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Rail Transit Standards Vehicle Inspection and Maintenance Working Group

Electric Motor Periodic Inspection and Maintenance

Abstract: This *Recommended Practice* covers basic procedures for periodic inspection and maintenance of electric motors on rail transit vehicles, with emphasis on maintenance of safety-critical components.

Keywords: electric motor, periodic inspection and maintenance

Summary: This document establishes a recommended practice for electric motor inspection and maintenance. Rail transit systems should tailor these recommendations to accommodate their specific equipment and mode of operation.

Scope and purpose: This *Recommended Practice* includes essential periodic inspection and maintenance requirements for integral horsepower electric motors utilized on rail transit vehicles. Running maintenance should be developed by the rail transit system based on its service requirements and mileage. Rail transit systems may exceed recommendations given herein. This *Recommended Practice* is intended for use by rail equipment maintenance organizations.

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Introduction

This introduction is not a part of APTA RT-RP-VIM-010-02 Rev 2 '*Recommended Practice for Passenger Electric Motor Periodic Inspection and Maintenance'*.

This *Recommended Practice* 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 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 this standard. 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 requirements for electric motors found on rail transit vehicles. APTA recommends the use of this *Recommended Practice* by:

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

Electric Motor Periodic Inspection and Maintenance

1. Frequency of conduct

Periodic inspection and maintenance tasks on the electric motors should be performed on a regular schedule as determined by the rail transit system (RTS). The frequency of any task contained within this Recommended Practice shall comply with all applicable federal, state and local regulations. Maintenance tasks on electric motors should be performed on a regular schedule to ensure proper operation of the equipment. Further, in the conduct of a RTS's periodic inspection and maintenance programs, the 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
- RTS's testing and experience
- reliability-centered maintenance programs

2. Requirements and specific tasks

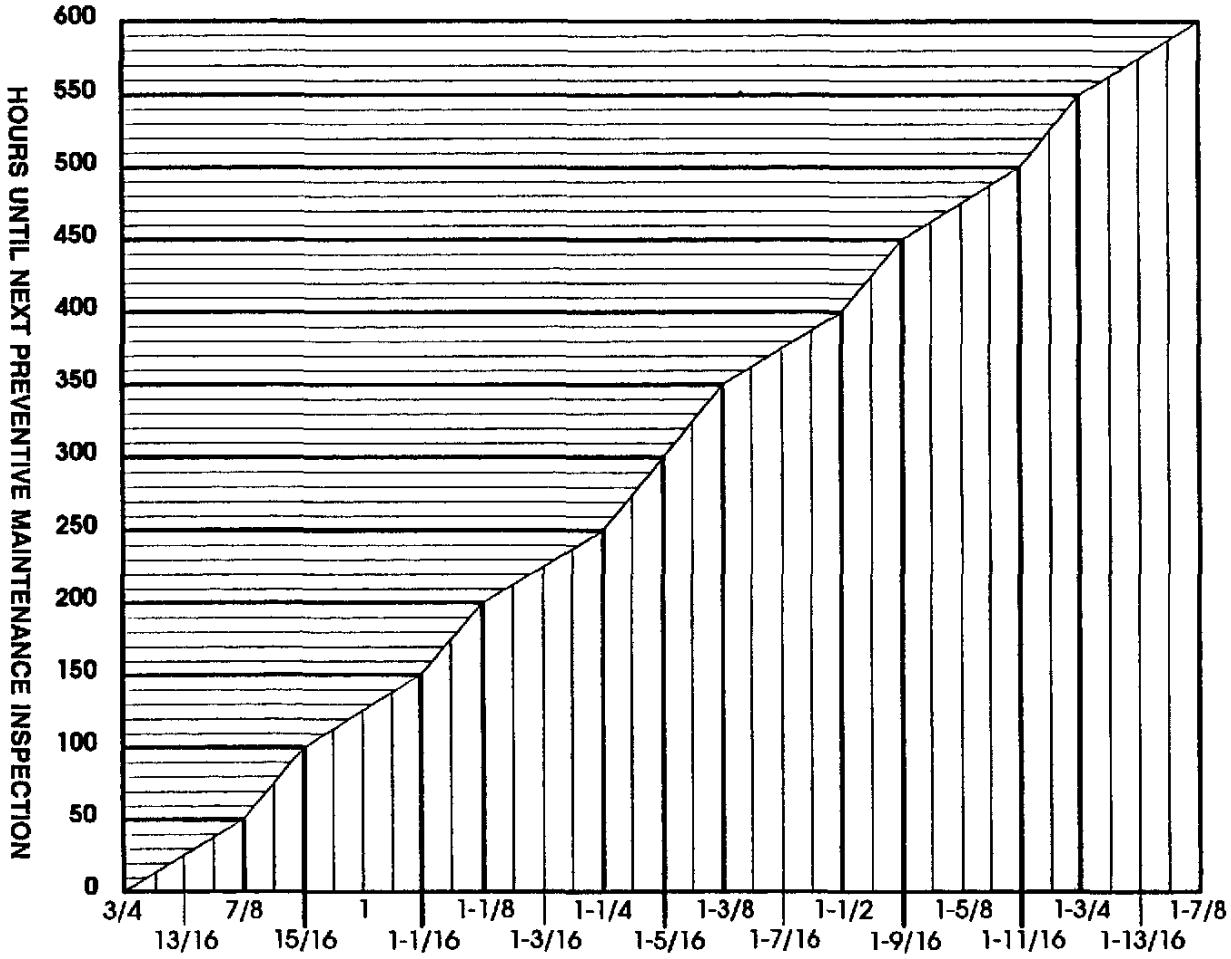
WARNING: Before working on electrical motors, make sure that the appropriate system circuit breakers or knife switches are open and properly locked and/or tagged in accordance with the RTS procedures.

