18. Recommended Practice for Propulsion Controls Periodic Inspection and Maintenance

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Abstract: This Recommended Practice provides guidance to establish the minimum requirements for the periodic inspection and maintenance of propulsion controls used on rail transit vehicles.

Keywords: propulsion controls, rail transit vehicle
Introduction

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

This Recommended Practice for Propulsion Controls 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 rail transit agencies, may be either more or less restrictive than those given in this document.

This recommended practice describes the basic inspection and maintenance procedures for 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.
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Recommended Practice for Propulsion Controls
Periodic Inspection and Maintenance

1. Overview

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
- dc-ac inverter

1.1 Scope

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 (RTS’s) instructions and Original Equipment Manufacturer (OEM) recommendations to perform periodic inspection and maintenance of rail transit vehicles.

1.2 Purpose

This recommended practice provides a framework to develop periodic inspection, maintenance and testing procedures which will result in safe, reliable and economical operation of propulsion controls.

2. References

Original Equipment Manufacturer’s inspection, maintenance and testing manuals.

RTS procedures for testing and inspection of electrical equipment and related safety procedures
3. Definitions, abbreviations, and acronyms

3.1 Definitions

For the purposes of this recommended practice, the following terms and definitions apply:

3.1.1 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.

3.1.2 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.

3.1.3 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.

3.2 Abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>ac</td>
<td>alternating current</td>
</tr>
<tr>
<td>dc</td>
<td>direct current</td>
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<tr>
<td>OEM</td>
<td>Original equipment manufacturer</td>
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<tr>
<td>RTS</td>
<td>Rail Transit System</td>
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4. Frequency of conduct

Periodic inspection and maintenance tasks on the propulsion controls should be performed on a regular schedule as determined by the RTS. The frequency of any task contained within periodic maintenance and inspection should comply with all applicable federal, state and local regulation. 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:

- OEM – recommended intervals
- Industry Experience
- Operating Environment/Conditions
- Historical Data
- Performance Requirements
- Failure Analysis
- RTS’s Testing and Experience
- Reliability Centered Maintenance Programs
5. 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 pounds per square inch.

**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 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 RTS 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, assure 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.

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

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

### 5.1 Materials

The following materials are normally required for propulsion controls inspection and maintenance:

- Approved lubricants.
- Referenced OEM’s maintenance manuals for additional materials.

### 5.2 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 recommended in this document:

- Multi-meter*
- Insulation tester (Megger)*
- Go/no-go gauges*

* These tools require periodic calibration as specified by the RTS’s practices.
5.3 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 tests.

5.4 Training requirements

Rail transit systems 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 their 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.

5.5 Inspection and maintenance

In all of 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 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, which 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. Checksheets are an effective way to accomplish this. The checksheet should be backed up by explanatory information. This information should be keyed to the checksheet 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 a place to record deficiencies. There should be a method of recording the disposition of items not corrected.
and tracking 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 checksheets. Completed inspection checksheets should be filed in
accordance with the RTS’s document retention policy.

5.5.1 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.

5.5.2 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:

- Air blow/vacuum, essential for switched resistor equipment, 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, the methods, tools and cleaning agents to be used. Wherever
possible, photographs and illustrations should be used to identify components to be cleaned.

5.5.3 Inspection, de-energized

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

a) Master Controller cam, switches and potentiometer - ensure that mechanical handle
interlocks function as intended. Lubricate in accordance with OEM and RTS procedures.

b) Control group enclosures for damage and proper fitting of covers, cooling ducts and
latches.

c) Electronic card racks for proper seating of circuit cards.

d) Bus, cable, and wiring harnesses for proper routing and securement.

e) Fuses, circuit breakers and other protective devices.

NOTE: The reasons for a blown fuse or tripped circuit breaker should be found and corrected.
f) Capacitors for signs of leakage.

g) Resistors for signs of overheating or loose connections.

h) Air lines for leakage and damage.

i) Electrical connectors for signs of looseness, overheating or corrosion.

j) Electrical insulating surfaces on semiconductors and other insulators for dirt or signs of flashover.

k) Switchgear - check tip condition, arc chutes, shunts, blow out coils, operating coils/air cylinders, mechanical components such as cam followers, springs, shafts. Repair or replace as required. Apply lubricant if 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) Manual wheel size compensation - adjust as required (if so equipped).

5.5.4 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.

5.6 Functional (road, track) test

At intervals specified by the rail transit systems 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.
- Instrument the car or prepare its diagnostic system to record the motoring and braking performance values per OEM and RTS procedures.

- Operate the car(s) in sufficient motoring and braking modes to ensure that motoring and braking rates are within transit system specifications.

### 5.7 Correction of deficiencies

Any deficiencies uncovered during the inspections recommended in Section 5.5 and 5.6 should be corrected and documented in accordance with RTS procedures and OEM recommendations.