10. Recommended Practice for Electric Motor Periodic Inspection and Maintenance

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Abstract: This recommended practice covers basic procedures for periodic inspection and maintenance of electric motors on rail transit vehicles.

Keywords: electric motor, periodic inspection and maintenance
Introduction

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

This Recommended Practice for Electric Motor 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 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.
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## Contents

1. Overview .............................................................................................................................................. 10.1
   1.1 Scope ............................................................................................................................................... 10.1
   1.2 Purpose .......................................................................................................................................... 10.1

2. References ........................................................................................................................................... 10.1

3. Definitions, abbreviations, and acronyms ........................................................................................... 10.2
   3.1 Definitions .................................................................................................................................... 10.2
   3.2 Abbreviations and acronyms ........................................................................................................ 10.3

4. Frequency of conduct .......................................................................................................................... 10.3

5. Requirements and specific tasks ......................................................................................................... 10.3
   5.1 Materials .................................................................................................................................... 10.4
   5.2 Tools .......................................................................................................................................... 10.5
   5.3 Safety/personal protective equipment .......................................................................................... 10.5
   5.4 Training requirements .................................................................................................................... 10.6
   5.5 Inspection and maintenance of dc motors .................................................................................... 10.6
   5.6 Inspection and maintenance of ac motors ................................................................................... 10.12
   5.7 Correction of deficiencies ............................................................................................................... 10.14

6. Documentation/maintenance log reports ............................................................................................ 10.14

Annex A (informative) Bibliography ..................................................................................................... 10.15
Recommended Practice for Electric Motor Periodic Inspection and Maintenance

1. Overview

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.

1.1 Scope

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 respective rail transit system based on their service requirements and mileage. Rail transit systems may exceed recommendations given herein.

1.2 Purpose

This recommended practice is intended for use by rail equipment maintenance organizations. It establishes procedures for periodic inspection and maintenance of electric motors on rail transit vehicles, with emphasis on maintenance of safety critical components.

2. References

Original Equipment Manufacturer’s Specifications for electric motor equipment inspection and maintenance.


IEEE Std 11-2000, IEEE Standard for Rotating Electric Machinery for Rail and Road Vehicles


Morganite Carbon Brushes and Electrical Machines, Reprint 1988


Local operating property procedures for electrical motor equipment inspection and maintenance.

29 CFR1910.242b, Compressed Air Used for Cleaning
3. Definitions, abbreviations, and acronyms

3.1 Definitions

For the purposes of clarity, the following terms and definitions will be used in this document:

3.1.1 armature: The part of a machine, whether rotating or stationary, that carries the winding connected to the external circuit in which the principal 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.

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

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

3.1.4 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 each other, and with screw holes for fastening in position.

3.1.5 commutator: An assembly of bars of segmental section, insulated from each other 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.

3.1.6 electromotive force: That voltage induced in a conductor when the conductor is moved across a magnetic field.

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

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

3.1.9 rotor: A rotating part of an electrical machine with a shaft.

NOTE: Usually applied to an ac machine.

3.1.10 slip ring: A conducting ring rotating with a winding and connected thereto, and serving to make connection with an external circuit by means of a brush or brushes.

3.1.11 stator: The fixed part of an electrical machine.

NOTE: A base or other support or suspension elements, if provided, is not ordinarily considered to be part of the stator.

3.1.12 total indicated run-out: Total deviation from perfectly round condition.
3.2 Abbreviations and acronyms

ac  Alternating Current
ANSI  American National Standards Institute
dc  Direct Current
EMF  Electromotive Force
MA  Motor Alternator
mph  Miles per hour
OEM  Original Equipment Manufacturer
OSHA  Occupational safety & Health Administration
TIR  Total Indicated Run-out
TM  Traction Motor
v  Volts

4. 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. The frequency of any task contained within this Recommended Practice for Electric Motor Periodic Inspection and Maintenance 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 rail transit system’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:

- 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

5. 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 rail transit system’s procedures.
5.1 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.
- Rail transit system’s or OEM approved brushes.
- Operation and Maintenance Manuals for respective property.
- Approved brush wear chart for each motor type operation. (Sample chart below)