2.1 Materials

The following materials are normally required for electric motor inspection and maintenance:

- approved lubricant required by the OEM
- reference OEM maintenance manuals for additional appropriate information
- RTS or OEM-approved brushes
- operation and maintenance manuals for respective property
- approved brush wear chart for each motor type operation (**Figure 1** shows a sample chart)

FIGURE 1
Minimum Motor Commutator Brush Length in 1/32 in. Increments



Sample chart only; charts vary by brush type

2.2 Devices and tools

The following devices and tools are normally required for electric motor inspection and maintenance:

- standard tools carried by maintenance personnel
- multimeter*
- torque wrench*
- spring gauge
- sandpaper (medium grade)

NOTE: Do not use conductive abrasive cloth.

- micrometer*
- depth gauge*
- grease gun (metered)
- grinding stones
- inspection mirror
- profiler/profilometer*

- dial indicator*
- flashlight
- brush holder brush box go/no-go gauge
- air hose
- megohmmeter (megger) 500 V or 1000 V*
- air nozzle, pressure regulated

NOTE: Devices and tools designated with an asterisk (*) require periodic calibration as specified by the rail transit system's practices.

2.3 Safety/personal protective equipment

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

2.4 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*. Visual aids are available from various brush manufactures exhibiting commutator and brush conditions for DC motors. Aids such as these will provide employees with various recognizable motor conditions.

2.5 Inspection and maintenance of DC motors

The inspection and maintenance checks below are general checks for all DC electrical motors using a supply voltage up to 1000 VDC. However, these checks should be applied only to those motors that are economically feasible to repair. These checks are tailored primarily for transit vehicle traction motors.

2.5.1 Visual interior inspection

Visually inspect the following:

a) The field coils wherever visible for overheating or charred conditions. If these conditions are found, then perform an electrical test as outlined in Section 2.5.4.
b) Field coil connectors wherever visible for discoloration, cracks or looseness of connections. If these conditions are found, then perform an electrical test as outlined in Section 2.5.4.
c) The security of brush holder to motor. If necessary, secure in accordance with OEM recommendations.
d) The condition of the string band or Teflon band. Epoxy type string band must not indicate signs of cracking, chipping, flaking appearance or uneven color. Teflon type must indicate a tight fit to V ring and contact with commutator bars with no peeling or any type of hole that may have been caused by motor flashover. If any of these conditions exist, then replace the motor.
e) The mounting hardware for looseness. All hardware shall be torqued to OEM specifications.
f) Bearing for lubrication leakage. No leakage is allowed on the interior of the motor.
g) Inspect for signs of flashovers (end of commutator, string/Teflon band and flash arc horns). If flashing is noted, then dress and clean all areas. Vacuum or blow out inside of motor after dressing flashovers.
h) The commutator condition. The ideal surface is shown in **Figure 2**. Review the commutator conditions shown in **Figure 3**: burnt bar edge, bar burning, streaking, grooving, copper dragging and threading. If any one of these conditions is observed, then stone the commutator as illustrated in **Figure 4** or replace the motor.

