ESR 0601

OVERHAUL OF 48 CLASS LOCOMOTIVE TRACTION MOTORS

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<thead>
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<tbody>
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Summary of changes from previous version

<table>
<thead>
<tr>
<th>Summary of change</th>
<th>Section</th>
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</thead>
<tbody>
<tr>
<td>NOTE – If the final document is small enough for the ‘Contents’ and ‘Document control’ to fit on one page remove the page break between the existing pages 2 and 3. HOWEVER if the ‘Document control’ page carries over to a second page separate pages must be used for ‘Contents’ and ‘Document control’</td>
<td></td>
</tr>
</tbody>
</table>
Contents

1 Scope ................................................................................................................................. 5
2 General .............................................................................................................................. 5
3 Torque settings .................................................................................................................. 5
4 Pre-inspection .................................................................................................................... 5
   4.1 Axle suspension bearing caps ...................................................................................... 5
   4.2 Testing for insulation condition ................................................................................... 6
      4.2.1 Polarisation index test ....................................................................................... 6
      4.2.2 Two voltage test ............................................................................................... 6
      4.2.3 Armature, fields and interpoles ....................................................................... 6
5 Service procedures ............................................................................................................ 7
   5.1 Armature and commutator ....................................................................................... 7
   5.2 Brushgear .................................................................................................................. 7
   5.3 Stator/motor frame ................................................................................................... 8
   5.4 Pinion ........................................................................................................................ 8
   5.5 Bearings – (commutator end and pinion end) ............................................................ 8
   5.6 Motor painting .......................................................................................................... 8
6 Post service test ................................................................................................................ 9
   6.1 Summary of tests to be performed on the traction motor .......................................... 9
      6.1.1 Megga test ...................................................................................................... 9
      6.1.2 Direction of rotation test .............................................................................. 9
      6.1.3 Bearing temperature measurement ................................................................ 9
      6.1.4 Insulation resistance test ............................................................................. 9
      6.1.5 Overspeed test ............................................................................................ 9
      6.1.6 Commutator roundness ............................................................................... 10
   6.2 Instrumentation ........................................................................................................ 10
   6.3 Documentation .......................................................................................................... 10
   6.4 Air bellow openings ................................................................................................. 10
7 Overhaul/rewind procedure ............................................................................................. 10
   7.1 General ..................................................................................................................... 10
   7.2 Armature overhaul .................................................................................................. 10
   7.3 Brushgear ................................................................................................................ 11
   7.4 Stator/motor frame .................................................................................................. 11
   7.5 Pinion ....................................................................................................................... 12
   7.6 Bearings – (commutator end and pinion end) ............................................................ 12
   7.7 Motor Painting ........................................................................................................ 12
8 Post overhaul/rewind test ............................................................................................... 13
   8.1 General ..................................................................................................................... 13
      8.1.1 Continuous rating .......................................................................................... 13
      8.1.2 Rated voltage ............................................................................................... 13
      8.1.3 Rating speed ............................................................................................... 13
      8.1.4 Maximum speed of the traction motor ............................................................ 13
      8.1.5 Output of motor .......................................................................................... 13
8.1.6 Direction of rotation .....................................................................................................13
8.1.7 Eccentricity of commutator .......................................................................................13
8.1.8 Runout ........................................................................................................................13

8.2 General ............................................................................................................................13
8.2.1 Megger test ................................................................................................................14
8.2.2 Direction of rotation test ..........................................................................................14
8.2.3 Temperature rise test ...............................................................................................14
8.2.4 Overspeed test ..........................................................................................................14
8.2.5 Commutation test ......................................................................................................14
8.2.6 Insulation resistance test ..........................................................................................15
8.2.7 Commutator roundness ..............................................................................................15

8.3 Instrumentation .................................................................................................................15
8.4 Documentation ..................................................................................................................15
8.5 Air bellow openings ..........................................................................................................15

9 Technical specifications – GE 761 traction motor ...............................................................15
9.1 Pre inspection specifications ..........................................................................................15
9.2 Service/rewind specifications .......................................................................................16
9.3 Test specifications ............................................................................................................16

10 Technical specifications – AEI 253 traction motor ..........................................................17
10.1 Pre inspection specifications .......................................................................................17
10.2 Service/rewind specifications .......................................................................................17
10.3 Test specifications ............................................................................................................18

11 Referenced standards ........................................................................................................18
11.1 RailCorp standards .......................................................................................................18
11.2 RailCorp drawings ......................................................................................................18
11.3 Australian & British Standards .....................................................................................19
11.4 Other Standards ............................................................................................................19

Appendix A Torque Charts ....................................................................................................20
1 **Scope**

This standard sets out the minimum requirements for the inspection, overhaul and testing of GE 761 and AEI 253 CT traction motors used on 48 class locomotives.

