propulsion system that uses power semiconductors to regulate current to DC traction motors and thereby to accelerate the car and provide dynamic braking, if so equipped

switched resistance: A propulsion system that utilizes a camshaft or logic network to control the operation of a series of electrical contacts and/or contactors, which shunt out resistors to regulate current to DC traction motors and thereby to accelerate the car and provide dynamic braking, if so equipped. Control of the cam may be through analog electronics or a microprocessor.

Abbreviations and acronyms

AC	alternating current
ANSI	American National Standards Institute
APTA	American Public Transportation Association
ATC	automatic train control
ATO	automatic train operation
DC	direct current
NATSA	National American Transit Services Association
OEM	original equipment manufacturer
PC	personal computer
RTS	rail transit system

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. Four new sections added: "Related APTA Standards", "Summary of document changes," "Note on Alternate Practices" and "Document history."

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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.

Document history

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NOTE: This document was reaffirmed due to minor cosmetic changes and approved by the Rail Transit Vehicle Inspection & Maintenance Working Group at a meeting in Pittsburgh, PA November 3 & 4, 2015.

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