FIGURE 2
Ideal Surface

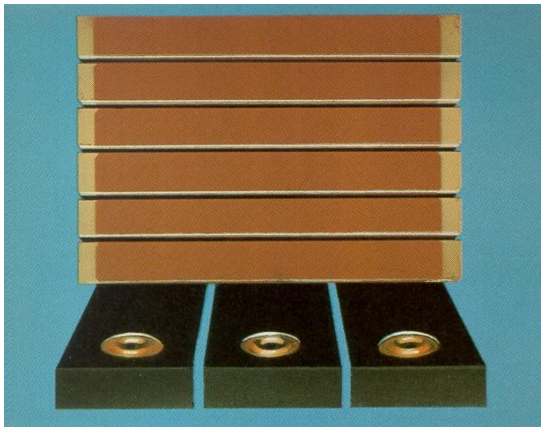
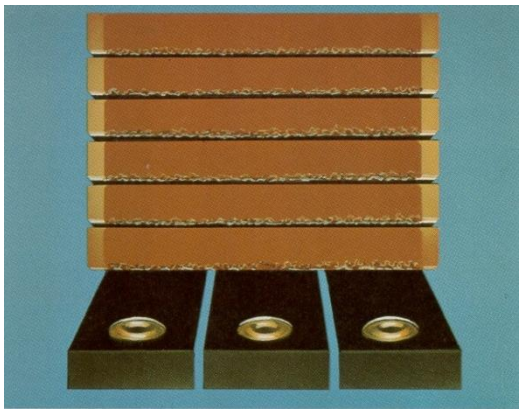
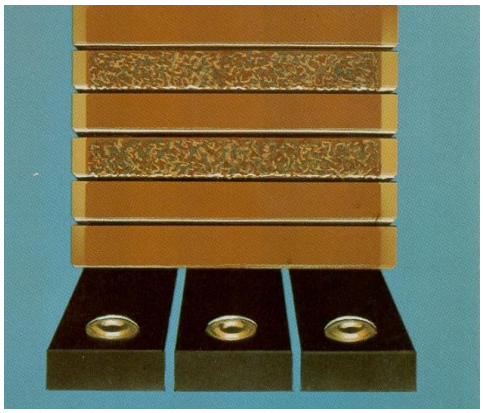