2 **General**

This standard is to be used in conjunction with the Manufacturer's Maintenance Instructions, drawings and technical information, listed herein, for the respective motor types and with Drawing 004-625, Traction Motor Service Flow Chart.

3 **Torque settings**

The following applications in traction motor assemblies are critical in relation to the tightness of the fastening:

- Mounting of brush holders in frame.
- Inter-field connections (where not brazed).
- Connection of interpole circuit leads onto brush holders.
- Mounting of main fields in frame.
- Mounting of interpoles in frame.
- Pinion lock nut (where used).
- Bearing housing bolts and screws.
- End shields.
- Spring washers must NOT be reused.

The fasteners used in the assembly of the motor shall also be tightened to correct torque settings.

Pneumatic impact wrenches or rattle guns shall not be used for tightening fasteners during assembly.

The checking of the fastening tightness or their installation during assembly must be effected by torque wrench, the torque values being appropriate for the size and grade of the fastenings as per an engineering reference approved by the Purchaser.

4 **Pre-inspection**

The following inspections shall be carried out after the motor has been dismantled, cleaned of all dirt and grease, immersion rinsed and oven dried.

4.1 **Axle suspension bearing caps**

Bore tolerances are as detailed in the relevant motor technical specification.

Axle bores are to be in place and all axle cap bolts torqued as per Manufacturer's Maintenance Manual.

**Note:** Axle caps are not interchangeable between frames. If new caps are fitted they are to be stamped with the frame serial number.
Axle bores are to be checked and measurements recorded as per RailCorp Standards ESR 0243 and ESR 0544.

Suspension bearing keyway and key to conform with key gauge (Drawings 305-329 and 305-331)

4.2 Testing for insulation condition

When the motor has been received in the working area it shall be tested prior to dismantling and cleaning to determine the quality of the insulation.

4.2.1 Polarisation index test.

Megger the motor at 1000 volts for ten (10) minutes. Record the insulation resistance after 1 minute (IR1) and after ten (10) minutes (IR10).

\[
\text{Polarisation Index P.I.} = \frac{\text{IR10}}{\text{IR1}}.
\]

A P.I. greater than or equal to one (1) is an initial indication of good quality insulation providing there have been no recorded failures or bookings in service.

Note - there shall be a discharge time allowance of 40 minutes after completion of the P.I. test.

4.2.2 Two voltage test.

Megger the motor at 500 volts for one (1) minute and record the Insulation Resistance (R1). Then megger at 2500 volts for one (1) minute and record (R5).

\[
\Delta R = R1 - R5.
\]

\[
\frac{\Delta R}{R1} \text{ should be less than 0.25.}
\]

PI = 1 and \(\frac{\Delta R}{R1} = 0.25\) indicates that the insulation is in good condition and normal servicing should be satisfactory.

PI < 1 and \(\frac{\Delta R}{R1} > 0.25\) indicates contaminated insulation and additional cleaning can be anticipated, perhaps to the extent of having to remove the armature bands.

PI < 1 and \(\frac{\Delta R}{R1} < 0.25\) indicates deteriorated or worn insulation and major work, either armature rewinding or field replacement can be anticipated. This should be referred to the Purchaser representative.

4.2.3 Armature, fields and interpoles

The following checks shall be carried out and the results recorded. Any non-conformance to specification shall be reported to the Purchaser to determine further action.

- Inspect armature shaft for straightness, size (including 4 points on each bearing seat for ovality or taper, length of shaft, overall and critical sections) and surface integrity or wear and if evident, arrange appropriate corrective action (see 7.2.).
- Visually check commutator for any bar pattern, grooving, high bars or high micas. If evident, investigate cause and arrange appropriate corrective action.
- Examine the armature insulation for charring and cracking and loose slot wedges and balance weights.
- Examine glass banding for cracks or burning.
• Examine wire banding (where applicable) for looseness or thrown soldier.
• Examine riser bars, commutator face and edge, field connections and internal surfaces for evidence of flashovers.
• Measure diameter of commutator to ensure it is above condemning size.
• Measure commutator for eccentricity.
• Measure armature resistance.
• Measure the resistance of the series field.
• Measure resistance of the interpole coils.
• Measure insulation resistance as per traction motor service flowchart, Drawing 004-625.
• Apply surge test and bar-to-bar comparison test at 250 volts to the commutator to check for open or short circuited coils.