![Minimum Motor Commutator Brush Length In 1/32” Increments](chart)

Sample Chart Only – Charts Vary By Brush Type
5.2 Tools

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

- Standard tools carried by maintenance personnel.
- Multi-meter*
- Torque wrench*
- Spring gauge
- Sand paper (medium grade) Note – Do Not Use Emery Cloth
- Micrometer*
- Depth gauge*
- Grease gun (metered)
- Commutator lathe and grinding stones
- Inspection mirror
- Profiler/Profilometer*
- Dial indicator*
- Flash light
- Brushholder brush box go/no-go gauge
- Air hose
- Megohm meter 500V or 1000V (megger)*
- Air nozzle, pressure regulated

* These tools require periodic calibration as specified by the rail transit system’s practices

5.3 Safety/personal protective equipment

Appropriate personal protective equipment, meeting minimum ANSI standards and as required by the rail transit system, shall be worn at all times in the performance of these inspection and maintenance tasks.
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. Visual aids are available from various brush manufactures exhibiting commutator and brush conditions for dc motors. Aids such as these will provide employee with various recognizable motor conditions.

5.5 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 primarily tailored for transit vehicle traction motors.

5.5.1 Visual interior inspection

Visually inspect the following:

a) The field coils wherever visible for overheating or charred conditions. If these conditions are found, perform electrical test as outlined in section 5.5.4.

b) Field coil connectors wherever visible for discoloration, cracks, or looseness of connections. If these conditions are found, perform electrical test as outlined in section 5.5.4.

c) The security of brushholder 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 “Vee” ring and contact with commutator bars with no peeling or any type of hole that may have been caused by motor flash-over. If any of these conditions exist, replace 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 interior of 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. Review the following commutator conditions (Figures 2 – 7), burnt bar edge, bar burning, streaking, grooving, copper dragging, and threading. If any one of these conditions is observed, stone commutator as illustrated in Figure 9, or replace motor. The ideal surface is shown in Figure 1 below. If a problem exists, then
measure the contact force, using a spring gauge, ascending and descending through the specified operating range. Compare the average of the two readings to that specified by the operating property. If necessary, make required adjustments to obtain desired contact force.
CAUTION: Under no circumstance should emery cloth or paper be used on the commutator surface.
5.5.2 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 opening in lead cleat. If found, determine cause and replace 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, reposition lead. If broken insulation is found, replace motor.

e) Bearing caps or cartridges for overheating and lubricant leakage. If found, perform corrective action to determine cause. Replace motor as required.

f) All mounting hardware for looseness. If any are found loose, torque to OEM specification. To expedite future inspections, apply torque stripes and/or witness marks to mounting hardware.

g) All ground straps/cables insulation are 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.

h) If any motor is found to be vibrating unusually or noisy, identify problem. If found, then, repair or replace motor as required.

5.5.3 Mechanical Inspection

a) Inspect brushes for 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 transit property specifications. Ensure they will not exceed condemning limits before next inspection. Use an approved chart for brush wear limits that is based on individual property operating limits (see sample in Section 5.1). Replace in kind if brushes do not meet specification of OEM/individual transit property or if brushes will not meet service life before next inspection. All brushes on same motor must be from the same brush manufacturer’s type and grade.

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

**NOTE:** Nominal distance on many motors is 3/32 to 1/8”.

d) Measure brushholder distance from commutator riser per OEM specifications. Adjust as required.
e) Measure brushholder distance from arc horn if applicable per OEM specification. Adjust as required.

f) If a problem is identified, then use spring gauge to measure spring tension at top of brush. Correct brush pressure is essential for optimum motor operation. Replace spring arm if OEM/individual property specification is not met.