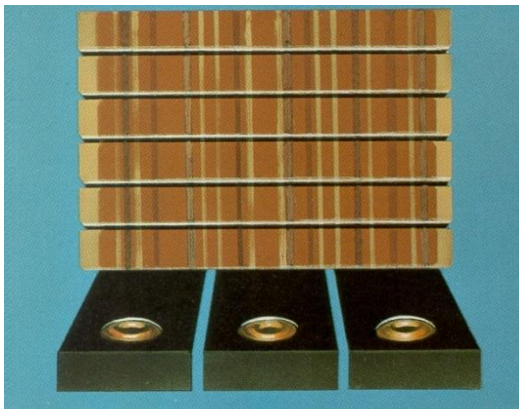
FIGURE 3
Commutator Problems



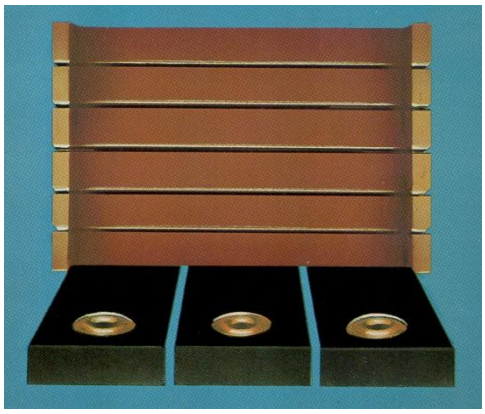
Burnt commutator bar edge



Commutator bar burning

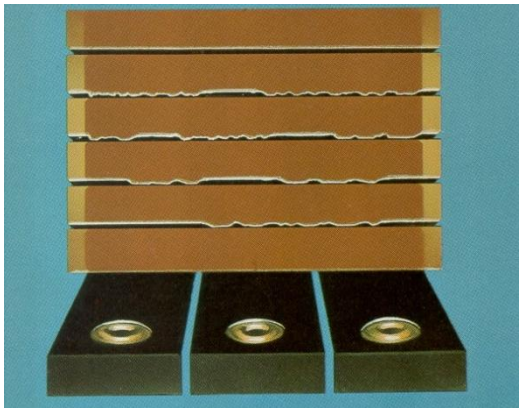


Streaking

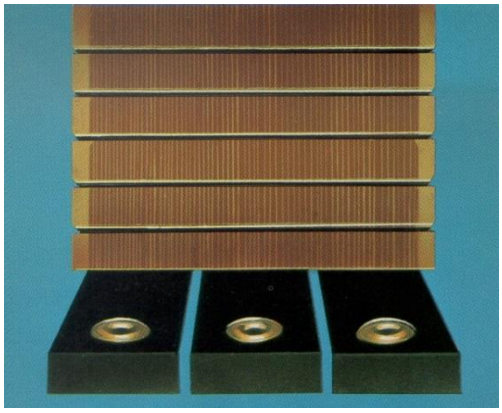


Grooving

FIGURE 3
Commutator Problems

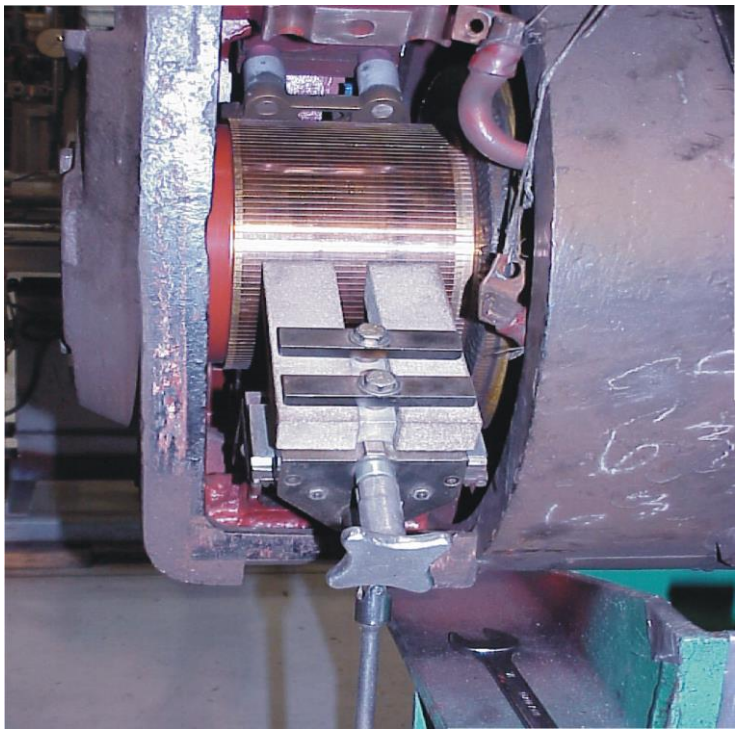


Copper dragging



Threading

FIGURE 4
Motor Stoning Tool



2.5.2 Visual exterior inspection

Visually inspect the following:

a) The inlet filter, if applicable, for excessive dirt or damage. Clean or replace filter per OEM recommendation.
b) Motor mounts, resilient or steel for failure or breakage condition. Resilient mounts with ground straps between stator and truck frame must not show signs of cracking or damage.

c) Leads for any overheating at the opening in the lead cleat. If found, determine cause and replace the lead as required. All loose hardware shall be torqued to OEM specifications.
d) Motor leads shall not chafe or indicate broken insulation. If chafing is found, then reposition the lead. If broken insulation is found, then replace the motor.
e) Bearing caps or cartridges for overheating and lubricant leakage. If found, then perform corrective action to determine the cause. Replace the motor as required.
f) All mounting hardware for looseness. If any are found loose, then torque to OEM specification. To expedite future inspections, apply torque stripes and/or witness marks to the mounting hardware.
g) That all ground straps/cables insulation is in good condition and show no signs of cracking, over heating or fraying. Replace if required. All loose hardware shall be torqued to OEM specifications.