5 Service procedures
Service work shall generally be in accordance with Manufacturer's Maintenance Manuals and Drawing 004-625 with particular attention being given to the following:

5.1 Armature and commutator
• Replace any defective or previously removed glass bands.
• Dress any components showing evidence of flashovers.
• Dip armature in varnish or VPI (compatible with existing insulation) where motors have been recovered by rinsing or there has been visible damage to the insulation.
• Resurface the commutator (where needed) with the minimum cut required to ensure surface integrity and roundness
• Undercut commutator micas to the width and depth shown in relevant motor maintenance manual.
• Chamfer the commutator bar edges (45°, 0.2 - 0.4mm across face).
• Dynamically balance armature. Balance quality grade 2.5 (AS 3709).

5.2 Brushgear
• Remove brush holders and check insulators for any visible damage (cracks or chips). Replace any defective insulators.
• Inspect for any flashover deposits on brush holders and correct.
• Inspect arc horns and arc rings and replace if damaged.
• Ensure brush boxes are not deformed.
• Clean brush holders, do not sand blast. Ensure brushways are free of obstructions.
• Ensure mounting screws and clamps are sound and correctly torqued. (See Section 3)
• Ensure brushgear alignment is parallel to commutator centre line.
• Ensure spacing of brush holders is correct.
• Fit new brushes.
• Inspect braiding of brushes and ensure tightness of brush terminal connections. (Braiding must be positioned to allow free movement of hammers.)
5.3 Stator/motor frame
- Inspect for any flashover damage and correct.
- Ensure connections are sound and correctly torqued. (See section 3)
- Ensure all mounting bolts and nuts are correctly torqued. (See section 3)
- Inspect general condition of main field and interpole insulation. Apply red air drying insulation varnish to inside assembly.
- Inspect cables, crimp lugs and markers for any signs of mechanical or electrical damage and replace any defective parts.
- Internal field leads must be securely bound to the bracing staples. Replace any loose or defective binding. (Cable ties are not permitted for this purpose.)
- Inspect and correct nose suspension lug and wear plate as per Manufacturer's Maintenance Manual. Restore to Manufacturer's tolerances.
- Ensure that flash rings or arc horns are clean and free of paint. Replace if damaged.
- Inspect end shields, bearing housings and seals for excess wear as indicated in relevant traction motor data and restore where necessary.
- Inspect condition of cable cleats. Replace if damaged.
- Ensure relevant inspection cover components including locating lugs, latching mechanisms, springs, bolts, cover and felts will provide correct securing of covers and sealing for cooling air.

5.4 Pinion
Replace pinion if broken teeth, fatigue cracks, or excessive wear are present or excessive signs of pitting, spalling or scuffing are evident. Check pinion tooth profile as per maintenance manual. When mounting the pinion, ensure that the bore and shaft taper fits and the pinion advance and the mounting procedure comply strictly with the maintenance manual specifications.

5.5 Bearings – (commutator end and pinion end)
New bearings shall be provided and fitted by the Repairer. Acceptable bearings are listed in the individual Motor Specifications.

5.6 Motor painting
All motors shall be painted with 1 coat of enamel paint - which shall be approved under GPC-E-24. The colour will be nominated by the Purchaser and shall comply with AS 2700.

Note: Areas to be masked:
- Manufacturer's data plate
- Leads
- Pinion
- End of armature shaft
- Suspension tunnels
- Air bellows openings
- Wick windows
Rust prevention to be applied to pinions and tunnels.

6 Post service test

6.1 Summary of tests to be performed on the traction motor

6.1.1 Megga test
Megger the complete traction motor at 1000 volts for one (1) minute. Insulation resistance shall not be below 20 megohms.

6.1.2 Direction of rotation test
Connect lead "AA" and "Y" together. Connect "A" to the positive side and lead "YY" to the negative side of a suitable rated power supply. Increase the voltage until the armature rotates. Rotation should be clockwise as viewed from the commutator end of the motor.