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

g) Verify that brushes move freely (no binding), but not excessively in the brush box. If binding or excessive movement is evident, use brushholder go/no-go gage to determine correct operating limits. Replace brushholder if no-go specifications fail OEM/rail transit system specifications. If the brushholder passes go, no-go inspection, yet the brushes still indicate signs of loose fit, measure brush dimensions according to OEM specification. 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 Specification for proper shunt dressing for 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 TIR with use of dial indicator or profiler/profilometer (see Figure 1 for dial indicator use). The profiler/profilometer provide a more accurate TIR read-out than the dial indicator. Nominal TIR for most motors shall not exceed 0.0005” after truing. Maximum TIR should not exceed 0.003”. If maximum TIR is exceeded, re-true commutator (see Figure 9 for typical commutator stoning equipment set-up) in place or replace motor.
5.5.4 Electrical

**WARNING:** Under no circumstances should a megger be used on energized lines or equipment. Do not use a megger in 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 of 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 rail transit system’s procedures, between each connected group of leads and a clean motor frame ground.

d) Operate megger and record megger reading after approximately 10 seconds. Minimum values for in-service motors:

- Traction motors – 5 Megohms

- Motors of all other types – 1 Megohm

**WARNING:** Discharge winding(s) after each test using the megger’s built-in shorting feature, if so equipped, or a separate insulated discharge jumper.
5.5.5 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 filter is removed. Replace or repair as necessary.
- d) If equipped with removable filters, clean in accordance with OEM recommendations.
- e) If filter has deteriorated to be uncleanable, replace with serviceable filter.
- f) Clean commutator and string/Teflon™ band with dry clean cloth.

5.5.6 Lubrication

**WARNING:** Do not over grease.

- a) Motor bearing and/or couplings must be serviced as recommended by OEM or rail transit system specification.
- b) Check for lubrication leakage, internal and external. If found, determine cause.
- c) Check motor coupling for proper lubrication by measuring depth if possible. Check OEM or rail transit system specification for proper depth.

5.6 Inspection and maintenance of ac motors

The inspection and maintenance checks below 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.

5.6.1 Visual interior inspection

- a) Inspect for bearing lubrication leakage. No leakage is allowed on interior of motor. If found, replace motor.
- b) Other checks not generally possible.

5.6.2 Visual exterior inspection

- a) Inspect mounting hardware for looseness. If any loose connections are found, then, torque to OEM specification.
b) If any motor is found to be vibrating unusually or noisy, identify problem. If found, then, repair or replace motor as required.

c) Inspect for bearing lubrication leakage. If found, replace motor.

### 5.6.3 Mechanical inspection

a) Inspect motor mounts for failure. Motor mounts with ground straps between stator and truck frame must not show signs of cracking or damage. If found replace mounts or motor.

b) Inspect all mounting hardware for looseness. If any loose connections are found, then, torque to OEM specification.

c) Inspect all ground straps and cable insulation are in good condition and show no signs of cracking. Replace if necessary.

### 5.6.4 Electrical inspection

a) Inspect leads at opening in lead cleat for signs of overheating. Check connection and tighten or replace motor.

b) Inspect motor leads for overheating, chafing or broken insulation. If chafing is found, reposition lead. If broken insulation is found, replace motor. If one or two leads are overheated, check starter resistance or inverted drive for cause of unbalanced phases. Repair inverter or motor as required.

c) Rail transit vehicle motor minimum insulation value should be 100 megohms at 1000 Vdc or as specified by OEM specifications. However each rail transit system may exceed this requirement.

### 5.6.5 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 dust and dirt from interior of motor at each preventive maintenance cycle or as determined by service environment.

### 5.6.6 Lubrication

**WARNING:** Do not over grease.

a) Motor bearing and/or couplings must be serviced as recommended by OEM or rail transit system procedures.
b) Inspect for lubrication leakage, internal and external. If found, determine cause. Replace motor as required.

c) Inspect motor coupling for proper lubrication by measuring depth if possible. Check OEM or rail transit system specification for proper depth.

5.7 Correction of deficiencies

Any deficiencies uncovered during the inspections required in Section 5.5 and 5.6 should be corrected and documented in accordance with rail transit system procedures and OEM recommendations.

6. 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 rail transit system. It should include:

- 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
Annex A (informative)

Bibliography