NOTE: If any motor is found to be vibrating unusually or noisily, identify the problem. If found, then, repair or replace the motor as required.

2.5.3 Mechanical inspection

a) Inspect brushes for missing, chipping (incidental chips do not require replacement), discoloration, loose/broken strands and fraying. Replace in kind if these conditions exist.
b) Measure brush lengths per OEM/individual RTS property specifications. Ensure that they will not exceed condemning limits before the next inspection. Use an approved chart for brush wear limits that is based on RTS operating limits (see **Figure 1**). Replace in kind if brushes do not meet the specifications of the OEM or RTS, or if brushes will not meet service life before next inspection.

NOTE: If brushes are replaced, all brushes on the same motor must be from the same brush manufacturer's type and grade.

c) Measure brush holder distance from commutator per OEM specifications. Adjust as required.

NOTE: Nominal distance on many motors is $\frac{3}{32}$ to $\frac{1}{8}$ in.

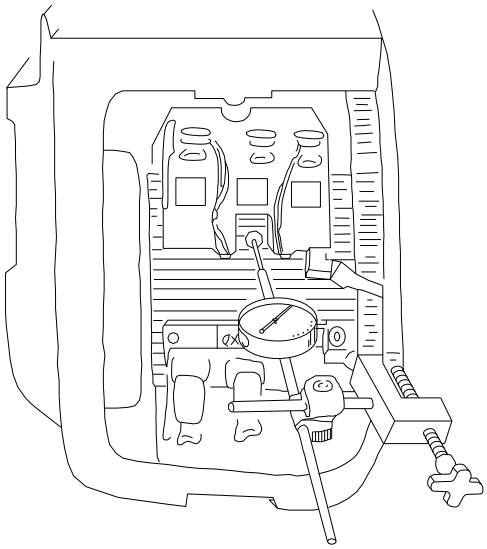
d) Measure brush holder distance from the commutator riser per OEM specifications. Adjust as required.
e) Measure brush holder distance from the arc horn if applicable per OEM specification. Adjust as required.
f) If a problem is identified, then use a spring gauge to measure spring tension at the top of the brush. Correct brush pressure is essential for optimum motor operation. Replace spring arm if OEM/RTS specification is not met.

NOTE: Nominal pressure for rail transit vehicle motors is 6 to 10 lb.

g) Verify that brushes move freely (no binding), but not excessively in the brush box. If binding or excessive movement is evident, then use the brush holder go/no-go gage to determine the correct operating limits. Replace the brush holder if no-go specifications fail OEM/RTS specifications. If the brush holder passes go/no-go inspection, yet the brushes still indicate signs of loose fit, and then measure the brush dimensions according to OEM specifications. Replace brushes as required.
h) Check for proper shunt dressing. Correct shunt dressing is essential for motor operation. Improper routing may cause brushes to bind in the brush box, causing the brush to lose contact with the commutator surface. Check OEM specifications for proper shunt dressing for the motor in question.
i) Check commutator for high mica, low mica or commutator deficiencies.
j) Check flash pins for signs of damage.

NOTE: Measure commutator total indicated runout (TIR) with use of dial indicator or profiler/profilometer (see **Figure 5** for dial indicator use).

FIGURE 5
Dial Indicate Commutator



2.5.4 Electrical

WARNING: Under no circumstances should a megger be used on energized lines or equipment. Do not use a megger in a flammable or explosive atmosphere.

a) Disconnect motor leads.
b) Connect the motor leads so that all leads to the field and armature windings of the motor (or motors) are together and insulated from ground. If it is not practical to connect all the windings together, then the leads to each individual winding should be connected together and insulated from ground.
c) Connect 500 or 1000 VDC megger, in accordance with the RTS procedures, between each connected group of leads and a clean motor frame ground.
d) Operate megger and record megger reading in accordance with RTS requirements. Repair or replace as required.