6.1.3 Bearing temperature measurement
Gradually increase the speed to 1500 rpm and run for thirty (30) minutes in the clockwise direction then thirty (30) minutes counter-clockwise.

Check that there is no indication of abnormal heat in the bearings. Temperature shall not exceed 30°C above ambient.

Record temperature of the commutator end and pinion end bearing every ten (10) minutes. Listen for any abnormal bearing noise during rotation.

Measure and record vibration of the motor running in each direction. This shall not exceed range classification 2.8 when tested in accordance with AS 2625.

6.1.4 Insulation resistance test
After the bearing temperature measurement test, the motor shall be subjected to a high potential test as below:

<table>
<thead>
<tr>
<th>60 Sec High Potential Testing</th>
<th>All Windings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Volts</td>
<td>2,500 DC (except 485 and 272 - 3,500 DC)</td>
</tr>
<tr>
<td>Pass Criteria</td>
<td>less than 15 μA disruptive discharges</td>
</tr>
</tbody>
</table>

6.1.5 Overspeed test
The motor, when hot shall be required to run at a rotational speed in excess of the maximum service speed for one (1) minute.

<table>
<thead>
<tr>
<th>Motor type</th>
<th>Speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>761</td>
<td>2770</td>
</tr>
<tr>
<td>253</td>
<td>3200</td>
</tr>
</tbody>
</table>
6.1.6 Commutator roundness
Position dial gauge to touch the commutator surface. Rotate armature slowly by hand and measure the commutator eccentricity and run out. Record values on test sheet.

6.2 Instrumentation
The serial numbers of all instruments and meters used to perform the tests outlined in section 6 shall be recorded, together with the date of their most recent calibration check.

6.3 Documentation
The recorded measurements shall be entered in dated test report sheets and returned with the machine.

6.4 Air bellow openings
After testing is completed, the motor air bellow opening shall be sealed with a cardboard plate to prevent foreign material entering the motor.

7 Overhaul/rewind procedure

7.1 General
This part of the specification covers the rewind/overhaul of the traction motors. The work shall incorporate rewinding the armature, correcting motor frame and fields and installation of the following new components:

- Commutator (new or rebuilt)
- Armature Bearings
- Brushes

The following shall be inspected for suitability for further duty and restored to service specifications. If beyond repair they shall be replaced with new components:

- Commutator (new or rebuilt)
- Pinion
- Armature shaft
- Suspension bearing components
- Brushboxes
- Commutator inspection covers
- Motor leads and cleats
- Motor frame

The commutators, fields and pinions removed from motors and replaced shall be returned to the Purchaser.

7.2 Armature overhaul
- Remove pinion and bearings.
- Strip the armature of coils, insulation and commutator.
• Shafts suitable for resizing may be repaired by hard chrome (in accordance with AS 2453) or metal spray. Full technical details of the proposed procedures for reclamation shall be referred to the Purchaser’s representative for approval prior to the work being commenced.

• Fit new shaft, where required, in accordance with the relevant drawing as nominated in the individual technical specifications.

• Flux test the core to ensure no shorts or damage exist in the laminations. Defective cores are to be referred to the Purchaser.

• Fit new or rebuilt fully seasoned commutator as required.

• Rewind armature with new main and equaliser coils insulated to classification 180 of AS 2768.

• TIG weld coil ends to riser bars.

• Fit new shaft, where required, in accordance with the relevant drawing as nominated in the individual technical specifications.

• Flux test the core to ensure no shorts or damage exist in the laminations. Defective cores are to be referred to the Purchaser.

• Fit new or rebuilt fully seasoned commutator as required.

• Rewind armature with new main and equaliser coils insulated to classification 180 of AS 2768.

• TIG weld coil ends to riser bars.

• VPI the armature with Isonel 772 varnish or compatible.

• Oven dry.

• Resurface the commutator, with the minimum cut required to ensure surface integrity and roundness.

• Undercut commutator micas to width and depth of cut specified in individual motor manual.

• Chamfer commutator bar edges (45°, 0.2 to 0.4 mm across face).

• Dynamically balance the armature. Balance quality grade 2.5 (AS 3709).

• Cleaning, drying, rewinding, testing and banding throughout the process shall be in accordance with the Manufacturer’s Maintenance Manuals for original equipment or previously approved replacement material eg glass band.