WARNING: Discharge winding(s) after each test using the megger's built-in shorting feature, if so equipped, or a separate insulated discharge jumper.

2.5.5 Cleaning

WARNING: To avoid possible injury while using compressed air for dislodging dirt and debris, wear appropriate eye and respiratory protection. Compressed dry air used for cleaning must be reduced to less than 30 psi per OSHA 29 – CFR 1910.242b.

a) Use low-pressure compressed air nozzle to blow carbon dust and dirt from interior of motor at each preventive maintenance cycle or as determined by service environment.
b) Filters with gaskets should be checked for proper seal when installed.
c) Check security of gaskets when the filter is removed. Replace or repair as necessary.
d) If equipped with removable filters, then clean in accordance with OEM recommendations.

e) If the filter has deteriorated to be uncleanable, replace with serviceable filter.
f) Clean brush holder insulators and string/Teflon band with dry, clean cloth.

2.5.6 Lubrication

 **WARNING:** Do not over grease.

a) Motor bearing and/or couplings must be serviced as recommended by OEM or RTS requirements.
b) Check for lubrication leakage, internal and external. If found, then determine the cause. Replace the motor in accordance with RTS requirements.
c) Check motor coupling for proper lubrication by measuring depth if possible. Check OEM or RTS specifications for proper depth.

2.6 Inspection and maintenance of AC motors

The inspection and maintenance checks in this section are general checks for all AC electrical motors up to 1000 VAC. However, these checks should be applied only to those motors that are economically feasible to repair. These checks are primarily tailored for transit vehicle traction motors.

2.6.1 Visual interior inspection

Inspect for bearing lubrication leakage if possible. No leakage is allowed on the interior of the motor. If found, then replace the motor.

2.6.2 Visual exterior inspection

Visually inspect the following:

a) The inlet filter, if applicable, for excessive dirt or damage. Clean or replace filter per OEM recommendation.
b) Motor mounts, resilient or steel for failure or breakage condition. Resilient mounts with ground straps between stator and truck frame must not show signs of cracking or damage.
c) Leads for any overheating at the opening in the lead cleat. If found, determine cause and replace the lead as required. All loose hardware shall be torqued to OEM specifications.
d) Motor leads shall not chafe or indicate broken insulation. If chafing is found, then reposition the lead. If broken insulation is found, then replace the motor.
e) Inspect for bearing lubrication leakage. If found, then replace the motor.
f) All mounting hardware for looseness. If any are found loose, then torque to OEM specification. To expedite future inspections, apply torque stripes and/or witness marks to the mounting hardware.
g) That all ground straps/cables insulation is in good condition and show no signs of cracking, over heating or fraying. Replace if required. All loose hardware shall be torqued to OEM specifications.

NOTE: If any motor is found to be vibrating unusually or noisily, identify the problem. If found, then, repair or replace the motor as required.

2.6.3 Electrical inspection

a) Conduct a motor insulation test as per RTS or OEM recommendations. Replace the motor if necessary.

2.6.4 Cleaning

WARNING: To avoid possible injury while using compressed air for dislodging dirt and debris, wear appropriate eye and respiratory protection. Compressed dry air used for cleaning must be reduced to less than 30 psi per OSHA 29 – CFR 1910.242b.

a) Use low-pressure compressed air nozzle to blow dust and dirt from the interior of the motor at each preventive maintenance cycle or as determined by the service environment.

2.6.5 Lubrication

WARNING: Do not over grease.

a) Motor bearing and/or couplings must be serviced as recommended by the OEM or RTS procedures.
b) Inspect for lubrication leakage, internal and external. If found, then determine the cause. Replace the motor if required in accordance with RTS requirements.
c) Inspect the motor coupling for proper lubrication by measuring the depth if possible. Check OEM or RTS specifications for proper depth.