• Fit new armature shaft bearings, as approved in the relevant motor specification.

• Fit pinion. Pinion advance to be recorded.

7.3 Brushgear

• Remove brush holders and check insulators for any visible damage (cracks or chips). Replace any defective insulators.

• Inspect for any flashover deposits on brush holders and correct.

• Clean brush holders, do not sand blast. Ensure brushways are free of obstructions.

• Inspect arc horns and replace if damaged.

• Replace any deformed brush holders.

• Ensure mounting screws and clamps are sound and correctly torqued. (See Section 3)

• Ensure brushgear alignment is parallel to commutator centre line.

• Ensure spacing of brush holders is correct.

• Fit new brushes.

• Inspect braiding of brushes and ensure tightness of brush terminal connections.

( Braiding must be positioned to allow free movement of hammers.)

7.4 Stator/motor frame

• Thoroughly clean the stator inside and outside, preferably by an ultrasonic process that does not utilise a detergent. Alternatively a spray wash may be used in
conjunction with a detergent incorporating a non-ionic surfactant wetting agent and such detergent shall have the Purchaser's written approval. Motors so cleaned shall have all traces of detergent removed by a clean water/steam rinse.

- Remove main and interpole coils and pole pieces.
- Inspect insulation quality. Where required re-insulate to ensure suitability for nominated duty requirements. Re-insulation shall be with an approved asbestos-free system incorporating B stage epoxy rich materials to classification 180 of AS 2768.
- Pot the coils onto the pole pieces.
- Fit all coils into the frame. Ensure pole pieces are centred and correct torque of all mounting bolts and nuts. (See Section 3)
- Inspect cables, crimp lugs and markers, correct any signs of mechanical or electrical damage and replace any defective parts.
- Interconnect the fields. Ensure correct torque of bolted connections. (See Section 3)
- Internal field leads must be securely bound to the bracing staples. Replace any loose or defective binding. (Cable ties are not permitted for this purpose.)
- Check and correct nose suspension lug and wear plate as per Manufacturer's Maintenance Manual. Restore to Manufacturer's tolerances.
- Ensure that flash rings or arcing horns are clean and free of paint. Replace if damaged.
- Inspect end shields, bearing housings and seals for excess wear as indicated in relevant traction motor data and restore where necessary.
- Inspect condition of cable cleats. Replace if damaged.
- Spray the interior of the machine with red air drying insulating varnish.
- Ensure relevant inspection cover components including locating lugs, latching mechanisms, springs, bolts, cover and felts will provide correct securing of covers and sealing for cooling air.

7.5 Pinion

New pinions as required shall be provided and fitted by the Repairer. Pinion details are listed in the individual motor specifications.

7.6 Bearings – (commutator end and pinion end)

New bearings shall be provided and fitted by the Repairer. Acceptable bearings are listed in the individual motor specifications.

7.7 Motor Painting

All motors shall be painted with 1 coat of enamel paint - which shall be approved under GPC-E-24. The colour will be nominated by the Purchaser and shall comply with AS 2700.

Note: Areas to be masked:

- Manufacturer’s data plate
- Leads
- Pinion
- End of armature shaft
• Suspension tunnels
• Air bellows openings
• Rust prevention to be applied to pinions and tunnels.

8 Post overhaul/rewind test

8.1 General
This procedure covers the performance testing of direct current traction motors used for propulsion on rail vehicles.

The definitions applicable to this standard are:

8.1.1 Continuous rating
The rating that corresponds to a load that the D.C. traction motor can withstand on the test for an unlimited period, without exceeding the limits of temperature rise as given in BS 173 the test being started with the machine cold.

8.1.2 Rated voltage
The specified value of the voltage at the terminals of the machine.

8.1.3 Rating speed
The speed corresponding to the manufacturer's guarantee.

8.1.4 Maximum speed of the traction motor
The maximum rotational speed of the traction motor corresponding to the maximum service speed of the vehicle. (Half-worn wheel diameter condition).

8.1.5 Output of motor
The mechanical output at the motor shaft, expressed in kilowatts.

8.1.6 Direction of rotation
The direction of rotation of the armature when facing the commutator end of the motor unless specifically stated otherwise.

8.1.7 Eccentricity of commutator
Out of round measured over the full circumference of the commutator.

8.1.8 Runout
Maximum out of round measured over twelve (12) segments.

8.2 General
The test programme shall, in principle, be carried out in accordance with the requirements of BS 173.
8.2.1 **Megger test**
Megger the complete traction motor at 1000 volts for one (1) minute, except 272 and 485 motors which shall be tested at 2,500 volts. Insulation resistance shall not be below 20 megohms.

8.2.2 **Direction of rotation test**
Connect lead "AA" and "Y" together. Connect "A" to the positive side and lead "YY" to the negative side of a suitable rated power supply. Increase the voltage until the armature rotates. Rotation should be clockwise as viewed from the commutator end of the motor.

8.2.3 **Temperature rise test**
A temperature rise test, generally in accordance with BS 173, but of two (2) hours duration (one (1) hours each direction) and test conditions specified herein and utilising state of the art instrumentation. During this test the main and interpole temperatures and bearing temperatures shall be logged and the armature winding temperature and commutator temperature shall be measured immediately upon shutdown.

A Pyrometer shall be used to measure the commutator surface temperature.

Bearing temperature during and at completion of the test shall not exceed 30° C above ambient.

Measure and record vibration of the motor while running in each direction. This shall not exceed range classification 2.8 when tested in accordance with AS 2625.

8.2.4 **Overspeed test**
An overspeed test as per BS 173 under the test conditions specified in item 8.2.5 shall be carried out.

8.2.5 **Commutation test**
A commutation test shall be carried out as per “BS 173: Traction Motors of thermoelectric vehicles designed to run in both directions The test conditions shall be as specified herein.

A perspex inspection cover shall be provided to permit observation of any sparking during the commutation test. Note commutation points are held for 30 seconds only, the higher current is tested first and the cooling procedure of BS 173, may be adopted.

As an alternative to back to back testing as specified in BS 173, a dynamometer may be used.

The test condition for the above shall be:

<table>
<thead>
<tr>
<th>Motor type</th>
<th>4 Hour temperature rise test</th>
<th>Overspeed test</th>
<th>Commutation test</th>
</tr>
</thead>
<tbody>
<tr>
<td>761</td>
<td>590A 315V 455RPM 1850CFM</td>
<td>3240 RPM for 1 Minute</td>
<td>830A 250V 250A 850V</td>
</tr>
<tr>
<td>253</td>
<td>590A 315V 455RPM 1850CFM</td>
<td>3810RPM for 1 Minute</td>
<td>830A 250V 250A 850V</td>
</tr>
</tbody>
</table>
8.2.6 **Insulation resistance test**

After the commutation test, the motor shall be subjected to a high potential test as below:

<table>
<thead>
<tr>
<th>60 Sec high potential testing</th>
<th>All windings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test volts</td>
<td>2,500 DC DC</td>
</tr>
<tr>
<td>Pass criteria</td>
<td>less than 2.5μA disruptive discharges</td>
</tr>
</tbody>
</table>

8.2.7 **Commutator roundness**

Position dial gauge to touch the commutator surface. Rotate armature slowly by hand and measure the commutator eccentricity and run out. Record values on test sheet.

8.3 **Instrumentation**

The serial numbers of all instruments and meters used to perform the tests outlined in section 8.2 shall be recorded, together with the date of their most recent calibration check.

8.4 **Documentation**

The recorded measurements shall be entered in dated test report sheets and returned with the machine.

8.5 **Air bellow openings**

After testing is completed, the motor air bellow opening shall be sealed with a cardboard plate to prevent foreign material entering the motor.

9 **Technical specifications – GE 761 traction motor**

9.1 **Pre inspection specifications**

Axle bearing caps Refer specifications ESR 0243, ESR 0544

Armature

- Insulation resistance 20 M ohms 25° C (min)
- Armature resistance 0.0206 ohms +/- 2% @ 25° C
- Commutator diameter 305 mm (min)

Fields and interpoles

- Series field resistance 0.01123 ohms +/- 2% @ 25° C
- Interpole coil resistance 0.00739 ohms +/- 2% @ 25° C
9.2 Service/rewind specifications

Armature and commutator
- Shaft dimensions Refer Drg. 79374
- Commutator runout 0.01 mm (max)
- Commutator eccentricity 0.025 mm (max)

Brushgear
- Spring tension 4.5 kg +/- 0.4 kg
- Replacement brushes Refer Drg. 302-560

Motor Frame
- Nose suspensioning Lug and Wear plate spacing 241 mm +1/-0 mm

Pinion Refer AEI Cat-AEI 41105
MI 15517303

Bearings (Approved)
- Pinion end SKF NU326 ECM/C4 VA301
MI 58100504 KOYO NU326 ESRQ3C4LYPZM
FAG NU326 EMIC4F1
STEYR NU326 E/B/M2/C4/SV1
- Commutator end 6318 M/C4 type from any acceptable repairer.