2.7 Correction of deficiencies

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

3. Documentation/maintenance log reports

All maintenance performed on rail transit vehicle motors must be documented. This documentation should be noted on a unified type of form (electronic or paper) developed by the RTS. It should include the following:

- car number
- motor serial number
- date maintenance performed
- location of motor
- description of problem
- corrective action and part replaced
- operational test and inspection
- mileage/hours/date since last maintenance activity
- serial number of part installed and removed if applicable
- signature or identification number of person performing the maintenance activity

Related APTA standards

APTA PR-E-RP-004-98, *"Gap and Creepage Distance"* (previously numbered as APTA RP-E-04-98)
APTA PR-E-RP-009-98, *"Wire Used on Passenger Equipment"* (previously numbered as APTA RP-E-009-98)

References

This document should be used in conjunction with the following publications:

- Original equipment manufacturers' (OEM) specifications for electric motor equipment inspection and maintenance.
- Local operating property procedures for electrical motor equipment inspection and maintenance.
- Brush Digest, NATIONAL, Union Carbide Corporation, (11th and 13th reprinting).
- 29 CFR1910.242b, Compressed Air Used for Cleaning
- Institute of Electrical and Electronics Engineers:
- IEEE 100, The Authoritative Dictionary of IEEE Standards and Terms - Seventh Edition
- IEEE Std. 11-2000, IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles
- James G. Biddle Co., "A Stitch in Time: Electrical Insulation Testing for the Practical Man," Second Edition, December 1978
- James G. Biddle Co., Instruction Manual for the use of "MEGGER" Insulation Testers, Third Edition, January 1950.
- Morganite Carbon Ltd., "Morganite Carbon Brushes and Electrical Machines," reprint, 1988.

Definitions

armature: The part of a machine, whether rotating or stationary, that carries the winding connected to the external circuit in which the principal electromotive force (EMF) is induced.

> **NOTE:** This term is usually limited to the rotating part of a DC machine and refers to the complete assembly of the winding with core and commutator.

brush: A conductor serving to provide, at a rotating surface, electrical contact with a part moving relative to the brush.

brush holder: A structure designed to carry a brush or brushes that enables it to be maintained in contact with a sliding surface.

cleat: A device used to secure motor cables in place. A cleat typically consists of an assembly of two pieces of insulating material provided with grooves for holding one or more conductors at a definite spacing from the surface, wired over and from one another, and with screw holes for fastening in position.

commutator: An assembly of bars of segmental section, insulated from one another and connected to the coils of an armature winding. The assembly comprises a hollow cylinder on which brushes bear, generally on the cylindrical surface but sometimes on the radial surface. The arrangement serves to connect each of the sections of the armature winding in turn with an external circuit connected to the brushes.

integral motor: A motor with an HP rating that is one (1) or greater.

megger/megohmmeter: A precision device designed to test dielectric strength of both motor and cable insulation.

profiler/profilometer: A precision device designed to measure commutator surfaces.

rotor: A rotating part of an electrical machine with a shaft, usually applied to an AC machine.

stator: The fixed part of an electrical machine. A base or other support or suspension elements, if provided, is not ordinarily considered to be part of the stator.

total indicated run out (TIR): Total deviation from perfectly round condition.

Abbreviations and acronyms

AC	alternating current
ANSI	American National Standards Institute
CFR	Code of Federal Regulations
DC	direct current
EMF	electromotive force
MΩ	megohm
NATSA	North American Transit Services Association
OEM	original equipment manufacturer
OSHA	Occupational Safety and Health Administration
psi	pounds per square inch
TIR	total indicated run out
TM	traction motor
V	volts

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been renumbered and moved.
- Scope of work and summary sections moved to the front page.
- Definitions, abbreviations and acronyms moved to the back 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 and other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- Section 2.2 - Title changed from Tools to Devices and Tools.
- Section 2.5.4 – (c) and (d) MG values deleted and left to the RTS to determine acceptable values.
- Previous Section 5.6.2 renumbered to 2.6.2 – "Visual Exterior Inspection" Deleted and a new Section 2.6.2 added for 'Visual exterior inspection' added.
- Previous Section 5.6.3 renumbered to 2.6.3 – "Mechanical Inspection" subsections deleted and replaced with new subsections.
- Previous Section 5.6.4 renumbered to – "Electrical Inspection" – subsections (a) and (b) deleted and a new subsection (a) added.
- Section on Definition – New definition for Integral motor added
- Section on Definition – Definition for Slip ring deleted as it is not used in the document.

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Rail Standards Policy & Planning Approval	Publish Date
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