9.3 Test specifications

Resistance measurement
- Main field 0.01123 ohms +/- 2% @ 25° C
- Interpole 0.00 ohms +/- 2% @ 25° C
- Armature 0.00739 ohms +/- 2% @ 25° C

Insulation resistance 20 M ohms @ 25° C (min)

Bearing temperature
- Motor speed 1500 rpm
- Vibration 0.1 mm/sec (max)

Overspeed
- Motor speed Rewind - 3240 rpm (max)
Service - 2770 rpm (max)
10 Technical specifications – AEI 253 traction motor

10.1 Pre inspection specifications

Axle bearing caps
Refer standards
ESR 0243, ESR 0544

Armature
- Insulation resistance 20 M ohms 25°C (min)
- Armature resistance 0.0186 ohms +/- 2% @ 25°C C
- Commutator diameter 305 mm (min)

Fields and interpoles
- Series field resistance 0.0103 ohms +/- 2% @ 25°C C
- Interpole coil resistance 0.0099 ohms +/- 2% @ 25°C C

10.2 Service/rewind specifications

Armature and commutator
- Shaft dimensions Refer Drg. 90372
- Commutator runout 0.01 mm (max)
- Commutator eccentricity 0.025 mm (max)

Brushgear
- Spring tension 4.4 kg +/- 0.4 kg.
- Replacement brushes Refer Drg. 302-560

Motor frame
- Nose suspensioning and lug wear plate spacing 241 mm +1/- 0 mm

Pinion
Refer AEI Cat-AEI 41105

Bearings (Approved)
- Pinion end SKF NU326 ECM/C4 VA301
  KOYO NU326 ESRQ3C4LYPZM
  FAG NU326 EM1C4F1
  STEYR NU326 E/B/M2/C4/SV1
- Commutator end 6318 M/C4 Type from any acceptable Supplier.
10.3 Test specifications

Resistance measurement

- Main field
  0.0103 ohms +/- 2% @ 25°C
- Interpole
  0.0099 ohms +/- 2% @ 25°C
- Armature
  0.0186 ohms +/- 2% @ 25°C

Insulation resistance
  20 M ohms @ 25°C (min)

Bearing temperature

- Motor speed
  1500 rpm
- Vibration
  Classification 2.8, AS 2625

Overspeed

- Motor speed
  Rewind - 3810 rpm (max)
  Service - 3200 rpm (max)

11 Referenced standards

11.1 RailCorp standards

ESR 0243 Inspection and restoration of traction motor magnet caps.
ESR 0413 Specification for case hardened gear wheels and pinions.
ESR 0544 Requalification of traction motor suspension bearing ovality

11.2 RailCorp drawings

79374 48 class locomotive traction Motor GE 761 armature shaft.
90372 Diesel-electric locomotive 253 traction motor armature shaft.
94129 Magnet frame AEI 253.
001-140 Diesel locomotives traction motor suspension bearing axle caps
004-625 Traction motor service flow chart.
101-918 Diesel electric locomotives traction motor covers.
102-804 Diesel electric locomotives cast crimp lugs.
201-386 Bottom commutator cover assembly 253 motor.
302-560 Diesel electric locomotive brush for MV 253 and MV 254 traction motors.
302-610 43, 44 and 48 class type GE761AI and 731 traction motor brush.
304-678 Diesel electric locomotives traction motor commutator cover securing pin and bracket assembly.
305-329  Traction motor suspension bearing key gauge.
Traction motor suspension bearing keyway gauge.

307-216  48 class locomotives 253 traction motor pinion.

11.3  **Australian & British Standards**

AS 1554.1  SAA structural steel welding code. welding of steel structures.

AS 2453  Electroplated coatings of chromium for engineering applications

AS 2625  Rotating & reciprocating machinery – mechanical vibration

AS 2700  Colour standards for general purpose

AS 2717.1  Welding electrodes - gas metal arc ferritic steel electrodes.

AS 2768  Electrical Insulating materials, evaluation and classification based on thermal endurance

AS 3709  Vibration & shock – balance quality of rotating rigid bodies

BS 173  Methods of specifying performance of rotating electrical machines for rail and road vehicles.

11.4  **Other Standards**

AEI Type 253AZ  traction motor, gears and gearcase maintenance manual.

MI-2029  Alco maintenance manual, electrical rotating equipment.

MI-15517303

GPC-E-24  Full gloss oil and petrol resistant enamel.

C4052775  Pinion AEI 254 motor.
**Appendix A Torque Charts**

### Recommended Maximum Bolt Loads and Torque Values (UNC Threads)

<table>
<thead>
<tr>
<th>UNC</th>
<th>Quality</th>
<th>S</th>
<th>T</th>
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<tbody>
<tr>
<td>in.</td>
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<td>7.344</td>
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### Recommended Maximum Bolt Loads and Torque Values (UNF Threads)

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<th>T</th>
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</thead>
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### Recommended Maximum Bolt Loads and Torque Values (Metric Coarse Threads)

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<td>7090</td>
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UNCONTROLLED WHEN PRINTED
Appendix A Torque Charts (Continued)

It should be understood that the subject of torque tension loading is beyond the scope of this manual. The information here supplied is an acceptable guide for normal conditions; for critical applications, however, further information and research will be necessary.

In preparing this guide to torque values, the following basic assumptions have been made:
(a) bolts and nuts are new, standard finish, uncoated and not lubricated*
(b) the load will be 90% of the bolt yield strength
(c) the coefficient of friction (μ) is 0.14
(d) the final tightening sequence is achieved smoothly and slowly, until the torque tool indicates full torque has been obtained.
*If lubrication has been applied to the bolt and/or the nut (other than the normal protective oil film), multiply the recommended torque by the appropriate factor shown in the table.
Example: Bolt and nut are both phosphated; required torque = torque recommended x 0.75.

CONVERSION FACTORS

<table>
<thead>
<tr>
<th>Torque</th>
<th>Flow</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbf ft</td>
<td>l/s</td>
<td>hp x 0.746 = kW</td>
</tr>
<tr>
<td>N m</td>
<td>cu ft/min</td>
<td>N m x rev/min x 0.472 = l/s</td>
</tr>
</tbody>
</table>

Lubrication Factor

<table>
<thead>
<tr>
<th>Surface condition of bolt</th>
<th>Self</th>
<th>Zinc</th>
<th>Cadmium</th>
<th>Phosphate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self</td>
<td>1.00</td>
<td>1.00</td>
<td>0.80</td>
<td>0.90</td>
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<tr>
<td>Zinc</td>
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<td>1.35</td>
<td>1.15</td>
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<tr>
<td>Cadmium</td>
<td>0.85</td>
<td>0.90</td>
<td>1.20</td>
<td>1.00</td>
</tr>
<tr>
<td>Phosphate and oil</td>
<td>0.70</td>
<td>0.65</td>
<td>0.70</td>
<td>0.75</td>
</tr>
<tr>
<td>Zinc with wax</td>
<td>0.60</td>
<td>0.55</td>
<td>0.65</td>
<td>0.55</td>
</tr>
</tbody>
</table>

N.B. Antiseize lubricants can reduce torque required by approximately 20%.

FORMULAE

Accepted formulae relating torque and tension, based on many tests, are:

\[ M = \frac{P \times D}{60} \]
\[ M = \text{torque lbf ft} \]
\[ P = \text{bolt tension lbf} \]
\[ D = \text{bolt dia. ins} \]
or for metric sizes:

\[ M = \frac{P \times D}{5000} \]
\[ M = \text{torque N m} \]
\[ P = \text{bolt tension Newtons} \]
\[ D = \text{bolt dia. mm} \]

These formulae may be used for bolts outside the range of the tables.

FORMULA FOR CALCULATING THE EFFECT OF TORQUE WRENCH EXTENSIONS

\[ M_2 = M_1 \times \frac{L_2}{L_1} \]

where \( L_1 \) is the normal length and \( L_2 \) is the extended length, \( M_1 \) is the set torque and \( M_2 \) the actual torque applied to the nut.

Example: Torque setting 100N m.
\[ L_1 = 500 \quad L_2 = 650 \quad \text{units of length not important; this is a ratio} \]
\[ M_2 = 100 \times \frac{650}{500} = 130 \text{ N m}. \]